Palo Pinto Creek and Tucker Lake Aquatic Survey; Stephens and Palo Pinto Counties, Texas, within Palo Pinto Mountains State Park

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March 2019

TEXAS PARKS & WILDLIFE

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Water Quality Technical Series
WQTS-2019-01

Suggested citation for this report: Warren, J.B.M. 2019. Palo Pinto Creek and Tucker Lake Aquatic Survey; Stephens and Palo Pinto Counties, Texas, within Palo Pinto Mountains State Park. Water Quality Technical Series Publication WQTS-2019-01. PWD RP V3400-2725 (5/19). Texas Parks and Wildlife Department, Austin, Texas.

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Acronyms

Acronym	Definition
ALU	aquatic life use
BIBI	benthic index of biotic integrity
DO	dissolved oxygen
EPT	Ephemeroptera, Plecoptera, Trichoptera
GPS	Global Positioning System
HBI	Hilsenhoff Biotic Index
HQI	habitat quality index
IBI	index of biotic integrity
IF-WF	Inland Fisheries - Wichita Falls
m	meters
min	minute(s)
NLA	National Lakes Assessment
PHab	physical habitat
PPMSP	Palo Pinto Mountain State Park
SWQM	Surface Water Quality Monitoring
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TSI	Trophic State Index
TWQS	Texas Water Quality Standards
USEPA	United States Environmental Protection Agency
YSI	Yellow Springs Institute

Acknowledgments

A field project is only as successful as the dedicated staff in the field working hard, sweating and laughing during long days.

A huge thank you goes out to staff in the Texas Parks and Wildlife Department's (TPWD) State Parks Division who helped and supported the project. Paul Baldon, TPWD State Parks Region 5 Natural Resource Specialist, got the project started and has been a constant supporter, field companion, a walking encyclopedia for vegetation and habitat, and provided attentive edits. John Ferguson (retired Park Superintendent) made sure we knew where we were going and provided any information about the park we needed, and James Miller (Park interim manager), kept us going even when we ran out of gas, literally.

The TPWD Water Quality Program also thanks the Inland Fisheries River Studies team. Sarah Robertson was instrumental in providing guidance with planning, coordination, support and thoughtful edits. Gordon Linam, Clint Robertson and Alana Hoffmann helped with collecting fish data. Wes Dutter and Robert Mauk with the Inland Fisheries-Wichita Falls office also assisted with fish collection. Wes and Robert also survey and manage Tucker Lake's fishery on behalf of TPWD.

In addition to TPWD staff, Michael Caldwell with the Texas Commission on Environmental Quality's Surface Water Quality Monitoring Program in their Dallas/Ft. Worth office provided help with securing a boat to monitor Tucker Lake and participated in data collection on the lake.

Last, but not least, the author wishes to thank the TPWD Water Quality Program. Adam Whisenant, Cindy Hobson, Marty Kelly and Anne Rogers Harrison were a part of each aspect of the project and are constant morale boosters.

Executive Summary

In 2011, Texas Park and Wildlife Department acquired land for a new park in Stephens and Palo Pinto counties near Strawn, Texas. Since then, the department has continued to acquire land and the new park, Palo Pinto Mountains State Park (PPMSP) now totals approximately 17.8 km^2 (4,395 acres; Freeman 2015). The park was undeveloped at the time of this report and little to no historic data was available for the aquatic communities within the state park boundaries. In 2014, Texas Park and Wildlife Department's Water Quality Program reached out to the Park Superintendent, John Ferguson, about conducting a comprehensive biological assessment of the aquatic resources in the new property. An intra-divisional team was assembled comprised of staff from the Water Quality Program within the agency's Coastal Fisheries Division and from the River Studies Program within the Inland Fisheries Division to conduct an aquatic survey for Palo Pinto Creek and Tucker Lake located within the state park boundaries. During July 2015, the team collected baseline data from Tucker Lake and two locations on Palo Pinto Creek.

The baseline data includes physical aquatic habitat, fish, benthic macroinvertebrate, freshwater mussels, and physicochemical data collected from two sites on Palo Pinto Creek. For Tucker Lake, data collection included physicochemical data, Secchi Depth, physical habitat characterization, phytoplankton, zooplankton, and benthic macroinvertebrate data. The project provides the first aquatic survey of these waterbodies, with the exception of Tucker Lake fishery management data which is collected by TPWD every two years to manage the stocked fishery in the lake. Any future aquatic life surveys can be compared to this aquatic survey in order to understand potential changes within the state park's aquatic systems, and assist with decision making as the state park develops a site plan.

The Palo Pinto Creek aquatic survey produced 264 individuals and 13 species of fish and 583 individuals and 32 species of benthic macroinvertebrates. No live mussels were found; however, shells from four species were collected during a reconnaissance trip. The overall quality of the aquatic life in Palo Pinto Creek is high based on the index of biotic integrity (IBI) as assessed for fish, benthic macroinvertebrates and a habitat quality index for physical habitat. The physicochemical field measurements showed the creek to have water quality conditions for temperature, pH, specific conductance, and dissolved oxygen within expected ranges.

The Tucker Lake aquatic survey followed the Environmental Protection Agency's National Lakes Assessment protocols which included 10 physical habitat stations around the perimeter of the lake and one deep water station or index site near the dam. The physicochemical field measurements for water quality fell within expected ranges, and the lake is categorized as eutrophic based on the Carlson's Trophic Status Index using Secchi disk depth. Benthic macroinvertebrates were collected from the 10 stations and included 294 individuals and 29 taxa. TPWD's Wichita Falls Fisheries Management office manages Tucker Lake's fishery and surveys the lake every two years. The surveys for 2011 and 2015, collectively, included eleven species of fish. Specimens of the freshwater mussel, Giant Floater *Pyganodon grandis*, were found stranded along the shoreline during the field reconnaissance for the survey and may still be present in the reservoir, although mussels were not surveyed in the lake as part of this study.

Introduction

Texas Parks and Wildlife Department's (TPWD) mission is to manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations (TPWD 2015a). One of the ways that TPWD manages and conserves the natural and cultural resources of Texas is by creating and managing state parks. Developing a new park includes documenting natural and cultural resources including the resources in and around water features (TPWD 2016b). The natural resources available in water features (rivers, streams and lakes) include fish, benthic macroinvertebrates, freshwater mussels and aquatic plants.

In 2011, TPWD purchased land in Stephens and Palo Pinto counties and created a new state park, Palo Pinto Mountains State Park (PPMSP). The new park was named after the local mountain range in Palo Pinto County. In order to create a baseline for the natural diversity within PPMSP's water features, TPWD staff collected biological data from Palo Pinto Creek and Tucker Lake. The intra-divisional team was able to document the new park's aquatic resources prior to park development. The aquatic resources are integral to the ecosystem functions of the state park and serve as a destination for the park visitors. The intra-divisional team includes River Studies (Inland Fisheries) who provided fish and mussel expertise, the Water Quality Program (Coastal Fisheries) who provided habitat and bioassessment knowledge, and State Parks staff who guided the group and assisted with riparian observations.

The objectives of the study were to document the aquatic biological resources available to PPMSP in Palo Pinto Creek and Tucker Lake. The study contributes baseline data that can be used to support the natural resources found in the park, help make adaptive management decisions, and to observe any changes that may occur as the new park develops.

Study Area

Palo Pinto Mountain State Park is located in the Western Cross Timbers Ecoregion (Ecoregion 29c) spread across Stephens and Palo Pinto counties. Cities nearby are Strawn, Mingus, and Thurber in Palo Pinto County and Ranger in Eastland County. The park's northern boundary and other areas of the park incorporate Palo Pinto Creek and abuts the historic Texas and Pacific Railroad right-of-way (Freeman 2015).

The state park is 17.8 km^2 (4,395 acres; Miller 2014) which includes Russell Creek, Tucker Lake, and portions of Palo Pinto Creek. Russell Creek is an intermittent stream that begins in Eastland County and runs seven miles northeast before joining Palo Pinto Creek (Figure 1; Heart of Texas Online (HOTO), "Russell Creek (Eastland County)"). North Fork Palo Pinto Creek (referred to as Palo Pinto Creek in the rest of the paper) begins just east of Ranger in Eastland County and flows as a perennial stream for 40 km (25 mi.) to the confluence with South Fork Palo Pinto Creek (HOTO, "Palo Pinto Mountains"). Approximately 8 km (5 mi.) of stream flow through the state park (Figure 2).

Tucker Lake is the second reservoir on Russell Creek, covering 0.38 km^2 (95 surface acres; TPWD 2016b). The lake is the drinking water source for the City of Strawn and will provide recreational opportunities for park visitors. The lake is located in the center of the property and is surrounded by rugged hills and is bordered by stands of native trees and grasses (Figure 1). The lake was built in 1937 by the national Works Progress Administration, an agency created under President Franklin Roosevelt's New Deal to help the country rebuild its infrastructure during the Great Depression. There are still remnants of cabins built during that time which families would later use as fishing camps.

Figure 1. Palo Pinto Creek and Tucker Lake at Palo Pinto Mountains State Park, Stephens and Palo Pinto counties, July 2015.

The Clean Water Act requires all states to adopt water quality standards for surface water. A water quality standard consists of the designated beneficial use or uses of a water body or a segment of a water body and the water quality criteria that are necessary to protect the use or uses of that particular water body. Water quality standards are the basis for establishing discharge limits in wastewater and storm water discharge permits, setting instream water quality goals for total maximum daily loads (TMDLs), and providing water quality targets to assess water quality monitoring data. In Texas, Texas Commission on Environmental Quality (TCEQ) is the regulatory agency that assesses whether the health of Texas' water bodies (lakes, streams, bays, etc.) are meeting standards. Assessing the state's waters requires comparing water quality measurements to established Texas Surface Water Quality Standards (TSWQS). The TSWQS are found in the Texas Administrative Codes §§307.1-307.10. The TSWQS describe Palo Pinto Creek (TCEQ Segment 1230A) as a "perennial stream from the confluence with the normal pool elevation of Lake Palo Pinto which is near the confluence with an unnamed tributary at the Texas and Pacific Railroad crossing upstream to the dam forming Hagaman Lake" (TCEQ 2014b). The TSWQS also state that the aquatic life use (ALU) for Palo Pinto Creek is high and the dissolved oxygen (DO) criterion is a mean of 5.0 mg/L or greater and a minimum of 3.0 mg/L during summer months and a mean DO of 5.5 mg/L or greater and a minimum is 4.5 mg/L during the rest of the year (TCEQ 2014b).

