Conservation Status of Texas Freshwater Fishes: Informing State-based Species Protections

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Abstract: In Texas, freshwater fishes recognized as State Threatened or Endangered (STE) receive special attention when Texas Parks and Wildlife Department (TPWD) consults with other agencies on projects that have the potential to alter freshwater systems. Regulatory oversight by TPWD of scientific and zoological collections, fish stockings, commercial fishing, disturbances to state-owned streambeds, and exotic species management must also ensure that no adverse impacts occur to STE freshwater fishes. Furthermore, STE species are prioritized by TPWD for voluntary-based investments in research, monitoring, habitat restoration, and habitat protection. Given these and other protections afforded to STE freshwater fishes, it is important that the lists of STE species be frequently assessed using the best available science on status, trends, and threats to species and their habitats. In 2018, TPWD adopted standardized methodologies, listing criteria, and listing thresholds to comprehensively assess the status of the diversity of species of fish, wildlife, and plants within the resource management purview and jurisdiction of TPWD. This methodology was applied to assess the status of Texas freshwater fishes and recommend revisions to the lists of STE species. As a result, 16 additional species of freshwater fish were recognized as STE in 2020. This article profiles the species conservation status assessment and stakeholder input processes used to identify species recommended as STE, and shares recommendations and lessons learned transferrable to other states that maintain similar state-based protected species lists.

Key words: native fish conservation, threatened and endangered species, conservation status assessment, species protection

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Declining freshwater fish diversity is a conservation issue not unique to Texas (Haslouer et al. 2005, Jelks et al. 2008). Freshwater fishes are threatened globally (Dudgeon et al. 2006, Strayer and Dudgeon 2010, Dodds et al. 2013) and currently have the highest extinction rate among vertebrates; of the 13,661 species of freshwater fish known to the planet, 83 are considered extinct (Burkhead 2012). Of the 1213 freshwater fishes found in North America, 39 species and 18 subspecies are considered extinct (Miller et al. 1989, Jelks et al. 2008). The primary causes of extinction of North American freshwater fishes have been physical habitat alteration, introduction of non-native species, water quality degradation, hybridization, and overharvest (Miller et al. 1989; Stein et al. 2000; H. John Heinz III Center for Science, Economics and the Environment 2002; Jelks et al. 2008). Since the 1950s, the extinction rate for North American freshwater fishes is approximately 7.5 extinctions per decade, and models predict 53 to 86 additional freshwater fishes will become extinct in North America between 2010 and 2050 (Burkhead 2012).

Texas harbors 191 species of native freshwater fish, 91 of which

are considered imperiled (Cohen et al. 2018, Birdsong et al. 2019). An additional 67 native estuarine fishes have been documented to occur in Texas freshwater systems, with nine of those species considered imperiled (Cohen et al. 2018). Similar to other areas of the United States, the primary cause of fish imperilment in Texas is anthropogenic alteration of freshwater systems (e.g., groundwater extraction and concomitant reductions in spring discharge, river fragmentation, alteration of natural river flow patterns, degradation of water quality, introduction of non-indigenous species), which continues to occur at rates and scales that threaten the longterm persistence of native freshwater fishes (Costigan and Daniels 2012, Dodds et al. 2013, Perkin et al. 2014). Furthermore, changing climate trends have the potential to impact freshwater fishes (Lynch et al. 2016). Droughts are expected to increase in frequency and severity in Texas, affecting the timing and frequency of flows and water levels necessary to support spawning and other habitat requirements of freshwater fishes. Complex interactions are also expected to occur between climate change and existing anthropogenic stressors. Left unchecked, these issues will likely continue to

contribute to the imperilment and loss of native fishes and other freshwater species (Gido et al. 2010, Hoagstrom et al. 2011). Five of the 191 species of Texas freshwater fish are considered likely extinct. Another six species are currently considered extirpated from the state but continue to occur in other portions of their native ranges in adjacent U.S. states or Mexico, and concerted efforts to repatriate some taxa to Texas are ongoing (Birdsong et al. 2019).

A suite of specific regulatory and voluntary-based conservation measures has been implemented by Texas Parks and Wildlife Department (TPWD) and cooperators in the management and conservation of Texas freshwater fishes (Table 1), many of which are unique to species recognized as Species of Greatest Conservation Need (SGCN) or State Threatened or Endangered (STE). Fish recognized as SGCN (TPWD 2012) represent state-level recognition of species with low or declining populations in need of conservation action. This may include species already recognized as STE, species at risk due to threats to their life history needs or habitats, species that are rare due to few, small or declining populations, abundance, or distribution, or species with declining trends in their habitats and populations (Association of Fish and Wildlife Agencies 2012). Species listed as State Endangered (SE) are defined as species native to Texas that are listed as endangered under the U.S. Endangered Species Act (ESA) or those threatened with extinction or statewide extirpation. Species listed as State Threatened (ST) are generally defined as those species with a high potential to become SE without conservation intervention.