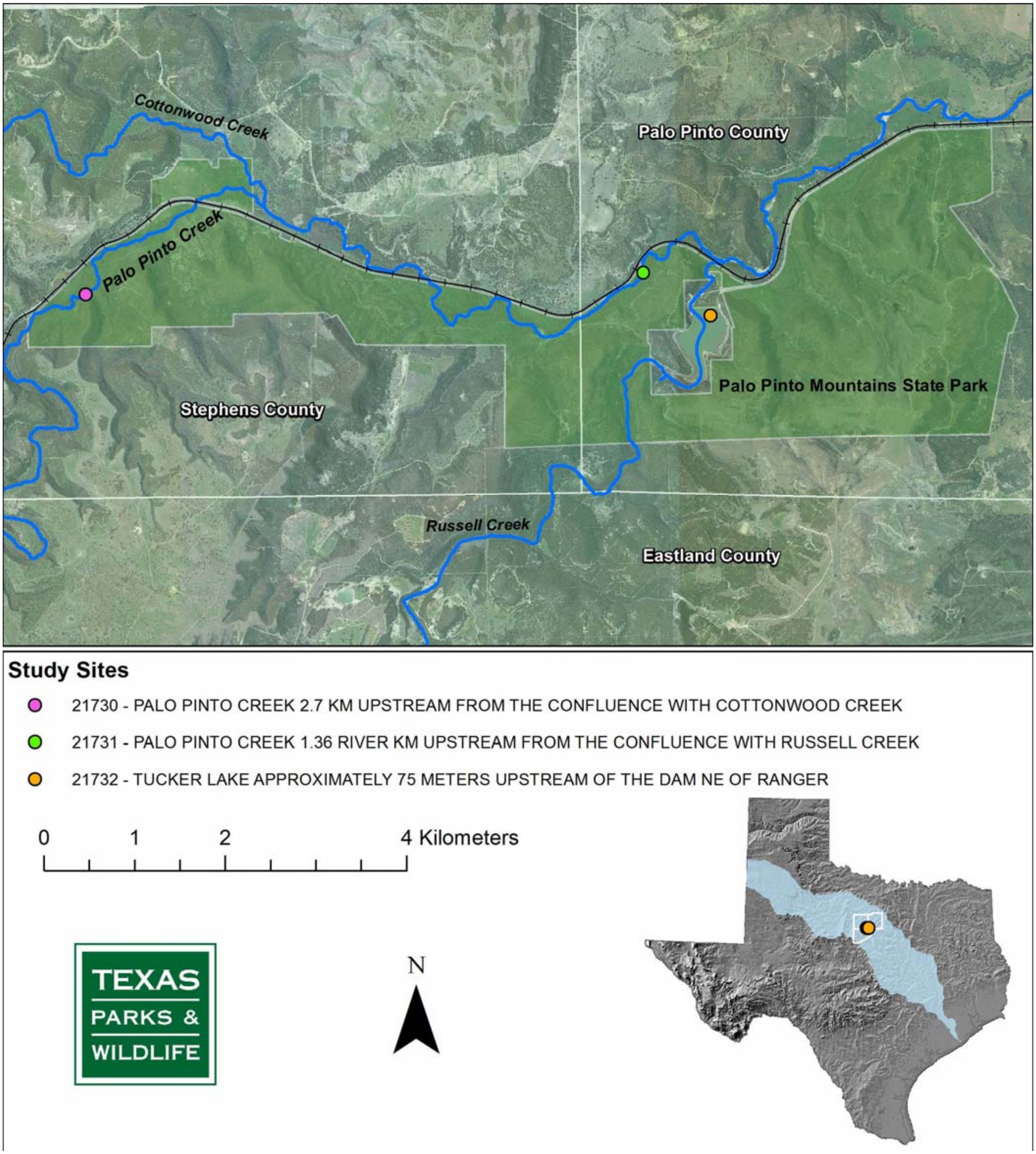

Figure 2. Overview of Palo Pinto Mountain State Park and station locations for Palo Pinto Creek and Tucker Lake. (Courtesy of Adam Whisenant, TPWD)

Water quality standards for Tucker Lake have not been established; however, Lake Palo Pinto is of similar size and located downstream of PPMSP thus its criteria can be used as a proxy for Tucker Lake. Lake Palo Pinto (Segment 1230) has site-specific criteria as described in TSWQS (TCEQ 2014b). The site-specific criteria include a high ALU, domestic water supply use, mean DO of 5.0 mg/L or greater, pH range from 6.5–9.0, and a maximum temperature of 34°C (93˚F; Lake Palo Pinto is a power plant cooling reservoir making the average temperature higher than other water bodies; TCEQ 2014b). While

Tucker Lake (unclassified segment) is smaller, this gives a point of reference to assess data collected during this study; however, it should not be used to assess the lake for meeting surface water quality standards.

Site Selection

The aquatic survey of PPMSP included Palo Pinto Creek and Tucker Lake. Two stations were selected along Palo Pinto Creek based on creek access, availability of perennial pools, and geographical location based on county. Palo Pinto Creek station 21730 is located in Stephens County 2.7 km upstream from the confluence with Cottonwood Creek. Palo Pinto Creek station 21731 is in Palo Pinto County 1.36 km upstream from the confluence with Russel Creek (Table 1; Figure 2). These stations were created for the study and are part of TCEQ's Surface Water Quality Monitoring (SWQM) stations, are affiliated with the TCEQ's database, and can be monitored by TCEQ or other agencies in the future.

A station was created within TCEQ's SWQM database as a reference location for Tucker Lake (21732) and can be monitored by TCEQ or other agencies in the future (Table 1). The Environmental Protection Agency's National Lake Assessment (NLA) protocols (USEPA 2011) used to assess Tucker Lake include ten physical habitat stations (sub-stations) located around the lake, and the deepest part of the lake, Site X, which was located near the dam (Table 2; Figure 3). These stations were spaced at equal distances around the lake with the first station sampled selected at random using desktop Geographical Information Systems (GIS) tools and were navigated to via Global Positioning System (GPS) instruments.

Table 1. Station descriptions and locations at Palo Pinto Mountains State Park.

Station No	Station Description	Latitude	Longitude
21730	Palo Pinto Creek 2.7 km upstream from the confluence with Cottonwood Creek	32.535483	-98.633983
21731	Palo Pinto Creek 1.36 river km upstream from the confluence with Russel Creek	32.536980	-98.568348
21732	Tucker Lake approximately 75 m upstream of the dam NE of Ranger	32.532563	-98.560501

Table 2. Tucker Lake physical habitat locations.

Station	Latitude	Longitude
A	32.533249	-98.56277
B	32.533288	-98.55967
C	32.531079	-98.55834
D	32.528695	-98.55933
E	32.528431	-98.56141
F	32.526023	-98.56153
G	32.525669	-98.56386
H	32.527288	-98.56275
I	32.529506	-98.56430
J	32.531032	-98.56340
X	32.532660	-98.56111

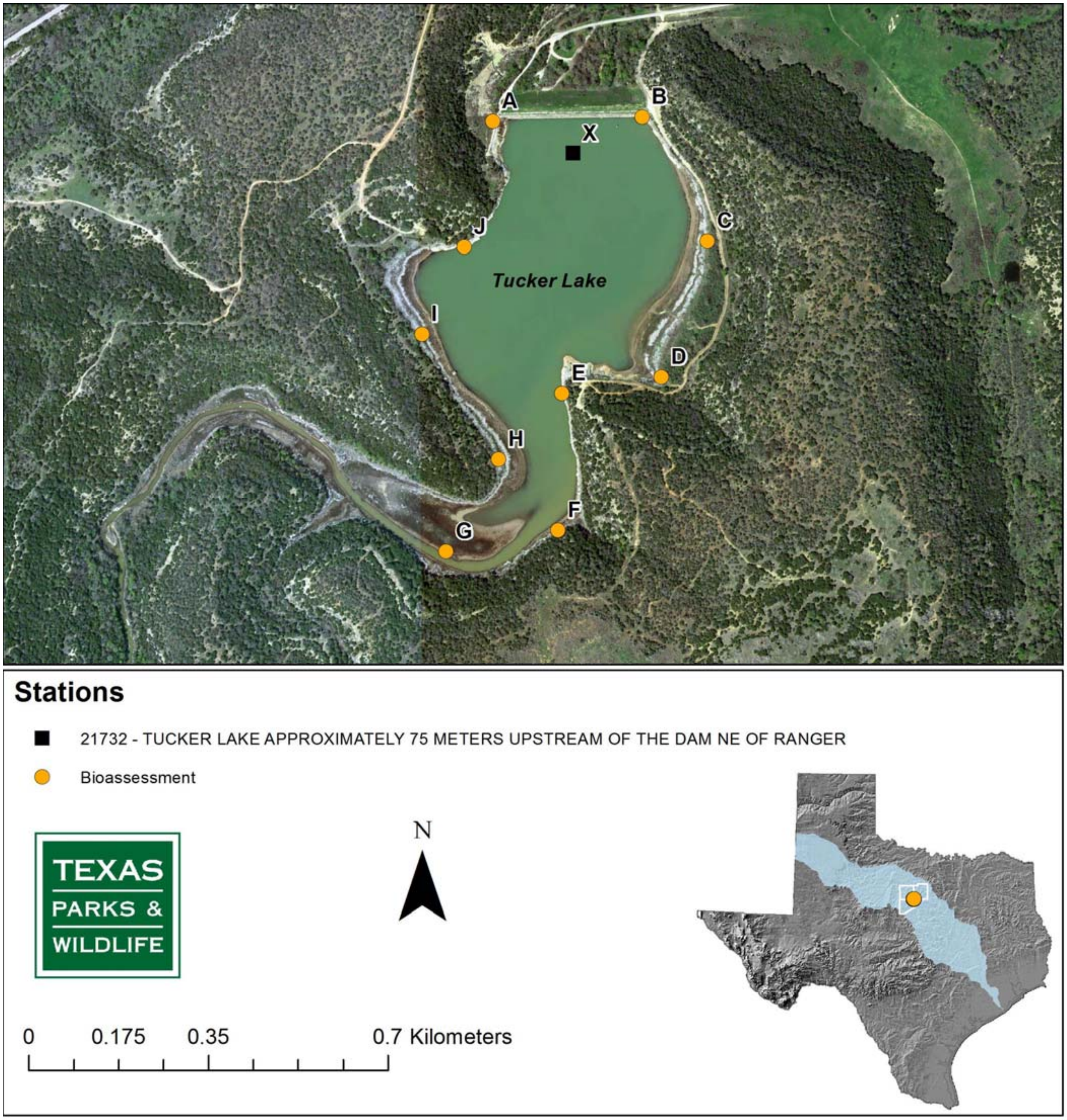

Figure 3. Map of the physical habitat stations sampled on Tucker Lake July 28, 2015. Site X is also station 21732. (Courtesy of Adam Whisenant, TPWD.)

Palo Pinto Creek

Methods for sample collection follow the TCEQ Surface Water Quality Monitoring (SWQM) Procedures Manual, Volumes 1 and 2 (TCEQ 2012; TCEQ 2014a), EPA's NLA protocols (USEPA 2011), and Strayer and Smith (2003) for mussel surveys as specified in the project Quality Assurance Project Plan (TPWD 2015b). Brief descriptions of the methods are given below.

Methods

Habitat

Palo Pinto Creek habitat assessment followed TCEQ SWQM Procedures, Volume 2 (TCEQ 2014a) without exception. Both stations 21730 and 21731 were sampled over a 240 m and 280 m reach respectively. Reaches were selected to incorporate perennial pools, accessibility, and creek representativeness (Table 1 and Table 18). The stations and reach locations are within the defined area of a station based on TCEQ SWQM definitions (station can represent up to 25 miles of stream). Meaning the reach length sampled does not always incorporate the latitude and longitude for the official station location.

Habitat data was used to calculate the habitat quality index (HQI) at both Palo Pinto Creek stations. The HQI is a measure of the overall health of the habitat along the creek. The HQI complements fish and benthic macroinvertebrate assemblage data and is useful when interpreting the biotic integrity of the stream (TCEQ 2014a). The HQI includes nine metrics that describe the quality of stream riparian habitat: available instream habitat, bottom substrate stability, number of riffles, number of bends, dimensions of the largest pool, channel flow status, bank stability, riparian buffer vegetation and the aesthetics of the reach. The results are reported as an aquatic life use and possible rankings include exceptional, high, intermediate, and limited (Appendix A).

Physicochemical Parameters

A YSI 600 XLM multi-parameter datasonde or similar instrument was used to measure dissolved oxygen, temperature, pH, and specific conductance at both stations on Palo Pinto Creek. Physicochemical data (also known as water quality data) were collected before other field work commenced to ensure measurements were not affected by sediment disturbance. Data recording, instrument calibration, and post-calibration followed TCEQ SWQM Procedures, Volume 1 (TCEQ 2012). Flow measurements were also taken at both Palo Pinto Creek sites using a Doppler meter following TCEQ SWQM Procedures, Volume 1 (TCEQ 2012).

Fish Assemblage

Fish were collected from both sites on Palo Pinto Creek using a backpack electrofisher and 15 foot seines. Sampling techniques were selected based on effectiveness at capturing fish at each particular sampling area given the depth, velocity, substrate, and cover present. Expanding on TCEQ sampling protocols (2014a), a minimum sampling effort of 10 seine hauls and 15 minutes of electrofishing effort was established for each site; however, additional sampling continued, if needed, until all habitats had been effectively sampled and new species were not collected.

Fish from each sample (i.e. electrofishing transect or seine haul) were kept separate and supplemental habitat data was recorded at the location of each sample. This supplemental habitat data included measurements of depth, velocity, substrate, and instream cover. While supplemental habitat data was not incorporated into this report, it will be available for future analysis of fish-habitat associations.

Once captured, large fish were identified to species, measured for total length, photographed, and released. Smaller specimens were fixed in a 10% solution of formalin for later 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 Biodiversity Collections Facility in Austin, Texas. This data will also be available online through the Fishes of Texas Project (Hendrickson and Cohen 2015).

A regionalized Index of Biotic Integrity (IBI), metrics developed for the Subhumid Agricultural Plains land use region (Linam et al. 2002), were calculated for the two study sites. The IBI provides a means of generally assessing the fish assemblage degradation due to water quality. Results are reported as an ALU and possible rankings include exceptional, high, intermediate, and limited.

Mussel Assemblage

Mussels were surveyed for a minimum of two person-hours per site using a combination of timed snorkel surveys and tactile searches in all available mesohabitat types (Strayer and Smith 2003). During a reconnaissance trip in November 2014, visual surveys were conducted along Palo Pinto Creek for mussel shells. Identification was completed by a professional malacologist when specimens were collected.

Benthic Macroinvertebrates Assemblage

Benthic macroinvertebrate samples were collected using kick-nets. The level of effort was recorded in five-minute intervals and samples were processed in the field to ensure that at least 175 individuals were collected at each station as specified in TCEQ SWQM Procedures, Volume 2 (TCEQ 2014a). The benthic macroinvertebrates were placed into labeled jars with 70% isopropyl alcohol. Preserved specimens were identified in the laboratory and at least 10% of the specimen collection was verified by a qualified benthic macroinvertebrate specialist.

A Benthic Index of Biological Integrity (BIBI) was calculated for each of the two study sites using both the statewide index of biotic integrity (IBI) (Harrison 1996) and the new regionalized IBI (Harrison 2017). The BIBI provides a set of metrics that integrate structural and functional attributes of macroinvertebrate assemblages to assess biotic integrity and can be used to set ALU categories for unclassified waterbodies (waterbodies that do not have a segment number assigned to them by TCEQ) or provide a baseline for existing uses for classified waterbodies (Harrison 1996). The results are reported as possible rankings that include exceptional, high, intermediate, and limited.

Results and Discussion

Habitat

The reach length for station 21730 was 240 m and five transects were evaluated (Table 18). Of the five transects, three crossed large pools (Figure 4) and two transects contained shallow water with large cobble and aquatic plants. The two shallow transects were not quite shallow enough to be called riffles (Figure 5). The pools are large with uneven bottoms and were difficult to seine and too deep for a backpack electrofisher (Figure 4). A barge electrofisher would be beneficial in future sampling, however, the terrain makes it difficult to launch a boat.

The aquatic habitat survey noted station 21730 had stable substrate, a good mix of adequate instream cover, the largest pool which covered more than 50% of the channel and was over a meter deep, and the reach contained riffles. The station scored lower for bank stability, channel flow status (low), and channel sinuosity (stream bends; Table 3). The habitat quality index scored 21. 5 or high (Appendix A).

The reach length for station 21731 was 280 m and included five transects (Table 18). Aquatic habitat for three transects contained pools and the other two transects contained riffles (Figure 6). Transect 4 was located immediately downstream of the largest and deepest pool in the reach. The most upstream side of transect 4 was a split channel. One side of the split channel was dry and the other side was a riffle (right bank; Figure 7). Transect 4 data incorporated the right bank data from the riffle and the left bank data from the dry channel. Transect 1 and a portion of transect 2 contained bedrock along the stream bottom with relatively deep pools (Figure 8).

The calculated HQI for station 21731 was 23.5 (high) based on the aquatic habitat survey data. This stream reach scored highest for stable substrate, had adequate instream cover, and the largest pool covered more than 50% of the channel and was over a meter deep. This reach also included four riffles and exhibited high channel sinuosity (number of stream bends; Table 3). The station reach scored lower for bank stability, channel flow status (low), riparian buffer and aesthetics of the reach (Appendix A).

Table 3. Habitat quality index for station 21730 and 21731, Stephens Palo Pinto counties, July 28, 2015. Scoring criteria; exceptional – 26-31, high 20-25, intermediate 14-19, and limited <14.

	21730		21731	
Metric	**Value**	**Score**	**Value**	**Score**
Mean % Instream Cover	39	3	22	2
Number of Riffles	2	3	4	3
Max. Depth of Largest Pool (m)	6	4	2.04	4
Bank Stability	-	1.5	-	1.5
Mean Bank Slope (degrees)	41.62	1	42.41	1
Mean % Bank Erosion	45.5	1	29.29	2
Riparian Buffer Width (m)	16.5	2	18	2
Channel Flow Status	low	1	low	1
Channel Sinuosity	low	1	high	3
Bottom Substrate Stability	88	4	70	4
Aesthetics	natural	2	natural	2
Reach length (m)	240	-	280	-
Number of Transects	5	-	5	-
Aquatic Life Use Score	21.5		22.5	
Aquatic Life Use Rating	High		High	

Figure 4. Station 21730 in Stephens County looking downstream at transect 5.

Figure 5. Station 21730 in Stephens County looking upstream at transect 3.

Figure 6. Riffle at transect 4 looking downstream at station 21731, Palo Pinto County.

Figure 7. Station 21731 at transect 4 looking downstream at the split channel. The channel to the left side of the photo was dry and the channel on the right side contained the riffle portion of the creek.

Figure 8. The pool at Transect 1 looking upstream at station 21731 in Palo Pinto County.

Physicochemical Parameters

Instantaneous and 24-hr diel physicochemical data were collected from both stream stations to help understand the quality of aquatic habitat available. Instantaneous readings were taken at the location of and prior to deployment of the 24-hr sonde in order to create a baseline for the 24-hr data. The collected data showed good water quality conditions and ranges fell within segment specific and general water quality standards (Table 4; TCEQ 2014b).

Standard physicochemical guidelines for healthy streams include a range from 6.0 – 9.0 mg/L for DO, 6.5 – 9.0 for pH, various segment standards for total dissolved solids (calculated from specific conductivity data), and maximum temperature limits. These guidelines are found in the TSWQ (TCEQ 2014b). The TSWQS provide protection for water quality in Texas' streams, rivers, lake and bays.

The 24-hr diel data collected from Palo Pinto Creek showed normal ranges for all parameters (Table 5). Dissolved oxygen ranged from 3.4 to 7.1 mg/L, pH ranged from 7.1 to 7.7, specific conductivity had little variation (767–884 µmhos/cm), and temperature varied minimally as well (25.7–32.4˚C).

Table 4. Instantaneous physicochemical data for both stations on Palo Pinto Creek, July 27, 2015.