Freshwater fishes recognized as SGCN or STE are prioritized by TPWD for voluntary based investments in research, monitoring, habitat restoration, and habitat protection (Table 1; Birdsong et al. 2019, Garrett et al. 2019). Those species also receive special consideration as TPWD provides recommendations through regulatory based consultations to local, state, and federal agencies that permit, construct, or manage projects that alter freshwater systems and fish habitats (e.g., hydropower relicensing, wastewater discharge, and construction or maintenance of dams, bridges, and stream crossings). For instance, projects that disrupt or remove stream bed materials may only be permitted by TPWD if determined to not damage or injuriously affect the river or freshwater fishes, not significantly or injuriously change the hydrology of the river, and not significantly accelerate erosion upstream or downstream (Table 1). Regulatory oversight of scientific and zoological collection of freshwater fishes, stocking of fishes into public waters, commercial fishing activities in public waters, and exotic species management also ensure that no adverse impacts occur to STE species.

Another regulatory based authority for protection of freshwater fishes is to seek full restitution or restoration of fish and habitat losses occurring as a result of anthropogenic activities (Table 1). This authority applies to any freshwater fish considered public trust resources that are unlawfully killed, caught, taken, possessed, or injured, regardless of their listing status. These broadly-defined authorities have been applied as a proactive deterrent through consultations with responsible parties who manage, construct, or maintain projects that alter freshwater systems, and have routinely resulted in cooperation between TPWD and responsible parties on development of conservation plans that attempt to avoid, minimize, and mitigate project-level impacts. When necessary, restitution value of the lost or injured resources is determined through use of assessment procedures and cost values established by the American Fisheries Society (Southwick and Loftus 2017). Occurrence of STE freshwater fishes within a project area offers additional incentive for responsible parties to implement proactive avoidance measures, given the stipulated values of SE and ST fish (Table 1). Since 2010, a total of US\$140,842 was collected by TPWD in civil restitution penalties for take of freshwater species, and penalties for pending cases exceeded \$600,000. These restitution funds were primarily invested in the restoration or enhancement of aquatic and riparian habitats. An event on the Sulphur River, Texas in 2010 killed large numbers of ST paddlefish (Polyodon spathula) valued at approximately \$54,000, and precipitated the proactive consultations now considered routine between TPWD and responsible parties.

The existence of protective regulations for STE species in Texas is one reason why the lists of STE fishes should be frequently updated and informed by the best available science on status, trends, and threats to species and their habitats. Frequently updating these lists also supports prioritization of species in need of conservation action and enables access to project-based funding for research, monitoring, and habitat restoration and provides the basis for additional regulatory authorities used to intervene and reverse trends for species in decline. Furthermore, these actions have the potential to contribute to recovery of species listed as endangered or threatened under the ESA or support proactive measures that avoid the need for federal listing.

As TPWD prepared to revise the lists of STE fish species in 2018, we decided to adopt a species conservation status assessment approach that uses standard methods and consistent assessment criteria and provides a starting point to obtain additional input from subject-matter experts. Prior updates and revisions to our lists of STE fishes were infrequent and without standard methodologies, listing criteria, or thresholds. Updates to the lists were typically made in response to surveys, monitoring, or research conducted by TPWD biologists or academic researchers that recognized population declines for specific species. The new TPWD strategy was **Table 1.** Examples of voluntary and regulatory based conservation programs that support the conservation of freshwater fishes in Texas recognized as State Threatened or Endangered (STE) or as Species of Greatest Conservation Need (SGCN) by Texas Parks and Wildlife Department (TPWD).