Station ID	Depth (m)	Temp (˚C)	pH	DO (mg/L)	DO (%)	Conductivity (µmhos/cm)
21730	0.3	28.7	7.6	7.5	98.6	885
21731	0.3	32.3	7.6	6.7	92.1	768

Table 5. Diel (24-hr) physicochemical data for both stations on Palo Pinto Creek. The average, minimum and maximum were calculated from the 24-hr data collected July27-28, 2015.

Station ID	Deployment Date	Depth (m)	Temp Min	Temp Max	Temp Avg	pH Min	pH Max	DO Min mg/l	DO Max mg/l	DO Avg mg/l	Specific Conductivity Min µmhos/cm	Specific Conductivity Max µmhos/cm	Specific Conductivity Avg µmhos/cm
21730	7/27/15	0.3	25.7	28.3	26.6	7.06	7.36	3.4	5.8	4.3	861	885	868
21731	7/27/15	0.5	28.8	32.4	30.2	7.57	7.67	4.9	6.8	5.7	767	773	770
TCEQ Standard		-	-	-	-	6.5	9.0	6.0	9.0	-	-	-	-

When comparing the 24-hr diel and instantaneous physicochemical data, there is a difference between the DO and pH readings for station 21730. This could be due to disruption of the sediment during deployment, reduced stream flow, and/or another reason that is unknown. The dissolved oxygen minimum is low but can still sustain aquatic life.

The flow measurements for stations 21730 and 21731 were recorded without error. The flow for station 21730 was 0.44 cubic feet per second (cfs), and the flow for station 21731 was 0.71 cfs.

Water chemistry samples were not collected due to funding constraints. If water chemistry samples were to be sampled, the following parameters are part of the routine conventional TCEQ sampling protocol; alkalinity, total suspended solids, chloride, sulfate, nitrite + nitrate, total Kjeldahl nitrogen, ammonia, total phosphorus, total organic carbon, and chlorophyll *a* (TCEQ 2012).

Fish Assemblage

Fish community data was collected without exception for both stream stations. A total of 122 individuals consisting of 7 species were collected at station 21730 and a total of 142 individuals consisting of 12 species were collected from station 21731 (Table 6). Four species, Common Carp *Cyprinus carpio*, Bluegill *Lepomis macrochirus*, Gray Redhorse *Moxostoma congestum*, and Gar *Lepisosteus* sp. were seen in the creek but not collected by seine or electrofishing. They were added to the calculation of the IBI. The fish IBI scores were 34 (limited) for station 21730 and 42 (high) for station 21731 (Appendix A). The three most abundant species for stations 21730 and 21731 were Green Sunfish *Lepomis cyanellus,* Western mosquitofish *Gambusia affinis*, and Largemouth bass *Micropterus salmoides*. The most dominant species at 21730 was Green Sunfish and at station 21731 the most dominant species was Largemouth bass.

Station 21730 scored “limited” on the fish IBI due to lower species diversity (low numbers of individuals in seine hauls) and the absence of native cyprinid species (minnows) and benthic invertivores species (*Table* 20). Station 21730 scored well for the percentage of omnivores and piscivores, and for the lack of non-native species. Station 21731 also lacked native cyprinid species and had a low number of individuals caught in the seine. Station 21731 metrics that support a healthy system were number of total fish species, number of benthic invertivores, number of sunfish species, percent of individuals as omnivores and piscivores, and absence of non-native species. The lower scoring metrics could reflect water quality issues, impacts from the recent drought, reduced available instream habitat or some other issue that is unknown. The instream cover (available fish habitat) was 20% or less at three transects and bedrock was the major substrate type at one transect. In order to understand more about the fish community, more sampling would support or deny the IBI scores by providing another dataset for the fish community in Palo Pinto Creek. However, the presence of Green Sunfish and Largemouth Bass provides great recreational opportunities for park visitors.

Table 6. Fish species collected from North Palo Pinto Creek in Stephens and Palo Pinto Counties (stations 21730 and 21731, respectively), July 28, 2015.

Common Name	Species	21730	21731
Yellow Bullhead	*Ameirus natalis*	*4*	3
Common Carp*	*Cyprinus carpio*	*1*	

Western Mosquitofish	*Gambusia affinis*	*30*	14
Channel Catfish	*Ictalurus punctatus*		2
Green Sunfish	*Lepomis cyanellus*	*55*	39
Warmouth	*Lepomis gulosus*		2
Orangespotted Sunfish	*Lepomis humilis*		3
Bluegill	*Lepomis macrochirus*	*1*	7
Longear Sunfish	*Lepomis megalotis*	*2*	10
Largemouth Bass	*Micropterus salmoides*	*29*	66
Gray Redhorse*	*Moxostoma congestum*		1
Bigscale Logperch	*Percina macrolepida*		1
Flathead Catfish	*Pylodictis olivaris*		1
Gar*	*Lepisosteus* sp.		1

*observation

Mussels

No live mussels were found in Palo Pinto Creek after searching a total of five-person hours (Table 7). Mussel shells were found during a reconnaissance trip to Palo Pinto Creek on November 18, 2014, and include paper pondshell *Utterbackia imbeciillis*, pondhorn *Uniomerus declivis*, giant floaters *Pyganodon grandis*, fingernail clams (Family Sphaeriidae), and the invasive *Corbicula*. The shell specimens ranged from recently dead to long dead except for one pondhorn specimen that was very recently dead (Figure 9). In general, freshwater mussels are indicators of good water quality. The species found in Palo Pinto Creek are all common species. The paper pondshell, pondhorn and giant floaters are found in slower waters with softer sediment. The fingernail clams are also widespread and are thought to be short-lived, and the *Corbicula* are invasive species that reproduce quickly and are found in all substrate types (Howells 2014).

The reconnaissance trip occurred on November 18, 2014 during a drought. There was no flow in Palo Pinto Creek, but perennial pools were available as refuges throughout the state park boundaries. Sometime between the reconnaissance trip in November 2014 and April 8, 2015, the creek began flowing again. The drought index showed drought relief for the area starting in April 2015 with the drought completely resolved by the end of May 2015. This provided time for aquatic organisms to repopulate the creek before the aquatic survey trip on July 27–28, 2015; however it was not enough time for freshwater mussels to recolonize the area. It is possible that with consistent flow, freshwater mussels could be found in the creek again. Some of the known fish hosts for mussel shells found were present in the fish collections (minnows, sunfish, black bass).

Figure 9. Pondhorn (Uniomerus tetralasmus) specimen from Palo Pinto Creek, Palo Pinto County, 18 November 2014.

Table 7. Freshwater mussel survey results from Palo Pinto Creek, Palo Pinto and Stephens Counties, July 28, 2015. (Mesohab = mesohabitat, Sub1, 2 & 3 = Substrate type)

Date	Site (County)	Sample	Mesohab	Sub1	Sub2	Sub3	Time (min)	Searchers	Person Hrs	Comment
7/27/2015	Stephens	TS1	pool	cobble	gravel	sand	20	3	1	no mussels
7/27/2015	Stephens	TS2	riffle	cobble	gravel		20	3	1	no mussels
7/27/2015	Palo Pinto	TS1	pool	bedrock	cobble	gravel	15	4	1	no mussels
7/27/2015	Palo Pinto	TS2	pool	gravel	bedrock		15	4	1	no mussels
7/28/2015	Palo Pinto	TS3	pool	gravel	cobble		30	2	1	no mussels

Benthic Macroinvertebrates

Benthic macroinvertebrate collection followed kick-net protocol without exception (TCEQ 2014a). The results were used to calculate a BIBI for each stream station. For station 21730 and 21731, a total of 270 and 313 individuals were collected, respectively. A total of 22 taxa were collected at station 21730 and 26 taxa were collected from station 21731 (Table 8). Both the statewide and regional BIBI scores were calculated for each station. The BIBI scores did not vary between the regional and statewide BIBI. The BIBI for both stations were high; station 21730 scored 31 and station 21731 scored 30 (Table 22).

For Station 21730, the most upstream station, the highest scoring metrics within the statewide BIBI were for taxa richness, percent dominant taxa, percent dominant functional feeding group, and percent of collector-gatherers (Appendix A). The number of taxa suggests a stable environment and the dominant taxa were in proportion with the rest of the collected individuals. The resources for foraging in the stream were relatively stable and there was not an excess of fine particulate organic matter (FPOM) which can increase the number of benthic macroinvertebrates that use it as a food source. The lower scoring metrics within the statewide BIBI were due to the ratio of intolerant to tolerant taxa and the percent of individuals in the family Elmidae. The ratio of tolerant species to intolerant species collected was 0.63 which means a larger numbers of tolerant species were collected than intolerant species. The other low scoring metric was the number of species within the family Elmidae (riffle beetles). Riffle beetles are considered intolerant of poor water quality. However, one of the more common riffle beetles (*Stenelmis sp.*) are relatively tolerant of pollution and may become dominant in moderately enriched water (TCEQ 2014a). This metric scores low when the riffle beetles are either in low numbers or high numbers due to these characteristics.

For Station 21731, the farthest downstream station, the highest scoring metrics in the statewide BIBI were for taxa richness, EPT (Ephemeroptera, Plecoptera, Trichoptera) index, percent total Trichoptera as Hydropsychidae and percent collector-gatherers (Appendix A). The metrics suggest stable habitat (high taxa count) and a high number of pollution–sensitive taxa (mayflies and caddisflies). The percent of the Trichoptera as Hydropsychidae and percentage of collector-gatherers were balanced suggesting lack of water quality degradation. The lower scoring metrics were percent Chironomidae, ratio of tolerant to intolerant taxa, number of non-insect taxa, and percent of total taxa as family Elmidae. The lower scoring metrics represent degradation in water quality and physical habitat due to high numbers of Chironomids, which are considered to be tolerant taxa, an unbalanced ratio of intolerant to tolerant taxa, low numbers of non-insect taxa (n=1), and the lack of Elmidae among the specimens.

Table 8. Benthic macroinvertebrates collected from stations 21730 and 21731 on Palo Pinto Creek, Palo Pinto and Stephens County (respectively). July 28, 2015.

Phylum	Class	Order	Family	Genus	21730	21731
Annelida	Hirudinea				1	
Arthropoda	Crustacea	Amphipoda	Taltridae	*Hyallela*	14	5
		Ostracoda			1	
	Hydracarina				1	1
	Insecta	Coleoptera	Carabidae			1
			Elmidae	*Stenelmis*	2	
			Hydrophilidae	*Berosus*	1	
				Enochrus		3
				Paracymus		1
				Tropisternus	1	2
			Scirtidae	*Scirtes*		1
		Diptera	Chironomidae		31	60
			Simuliidae	*Simulium*	2	13
		Ephemeroptera	Baetidae	*Camelobaetidius*		6
				Fallceon	59	33
			Caenidae	*Caenis*	3	2
			Heptageniidae	*Stenonema*	1	5
			Isonychidae	*Isonychia*		1
			Leptohyphidae	*Tricorythodes*		1
			Leptophlebiidae	*Neochoroterpes*	1	1
		Hemiptera	Belostomatidae	*Belostoma*	1	1
			Hebridae	*Hebrus*		1
			Veliidae	*Microvelia*	1	
		Lepidoptera	Pyralidae	*Paraponyx*	6	
		Odonata	Calopterygidae	*Hetaerina*	2	10
			Coenagrionidae	*Argia*	55	28
			Libellulidae	*Brechmorhoga*	9	8
		Trichoptera	Hydropsychidae	*Cheumatopsyche*	43	23
				pupae/larvae		3
			Hydroptilidae	*Hydroptila*	1	1
				Ithytrichia		1
			Philopotamidae	*Chimarra*	34	101

Tucker Lake

Tucker Lake is an unclassified water body that joins Palo Pinto Creek within PPMSP. It is afforded the same protection as a classified lake that is a source for drinking water because it is the drinking water supply for City of Strawn. All water bodies that are designated as drinking water sources are given high aquatic life use classification by TCEQ.

Methods

National Lakes Assessment

The primary methods used for the assessment of Tucker Lake were the NLA protocols (USEPA 2011). These methods were developed to provide a national snapshot of the aquatic life and recreational status of the nation's lakes, and to help identify stressors to lakes showing evidence of degradation. Using portions of this protocol to assess Tucker Lake provided TPWD with established sampling methods that have been statistically tested and will be repeatable for future sampling efforts. The aquatic survey of the lake was intended to provide an overall status of the aquatic life and recreational uses of the lake. The protocols used are described below.

Physicochemical Parameters

A YSI 600 XLM multi-parameter datasonde or similar instrument was used to collect a vertical profile at predefined depth intervals. Measurements for dissolved oxygen, temperature, pH, and conductivity were collected from Tucker Lake at the index site, Site X (USEPA 2011). The physicochemical profile was taken at the deepest point of the lake, and parameters were measured 0.5m from the surface and bottom of the lake and every meter in-between. The top and the bottom of the metalimnion (where the temperature changes more than 1 degree per meter) is recorded, and a surface measurement was taken twice for equipment quality assurance. Data recording, instrument calibration, and post-calibration procedures can be found in USEPA 2011 and TCEQ 2014a.

Secchi disk depth measures the transparency of the water column and provides an estimate of the euphotic zone which is typically two times the Secchi depth or 2.3 m. The euphotic zone is the portion of the water column that receives enough sunlight for photosynthesis to occur (USEPA 2011). The Secchi disk was lowered on the shaded side of the boat by someone who is not wearing a hat or sunglasses. The total depth was recorded where the disk disappears and where the disk reappears, and then the two numbers were averaged.

Macrophyte Observation

Macrophyte abundance, type and the maximum depth of macrophyte colonization were recorded at the X site and at Station A. After Station A, macrophyte observations were recorded in the littoral plot portion of the data forms.

Physical Habitat Characterization

To characterize the near-shore habitat, 10 evenly spaced physical habitat (PHab) stations (Figure 10) were documented for several conditions. The 10 station locations were selected using GIS software to eliminate bias. Each PHab station consists of a plot (Figure 10) that is 15 m wide (parallel to the shoreline). The plot is separated into four sub-plots. Starting from the shoreline, the littoral plot extended 10 m into the reservoir, a second sub-plot (shoreline zone) is located from the shoreline extending 1 m inland, a draw-down zone sub-plot extending inland from the shoreline to the normal high-water level, and a 15 m riparian sub-plot that begins at the normal high-water level and extends 15 m landward.

Observations of zones (littoral, shoreline, draw-down zone, and riparian), physical habitat cover and structure, invasive plants, and macroinvertebrates were made at each station. Physical habitat characteristics were also observed including aquatic macrophyte cover, fish habitat cover, substrate type cover, general bank angle, cover and type of riparian vegetation, human influence, invasive plants and invertebrates, and macrophyte assemblage (including maximum depth of growth).

Phytoplankton and Zooplankton Sample Collection

Phytoplankton samples were collected at Site X at a depth of 0.3 m (Figure 10). A 2L amber jar was used to collect the water which was then poured into a 1L container and preserved with 5 mL of Lugol's solution.

Two zooplankton samples were collected: one fine mesh (50 µm) and one coarse mesh (150 µm) sample with Wisconsin plankton nets. The tows covered 5 m vertically in the water column. A total of 300 organisms were needed for a complete sample. The nets were washed into a collection jar, carbon dioxide tablets (Alka Seltzer) were used to relax the external structures, and then samples were preserved with 95% ethanol for identification. Taxonomic work to determine assemblage was performed by TPWD staff in the laboratory using a microscope.

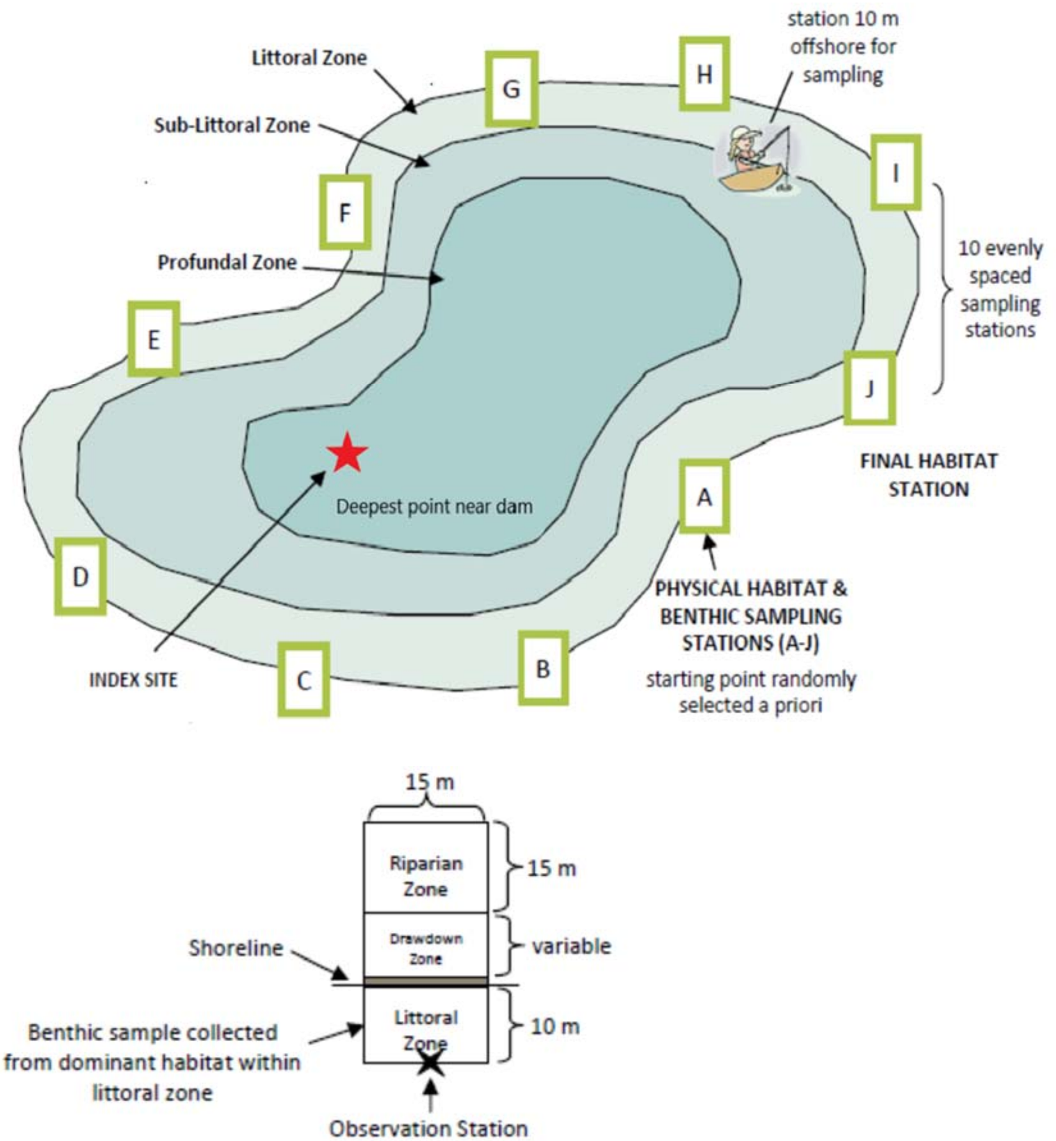

Figure 10. Location of sample collection points and physical habitat (PHab) stations. Index site represents "Site X" and description of the physical habitat station, USEPA 2011.

Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate samples were collected within the littoral zone at each PHab station. At each station, the dominant habitat type was sampled with a 500-µm mesh D-frame dip net by sweeping the net through 1 linear meter of the dominant habitat type. All habitat transect samples were combined into a composite sample and preserved with 95%

ethanol. Preserved specimens were identified in the laboratory and at least 10% of the specimen collection was verified by a qualified benthic macroinvertebrate specialist.

Freshwater Mussels

A visual survey along the eastern shoreline was conducted during a reconnaissance trip in November 2014.

Fish Assemblage

Texas Parks and Wildlife Inland Fisheries Wichita Falls District office (IF-WF) surveyed Tucker Lake in 2011-2012 and again in 2015 (TPWD 2012 and TPWD 2016a). The gear types used in 2011–2012 and 2015 were hoop nets, electrofishing, trap nets, and gill nets. Electrofishing occurred at five stations for 5 min intervals equaling 25 min of electrofishing. Gill nets were set at four stations overnight, trap nets were set at five stations overnight, and tandem baited hoop nets were set overnight at three stations. All captured fish were identified and recorded.

Results and Discussion

Physicochemical Parameters

Instantaneous physicochemical data were collected at Site X, the index site, (Figure 3) without exception. Total depth at Site X was 7.4 m. All physicochemical data were within the "normal" range for reservoirs and the metalimnion, the thermal layer of the water column that changes temperature rapidly with depth, was located between 2 and 3 m (Table 9). The Secchi disk reading at Site X was 1.15 m.

Lakes are classified according to their trophic state. This refers to how productive the lake is in terms of biomass and indicates how much nutrient loading is occurring in the lake. A lake with very little nutrient loading is oligotrophic and lakes with high nutrient loading are eutrophic. The primary measurements used in determining the trophic status of a lake are chlorophyll-a, total phosphorus, and Secchi disk depth. As no water quality samples were taken as part of this assessment, only Secchi disk depth measurements are available to assess trophic condition.

The Carlson's Trophic State Index (TSI) is used by TCEQ to assess the trophic condition of reservoirs and can be calculated by Secchi dish depth. Using the Secchi disk depth of 1.15 m, the TSI for Tucker Lake is 57.9, which places it into the eutrophic category (TCEQ 2018).

Table 9. Tucker Lake profile data taken at the index site, Palo Pinto County, July 28, 2015. (T=Top, B=Bottom). (The second reading at 0.3 m is a quality control check before completing the physicochemical profile.)

Depth (m)	Temperature (˚C)	DO (mg/L)	pH	Conductivity (µS/cm)	Metalimnion
0.3	32.8	8.8	8.4	347	
1.0	32.4	8.2	8.2	347	
2.0	32.1	8.4	8.2	347	
3.0	28.4	1.8	7.7	339	T
4.0	23.9	1.6	7.4	298	
5.0	20.9	1.7	7.2	311	B
6.0	20.2	1.7	7.1	313	
6.9	19.9	1.7	7.1	321	
0.3	32.8	8.3	8.1	347	

Macrophyte Observation

Macrophytes (aquatic plants that can be submerged, emergent, or floating) are often the preferred habitat for fish and benthic insects. The abundance and type of macrophytes are good indicators of the ecological health of a lake and reflect how stressors such as shoreline habitat loss, eutrophication, and invasive species can impact a lake. Some macrophytes can form large monocultures and become a nuisance for lake managers while others provide important habitat and are regarded as good water quality indicators.

Marcrophyte assemblage was observed at Site X and Site A (Figure 3). No macrophytes were observed at Site X with a depth of 7.7 m. Site A was dominated by emergent vegetation with American water willow *Justicia americana* being the dominant species (Figure 11). The only noted invasive plant recorded for the lake was common reed *Phragmites australis* at Site A.

Figure 11. Macrophyte assemblage located at Site A, Tucker Lake, Palo Pinto County, July 28, 2015.

Physical Habitat Characterization

The lake's physical habitat was characterized with the NLA protocol. The assessment included ten lake sites where several types of data were collected. The average depth from all ten sites was 3.1 m with a maximum depth of 7.1m (Station A) and a minimum depth of 1.3 m (Station D; Figure 3). Bank angles were defined as steep (30–75˚) to gradual (5–30 ˚) and algae mats were found on the surface of all but two stations (Stations A and J). Stations F and G had hydrogen sulfide surface odors. Substrate color was predominately gray with two stations having brown and black substrate descriptions (Table 10). The aquatic macrophytes extended lakeward at half of the stations (C, D, E, G, I), and emergent plants were dominant throughout all stations.

The bottom substrate descriptions were provided for the littoral bottom and 1-m shore zone. Descriptions are divided into nine types ranging from bedrock to vegetation/other (Table 11). The littoral bottom dominant substrate types were woody debris, silt/clay/muck, sand with organic matter, and vegetation/other types also being present. Gravel sizes and larger were noted at four stations (B, E, F, and J). The dominant substrate types for the 1-m shore zone were woody debris, vegetation/other, organic matter and sand, respectively. Sand/clay/muck, boulders, cobble, gravel and bedrock were present at lower coverage rates.

Fish cover in the littoral zone included aquatic and inundated herbaceous vegetation, woody brush/woody debris (<0.3 m diameter), and ledges or sharp drop-offs (Table 12). Less common cover types were woody debris/snags >0.3 m diameter, overhanging vegetation, boulders and artificial structures.

The riparian canopy zone around the lake was dominated by understory woody shrubs and saplings, and some small trees (trunk <0.3 m diameter at breast height). Ground cover included woody shrubs and saplings, herbs/grasses/forbs, and bare dirt or buildings. Noted human influence were roads in or near five of the stations, and powerlines, boats/docks, walls and trash at three of the stations. The walls represent the lake's spillway.

Table 10. Tucker Lake general physical habitat and aquatic macrophyte information, July 28, 2015. (Aquatic macrophyte coverage - 0=absent, 1=sparse (<10%), 2=moderate (10-40%), 3=heavy (40-75%), 4=very heavy (>75%))

General Station Information									Aquatic Macrophytes – Littoral			
Station	**Latitude**	**Longitude**	**Depth (m)**	**Bank Angle**	**Surface Film**	**Surface Odor**	**Substrate color**	**Extend lake ward**	**Sub-merged**	**Emergent**	**Floating**	**Total Cover**
A	32.53333	-98.56255	7.1	Steep	None	none	too deep	N	0	2	0	2
B	32.53331	-98.55966	3.6	Steep	Scum, Algal mat	none	gray	N	0	1	3	1
C	32.53134	-98.55842	2.4	Flat	Scum	none	black	Y	0	4	0	4
D	32.52868	-98.5594	1.3	Gradual	Scum	none	brown	Y	0	4	0	4
E	32.52875	-98.56128	1.7	Gradual	Algal mat	none	black	Y	2	4	0	4
F	32.52605	-98.56145	3.1	Steep	Scum	H2S	gray	N	0	2	0	2
G	32.52535	-98.56421	2.5	Steep	Algal mat	H2S	gray	Y	0	3	3	4
H	32.52672	-98.56411	1.8	Gradual	Algal mat	None	gray	N	0	1	1	2
I	32.52957	-98.56436	2.5	Flat	Scum, Algal mat	None	brown	Y	1	4	1	4
J	32.53115	-98.56339	5.2	Steep	None	None	other	N	0	2	1	3

Table 11. Tucker Lake substrate description for the littoral and meter shore zone, July 28, 2015. (0=absent, 1=sparse (<10%), 2=moderate (10-40%), 3=heavy (40-75%), 4=very heavy (>75%))

Station	**Depth (m)**	**Bedrock**	**Boulders**	**Cobble**	**Gravel**	**Sand**	**Sand/Clay /Muck**	**Woody debris**	**Organic**	**Vegetation/ Other**
Littoral Zone										
A	7.1	0	0	0	0	2	2	1	1	2
B	3.6	0	0	0	1	2	2	4	0	1
C	2.4	0	0	0	0	1	3	1	0	4
D	1.3	0	0	0	0	3	3	1	2	2
E	1.7	2	0	0	0	3	3	1	1	4
F	3.1	0	0	3	0	1	1	3	1	1
G	2.5	0	0	0	0	2	2	2	1	2
H	1.8	0	0	0	0	1	1	2	2	1
I	2.5	0	0	0	0	1	1	2	2	3
J	5.2	2	4	0	0	0	0	2	1	2
Meter Shore Zone										
A	7.1	0	2	2	1	1	0	2	1	2
B	3.6	0	2	1	1	1	1	2	0	2
C	2.4	0	0	0	0	2	1	1	3	3
D	1.3	0	0	0	0	1	1	2	3	3
E	1.7	0	0	0	0	1	1	1	2	3
F	3.1	0	0	1	2	2	1	2	1	2
G	2.5	0	0	0	0	1	1	2	2	2
H	1.8	0	0	0	0	1	1	3	2	1
I	2.5	0	0	0	0	0	0	3	2	3
J	5.2	3	2	1	0	0	0	3	0	2

Table 12. Tucker Lake fish cover habitat availability, July 28, 2015. (0=absent, 1=sparse (<10%), 2=moderate (10-40%), 3=heavy (40-75%), 4=very heavy (>75%))

Aquatic and Inundated Herbaceous Vegetation	Woody debris/ snags (>.3m)	Woody brush/ woody debris (<.3m)	Inundated live trees	Overhanging vegetation	Ledges/ sharp drop-offs	Boulders	Human structures
2	0	2	0	0	3	2	0
1	1	2	0	1	3	1	0
4	0	1	0	0	0	0	0
3	0	2	0	0	0	0	0
4	0	1	0	0	1	0	3
2	0	2	0	2	0	0	0
3	2	3	0	0	0	0	0
2	1	2	0	1	0	0	0
4	0	2	0	0	0	0	0
2	1	2	0	0	3	3	1

Phytoplankton and Zooplankton

In addition to indicators of trophic status and water quality, components of the aquatic ecosystem were surveyed. These included phytoplankton and zooplankton. Phytoplankton are the microscopic plant organisms in the water column. They include suspended algae and are very responsive to ecological stressors such as increased nutrient loading and sediment from runoff. Zooplankton are the microscopic animal organisms in the water column and consist of things like larval insects, rotifers, etc. and form the basis of the food web. They respond to similar stressors as phytoplankton.

Table 13. Phytoplankton collected from Tucker Lake, July 28, 2015.

Phytoplankton	Taxa	Number/mL (± SDev)
Chlorophyta	*Closterium*	0.67 ± 0.58
	Colonial sp. 1	0.67 ± 0.58
	Colonial sp. 2	24.33 ± 17.95
	Cosmarium	2.67 ± 0.58
	Filamentous species	8.00 ± 2.00
	Schroederia	83.67 ± 37.61
	Staurastrum sp. 1	2.67 ± 2.08
	Staurastrum sp. 2	0.33 ± 0.58
Chrysophyceae	*Dinobryon*	25.33 ± 1.53
Cyanobacterium	Filamentous species	0.67 ± 1.15
	Spirulina	12.33 ± 3.05
Diatom	*Fragilaria*	0.67 ± 1.15
	Naviculoid diatom sp. 1	3.00 ± 0.00
	Naviculoid diatom sp. 2	1.00 ± 1.00
Dinoflagellate	*Ceratium*	3.00 ± 1.73
Euglenozoa	*Phacus*	2.00 ± 1.00
	Species 1	1.33 ± 0.58

Table 14. Zooplankton collected from Tucker Lake, July 28, 2015.

Coarse Mesh Taxa (150µm)	Number/L (± SDev)	Fine Mesh Taxa (50µm)	Number/L (± SDev)
Cladocera		Cladocera	
Bosmina	4.0 ± 1.6	*Bosmina*	2.6 ± 3.2
		Ceriodaphnia	1.0 ± 1.8
Daphnia	4.0 ± 1.8	*Daphnia*	1.0 ± 0.9
		Ostracod	0.5 ± 0.5
Copepoda		Copepoda	
Calanoid copepod	0.3 ± 0.5		
Cyclopoid copepod	4.8 ± 2.5	Cyclopoid copepod	5.6 ± 1.7
Naupliia[1]	1.0 ± 1.2	Nauplii	12.7 ± 6.8
Rotifera		Rotifera	
Asplanchna	19.1 ± 2.4	*Asplanchna*	1.8 ± 2.0
		Brachionus	1.0 ± 0.5
		Conochilus	11.1 ± 4.8
Kellicottia	0.3 ± 0.5		
		Keratella	74.8 ± 8.0
		Polyarthra	15.1 ± 0.5
		Species 1	0.3 ± 0.5
MIDGE		MIDGE	
Chaoborus	4.8 ± 2.0	*Chaoborus*	1.6 ± 0.00

Phytoplankton was dominated by green algae (Chlorophyta), especially *Schroederia* (Table 13). Other components of the phytoplankton sample included flagellates such as *Dinobryon*, *Ceratium*, and *Phacus*, as well as diatoms and cyanobacteria. Phytoplankton communities composed of multiple species are a common feature of freshwater bodies worldwide (Wetzel 2001). Most of the species found in the sample are cosmopolitan in distribution. Zooplankton from both the coarse and fine mesh were dominated by rotifers (Table 14). Several genera of cladocerans and copepods were also present, as well as an insect (midge). These are typically the dominant zooplankton groups found in freshwater systems worldwide (Wetzel 2001). Like the phytoplankton, most of these taxa are ubiquitous and cosmopolitan.

Benthic Macroinvertebrate

Under the NLA protocols, benthic macroinvertebrates were collected at each of the 10 lake perimeter stations from the most dominant habitat represented in the littoral plot rather than from the "best" habitat. For example, if the dominant habitat in the 10 m x 15 m littoral plot is sand, but there are a few emergent macrophytes in the plot that would be considered "better" habitat for aquatic insects, the sample would be taken from the sand. Habitat dominance for benthic organisms was evenly split around the lake with rock dominant at five stations and macrophytes dominant at the remaining five stations (n=10). Depth seemed to be the predictor of whether rocks or macrophytes were dominant with rocks being the dominant substrate in deeper plots. All but one station at the dam (Station X) were sampled by wading within the littoral plot.

The 10 benthic macroinvertebrate samples were composited for analysis to provide a community snapshot. A total of 294 individuals were collected comprising 29 taxa (Table 15). The most numerous species were *Hyallela* (Amphipoda), *Scirtes*

[1] Immature copepod

(Coleoptera), and *Zoniagrion* (Odonata), respectively. *Hyallela* and *Zoniagrion* are considered tolerant species or species that can handle more disturbance. While TCEQ does not have an IBI for reservoirs, the stream IBI can be used to provide a base for analysis and then individual metrics can be expanded to help understand the health of the reservoir (Davis 1991).

The BIBI for streams scored the reservoir at 33 which translates as a high aquatic life use (Table 23). The highest scoring metrics were taxa richness, percent as Chironomidae, percent dominant functional feeding group, percent of total Trichoptera as Hydropsychidae, and percent of Elmidae per collected individuals (Appendix A).

In order to understand the benthic macroinvertebrate community at Tucker Lake, the sampling would need to be repeated and reservoirs with similar characteristics could be used to compare for water quality stability. This, however, was outside the scope of the project.

Table 15. Benthic macroinvertebrates collected from Tucker Lake, July 28, 2015.

Phylum	Class	Order	Family	Genus	Sample
Arthropoda	Hydracarina				1
	Crustacea	Amphipoda	Taltridae	*Hyallela*	151
	Insecta	Coleoptera	Elmidae	*Dubiraphia*	1
				Stenelmis	2
			Hydrophilidae	*Berosus*	3
			Noteridae	*Hydrocanthus*	11
			Scirtidae	*Scirtes*	23
			Staphylinidae	*Stenus*	2
		Diptera	Chironomidae		10
			Stratiomyidae	*Odontomyia*	1
			Sciomyzidae	*Sepedomerus/Sepedon*	1
			Tabanidae	*Tabanus*	2
		Ephemeroptera	Caenidae	*Caenis*	7
			Heptageniidae	*Stenacron*	2
		Hemiptera	Belostomatidae	*Belostoma*	6
		Hemiptera	Nepidae	*Ranatra*	1
		Odonata	Coenagrionidae	*Enallagma*	13
				Hesperagrion	1
				Zoniagrion	18
			Libellulidae	*Dythemis*	2
				Nannothemis	1
				Perithemis	2
		Trichoptera	Leptoceridae	*Oecetis*	1
			Polycentropodidae	*Cyrnellus*	4
		Hemiptera	Hebridae	*Lipogomphus*	1
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia*	1
			Planorbidae	*Gyraulus*	13
		Limnophila	Physidae	*Physa*	12
	Pelecypoda	Veneroida	Corbiculidae	*Corbicula*	1

Freshwater Mussels

Recently dead and long dead giant floaters were found along the shoreline during the reconnaissance trip when the water levels had receded. It is probable that giant floaters are still in Tucker Lake; however, a survey would be needed to confirm and quantify population size. It is possible other species are present in the lake as well.

Fish Assemblage

The IF-WF office survey protocols for community fishing lakes uses gear types that focus on sport and prey fish. The purpose of the surveys is to ensure balanced sport and prey fish populations that facilitate the best sport fish experience at community fishing lakes. If the surveys find a need to enhance the fishery, the management team creates a management plan to address needs, which might include fish stocking (TPWD 2012; TPWD 2016a).

Fish were sampled and collected with 4 gear types (nets – gill, trap, hoop and electrofishing) in 2011-2012 and only by electrofishing gear in 2015 due to floods restricting access to the Tucker Lake launch site. The survey resulted in collections of 11 species of fish with Gizzard Shad *Dorosoma cepedianum*, Bluegill *Lepomis macrochirus*, and White Crappie *Pomoxis annularis* (Table 16) being the top 3 collected species, respectively. Other species collected were Largemouth Bass, Redear Sunfish *Lepomis microlophus*, Longear Sunfish *Lepomis megalotis*, Green Sunfish, Warmouth *Lepomis gulosus*, Channel Catfish *Ictalurus punctatus* and Common Carp *Cyprinus carpio* (TPWD 2012; TPWD 2016a). The fish community may be more diverse than the species in Table 16 because smaller fish species (minnows, darters, etc.) are not collected or identified during management surveys. If more information about the fish community (big and small species) would assist with park management, a fish community survey would provide that data.

Fish stockings have taken place in the past for Tucker Lake and include Channel Catfish, Largemouth Bass, and Northern Pike *Esox lucius*. Channel Catfish were the most frequently stocked fish with 13 events between 1993 and 2017 (original stocking was 1971), and Largemouth Bass stocked in 1967, 2015 and 2016. Northern Pike were only stocked once in 1974. Fish stocking data is available on the TPWD website at: https://tpwd.texas.gov/fishboat/fish/management/stocking/fishstock_smallwater.phtml .

As part of this data collection, IF-WF also looked at genetic diversity for Largemouth Bass and found the population to have a large percentage of Northern Largemouth Bass genetics (TPWD 2016a) that can be used to help provide brood fish for the hatcheries. Channel Catfish populations were low in 2011-2012 and it was hypothesized it was due to illegal fishing methods observed during sample collection (TPWD 2012). Tucker Lake is now surrounded by state park land which provides an opportunity for more frequent observation of fishing pressure by staff and by including a voluntary creel box.

Table 16. Tucker Reservoir fish survey results from 2011-2012 and 2015 sampling events, TPWD 2012 and 2016a..

		Electrofishing (n)		Trap Nets (n)	Gill Nets (n)
Common Name	**Scientific Name**	**2011**	**2015-2016**	**2011**	**2012**
Gizzard Shad	*Dorosoma cepedianum*	108	187		1
Bluegill	*Lepomis macrochirus*	221	36	46	1
Hybrid sunfish	*Lepomis hybrid*		2.4		
Largemouth Bass	*Micropterus salmoides*	50	15	1	
Common Carp	*Cyprinus carpio*			1	
Channel Catfish	*Ictalurus punctatus*				2
Warmouth	*Lepomis gulosus*	4			
White Crappie	*Pomoxis annularis*			138	
Green Sunfish	*Lepomis cyanellus*	8			
Longear Sunfish	*Lepomis megalotis*			50	
Redear Sunfish	*Lepomis microlophus*	35		27	

Summary

The physicochemical and biological sampling conducted during the aquatic survey provides a snapshot of the area at the time of sampling. The physicochemical or water quality data represents short-term environmental conditions, while biological data provides long-term environmental data about the area studied. By creating a snapshot of the current aquatic habitat and fauna before park development begins, any future surveys can be compared to this baseline data set. Any adaptive management needs can be based on known species in the area rather than from a county species list.

The overall aesthetic of the area is natural and the water quality of Palo Pinto Creek and Tucker Lake is desirable. Some highlights include the prolific benthic macroinvertebrate community, continuous riparian habitat along the creek, and variation in creek and lake substrates creating more complex instream habitat. Freshwater mussels have potential to return to Palo Pinto Creek with the presence of known fish species that host larval freshwater mussels and more consistent flow. The IBI scores for the Palo Pinto Creek support high aquatic life use for the perennial stream (Table 17). There were no threatened or endangered species at the state or federal level collected during the aquatic survey, however it does not mean that they are absent from the state park property.

The water features located within the state park will provide an enhanced experience for visitors and help to increase appreciation for the diverse landscape across the state. Palo Pinto Creek has simultaneous historic and natural educational opportunities. The dominant species collected in Palo Pinto Creek provide for great fishing opportunities within the park. The variation of creek bottom substrates creates different habitats for aquatic organisms and the historic low water dams, used to provide water for train steam engines, create perennial pool refuges for species during dry seasons. Continued management of the Tucker Lake fishery by the TPWD IF-WF office will continue to heighten fishing experiences in Tucker Lake. Adding a voluntary creel box at the lake would allow for fishing pressure data to be collected. Signage explaining the different aquatic habitats and species to the visitors promotes better understanding of our natural resources. Also, access points to Palo Pinto Creek and Tucker Lake will help maintain the integrity of the riparian areas and water quality along the waterways within the park.

Table 17. Overview of the index scores for Palo Pinto Creek stations 21730 and 21731, Stephens and Palo Pinto counties respectively. July 28, 2015.

	Fish		**Bugs**		**Habitat**	
	21730	27131	21730	27131	21730	27131
Numeric Score	34	42	31	30	21.5	22.5
Aquatic Life Use	Limited	High	High	High	High	High
Total species	7	12	22	26	-	-

To better understand how the fish community has recovered after the drought ended and consistent flows returned would require another sampling event(s). This would help to understand the current status of the fish community and could assist with decisions for best management practices as the state park develops.

Future studies may incorporate water chemistry sampling to understand the levels of nutrients and suspended sediments found in the creek and lake, collecting fish community data in Tucker Lake, enhancement of the fish community data from Palo Pinto Creek, a freshwater mussel survey of Tucker Lake, and sample for freshwater mussels in Palo Pinto Creek if flow conditions are consistent over a longer period of time.

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Appendix A. Data Tables

Table 18. Habitat reach latitude and longitude for the upstream (Transect 5) and downstream (Transect 1) transects for stations 21730 and 21731.

Station No	Transect	Description	Lat	Long
21730	1	Most downstream	32.54216	-98.62404
	5	Most upstream	32.54150	-98.62596
27131	1	Most downstream	32.53840	-98.56567
	5	Most upstream	32.53896	-98.56773

Table 19. Plant species observed in the riparian zone during the habitat assessment for stations 21730 and 21731, July 28, 2015.

Common Name	Scientific Name	Native/ Introduced
Cedar elm	*Ulmus crassifolia*	Native
Giant ragweed	*Ambrosia trifida*	Native
Sump weed	*Iva annua*	Native
Frostweed	*Verbesina virginica*	Native
Germander	*Teucrium canadense*	Native
Mesquite	*Prosopis glandulosa*	Native
Buttonbush	*Cephalanthus occidentalis*	Native
Poison ivy	*Toxicodendron sp.*	Native
Green ash	*Fraxinus pennsylvanica*	Native
Pecan	*Carya illinoinensis*	Native
Red oak	*Quercus buckleyi*	Native
Ashe juniper	*Juniperus ashei*	Native
American elm	*Ulmus americana*	Native
Switchgrass	*Panicum virgatum*	Native
Cockleburr	*Xanthium strumarium*	Native
Virginia creeper	*Parthenocissus quinquefolia*	Native
Bumelia	*Sideroxylon lanuginosum*	Native
Grape vine	*Vitis sp.*	Native
Pencil cactus	*Cholla leptocaulis*	Native
Inland sea oats	*Chasmanthium latifolium*	Native
Dock	*Rumex sp.*	Introduced
Paspalum sp.	*Paspalum sp.*	Native
Live oak	*Quercus fusiformis*	Native
Elbow bush	*Forestiera pubescens*	Native
Snail seed	*Cocculus carolinus*	Native
White honeysuckle	*Lonicera albiflora*	Native
Bermudagrass	*Cynodon dactylon*	Introduced
Broom weed	*Xanthocephalum sp.*	Native
Grass	*Unknonwn Poaceae*	Unknown
Baccharis	*Baccharis sp.*	Native
Mexican hat	*Ratibida sp.*	Native
Western ragweed	*Ambrosia sp.*	Native
Goldenrod	*Solidago sp.*	Native
KR bluestem	*Bothriochloa sp.*	Introduced
Sedge	*Cyperaceae*	Native

Common Name	Scientific Name	Native/ Introduced
Scalybark oak	*Quercus sinuata*	Native
Green briar	*Smilax bona-nox*	Native
Prickly pear	*Opuntia sp.*	Native
Johnsongrass	*Sorgum halepense*	Introduced
Texas ash	*Fraxinus albicans*	Native
Virginia wild rye	*Elymus virginicus*	Native
Rusty black haw	*Viburnum rufidulum*	Native
Frog fruit	*Phyla sp.*	Native
Sideoats grama	*Bouteloua curtipendula*	Native
Silver bluestem	*Bothriochloa laguroides*	Native
Hackberry	*Celtis laevigata*	Native

Table 20. Palo Pinto Creek fish index of biotic integrity for Station 21730, Stephens County, July 28, 2015. Scoring criteria for Ecoregions 27,29, and 32; exceptional ≥49, high 41-48, intermediate 35-40, and limited <35 (TCEQ 2014a).

Palo Pinto Creek @ Stephens Co., Stephens Co.			**Station 21730**		
Collector: Robertson, et. Al			July-15	Ecoregions 27,29,32	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
Species Richness and Composition	Drainage Basin Size (km^2)	122			
	Number of Fish Species	7	Total Number of Fish Species	7	3
	Number of Native Cyprinid Species	0	Number of Native Cyprinid Species	0	1
	Number of Benthic Invertivore Species	0	Number of Benthic Invertivore Species	0	1
	Number of Sunfish Species	3	Number of Sunfish Species	3	3
Trophic Composition	Number of Individuals as Tolerants[a]	57	% of Individuals as Tolerant Species[a]	46.7	3
	Number of Individuals as Omnivores	5	% of Individuals as Omnivores	4.1	5
	Number of Individuals as Invertivores	33	% of Individuals as Invertivores	27.0	1
	Number of Individuals as Piscivores	84	% of Individuals as Piscivores	68.9	5
Fish Abundance and Condition	Number of Individuals (Seine)	40	Number of Individuals in Sample	122	2
	Number of Individuals (Shock)	80	Number of Individuals/seine haul	4.0	1
	Number of Individuals in Sample	122	Number of Individuals/min electrofishing	5.4	3
	# of Individuals as Non-native species	1	% of Individuals as Non-native Species	0.8	5
	# of Individuals With Disease/Anomaly	0	% of Individuals With Disease/Anomaly	0.0	5
			Index of Biotic Integrity Numeric Score:		**34**
			Aquatic Life Use:		**Limited**

This data should be incorporated with water quality, habitat, and other available biological data to assign an overall stream score.

[a] Excluding Western Mosquitofish

Table 21. Palo Pinto Creek fish index of biotic integrity for Station 21731, Palo Pinto County, July 28, 2015. Scoring criteria for Ecoregions 27,29, and 32; exceptional ≥49, high 41-48, intermediate 35-40, and limited <35 (TCEQ 2014a).

Palo Pinto Creek @ Palo Pinto Co. , Palo Pinto Co.			**Station 21731**		
Collector: Robertson, et. Al			July-15	Ecoregions 27,29,32	
Metric Category	**Intermediate Totals for Metrics**		**Metric Name**	**Raw Value**	**IBI Score**
Species Richness and Composition	Drainage Basin Size (km2)	135			
	Number of Fish Species	12	Total Number of Fish Species	12	5
	Number of Native Cyprinid Species	0	Number of Native Cyprinid Species	0	1
	Number of Benthic Invertivore Species	2	Number of Benthic Invertivore Species	2.0	5
	Number of Sunfish Species	5	Number of Sunfish Species	5.0	5
Trophic Composition	Number of Individuals as Tolerants[a]	51	% of Individuals as Tolerant Species[a]	35.9	3
	Number of Individuals as Omnivores	5	% of Individuals as Omnivores	3.5	5
	Number of Individuals as Invertivores	29	% of Individuals as Invertivores	20.4225	1
	Number of Individuals as Piscivores	108	% of Individuals as Piscivores	76.1	5
Fish Abundance and Condition	Number of Individuals (Seine)	83	Number of Individuals in Sample		2
	Number of Individuals (Shock)	58	Number of Individuals/seine haul	7.5	1
	Number of Individuals in Sample	142	Number of Individuals/min electrofishing	3.5	3
	# of Individuals as Non-native species	0	% of Individuals as Non-native Species	0	5
	# of Individuals With Disease/Anomaly	0	% of Individuals With Disease/Anomaly	0	5
				Index of Biotic Integrity Numeric Score:	**42**
				Aquatic Life Use:	**High**

This data should be incorporated with water quality, habitat, and other available biological data to assign an overall stream score.

a Excluding Western Mosquitofish

Table 22. Palo Pinto Creek benthic index of biotic integrity (BIBI) station 21730, Stephens County, and station 21731, Palo Pinto County, July 28, 2015. Scoring criteria; exceptional >36, high 29-36, intermediate 22-28, and limited <22.

	21730		**21731**	
Metric	**Value**	**Score**	**Value**	**Score**
Taxa Richness	22	4	26	4
EPT Index	7	3	13	4
HBI	5.15	2	4.36	3
% Chironomidae	11.48	2	19.17	1
% Dominant Taxon	21.85	4	32.69	2
% Dominant FFG	33.09	4	51.44	2
% Predators	30.31	2	23.32	3
Intolerant : Tolerant	0.63	1	1.13	1
% Total Trichoptera as Hydropsychidae	55.13	2	17.69	4
Number of Non-Insect Taxa	3	2	1	1
% CG	19.20	4	15.97	4
% n as Elmidae	0.74	1	0	1
Aquatic Life Use Score	**31**		**30**	
Aquatic Life Use Rating	**High**		**High**	

Table 23. Tucker Lake benthic index of biotic integrity (BIBI) 21732, Palo Pinto County, July 28, 2015. The BIBI is not meant for use in lakes.

Metric	**Value**	**Score**
Taxa Richness	29	4
EPT Index	6	2
HBI	7.67	1
% Chironomidae	3.4	4
% Dominant Taxon	51.71	1
% Dominant FFG	35.11	4
% Predators	23.88	3
Intolerant : Tolerant	0.03	1
% Total Trichoptera as Hydropsychidae	0	4
Number of Non-Insect Taxa	5	3
% CG	30.79	2
% n as Elmidae	1.02	4
Aquatic Life Use Score	**33**	
Aquatic Life Use Rating	**High**	

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