Conservation program	Responsible organization(s)	Type of authority	Program description
National Fish Habitat Partnership	Desert Fish Habitat Partnership, Southeast Aquatic Resources Partnership, TPWD	Voluntary	Since 2008, nearly 60 fish habitat restoration projects have been supported in Texas through the Desert Fish Habitat Partnership and Southeast Aquatic Resources Partnership; projects restored more than 4000 ha of fish habitats
Crucial Habitat Assessment Tool (CHAT)	Western Association of Fish and Wildlife Agencies	Voluntary	GIS-based tool developed for the western USA; informs consideration of fish and wildlife habitats in land-use planning, zoning, and development decisions
Southeast Conservation Blueprint	Southeastern Association of Fish and Wildlife Agencies	Voluntary	Serves as a living, spatial plan that identifies important areas for fish and wildlife conservation across the southeastern USA and Caribbean
Texas Aquatic Gap Sampling Program	TPWD, University of Texas at Austin	Voluntary	Fills gaps in distributional data for freshwater fishes and mussels recognized as STE or SGCN; surveys are primarily conducted within riverscapes recognized by TPWD as Native Fish Conservation Areas
Cooperative Endangered Species Conservation Fund	TPWD, U.S. Fish and Wildlife Service	Voluntary	Provides cost-share funding to fill critical science needs and implement conservation measures to conserve federally listed species
State Wildlife Grants Program	TPWD, U.S. Fish and Wildlife Service	Voluntary	Provides cost-share funding to fill critical science needs and implement conservation measures to conserve freshwater fishes recognized as STE or SGCN
Landowner Incentive Program	TPWD, USFWS Partners for Fish and Wildlife Program, and numerous local cooperators	Voluntary	Provides cost-share funding to cooperating landowners to implement fish and wildlife habitat restoration projects on private lands; since 2010, the program has cooperated with approximately 140 landowners to support 160 projects that restored over 24,000 ha
Texas Farm and Ranch Lands Conservation Program	TPWD	Voluntary	Provides cost-share funding to cooperating land trusts for the purchase of conservation easements on private lands
Texas Instream Flow Program	TPWD, Texas Water Development Board, and Texas Commission on Environmental Quality	Voluntary	Performs studies to identify instream flow regimes needed to maintain sound ecological environments in Texas rivers and streams; studies use SGCN and STE freshwater fishes as focal species
Collaborative Conservation Agreements	TPWD and numerous cooperators	Voluntary	Through multi-agency conservation plans, TPWD cooperates with partners to implement interjurisdictional, watershed-scale, and range-wide conservation efforts for focal species
Texas Native Fish Conservation Areas	TPWD	Voluntary	Consists of a network of 20 watershed-based management units that serve as strongholds for freshwater fish SGCN and STE freshwater fishes
Texas Parks & Wildlife Code, §§ 67.001–67.0041, Nongame Species	TPWD	Regulatory	Provides authorities and mandates for conservation of non-game freshwater fishes, including research, species propagation, survey and monitoring, etc. to ensure the continued ability of non-game fishes "to perpetuate themselves"
Texas Parks & Wildlife Code, § 12.0011, Resource Protection	TPWD	Regulatory	Provides authorization to seek full restitution or restoration of fish and habitat losses occurring as a result of anthropogenic activities
Texas Parks & Wildlife Code, § 69.23, Fish and Wildlife Values	TPWD	Regulatory	Authorizes a substantial increase in the restitution value of STE species, with each State Endangered fish valued at US\$1000 per individual and each State Threatened fish valued at \$500 per individual
Texas Administrative Code, §§ 69.301–69.311, Scientific, Educational, and Zoological Permits	TPWD	Regulatory	Authorizes regulatory oversight by TPWD of scientific and zoological collection of freshwater fishes, listing as STE prohibits the take, possession, transport, or sale of a species in the absence of a Scientific Permit for Research
Texas Parks & Wildlife Code, §§ 52.101–52.401, Introduction of Fish, Shellfish, and Aquatic Plants	TPWD	Regulatory	Authorizes regulatory oversight by TPWD of stocking of fishes into public waters, ensuring that no adverse impacts occur to STE freshwater fishes
Texas Parks & Wildlife Code, sections §§ 57.377–57.386, Permits to Possess or Sell Nongame Fish Taken from Public Freshwater	TPWD	Regulatory	Authorizes regulatory oversight by TPWD of commercial fishing activities in public waters, ensuring that no adverse impacts occur to STE freshwater fishes
Texas Parks & Wildlife Code, §§ 57.111–57.137, Harmful or Potentially Harmful Fish, Shellfish, and Aquatic Plants	TPWD	Regulatory	Authorizes regulatory oversight by TPWD for management of aquatic invasive species, ensuring that no adverse impacts occur to STE freshwater fishes
Texas Parks & Wildlife Code, §§ 69.101–69.121, Issuance of Marl, Sand, and Gravel Permits	TPWD	Regulatory	Regulates disturbance of instream habitats within state-owned streambeds; projects that disrupt or remove stream bed materials may only be permitted if determined to not damage or injuriously affect the river or freshwater fishes

designed to comprehensively assess the status of the diversity of Texas plants and animals and ensure that the lists of STE species accurately reflect current status and trends.

Enabling a Data-Driven Approach for Assessing the Conservation Status of Texas Freshwater Fishes

Comprehensive and reliable data are foundational for determining conservation status and threats to any species. To inform fish species conservation status assessments, TPWD relied upon data available through the Biodiversity Center Fish Collection at the University of Texas at Austin. This collection contains more than 1.7 million specimens, and most (>75%) are from Texas freshwater systems. These specimens were used to compile the open-access database accessible through the Fishes of Texas website (www.fishes oftexas.org/home/). The database consists of a carefully curated, fully georeferenced, and high-quality compilation of all known specimen-based records of fish occurrences in Texas dating back to 1850.

The Biodiversity Center Fish Collection has been used for field guides (Page and Burr 2011), documentation of species ranges (Craig and Bonner 2019) and range expansions (Martin et al. 2012), historical community composition (Labay et al. 2011), bioassessments (e.g., Labay and Hendrickson 2014, Robertson et al. 2017, Labay et al. 2019), biodiversity conservation (e.g., Birdsong et al. 2018, Cohen et al. 2018, Birdsong et al. 2019), endangered species listing decisions (U.S. Fish and Wildlife Service [USFWS] 2014a), and invasive species management (Poulos et al. 2012, Cohen et al. 2014, McGarrity 2019). The high-quality data provided by the collection improve understanding of the distributional history of Texas fishes and current conservation status and provide insights into factors affecting the future of the state's fish fauna. For example, historical ranges and successive range changes (Figure 1)



Figure 1. Native range (dark grey HUCs) of Rio Grande shiner (*Notropis jemezanus*) within the middle and lower Rio Grande basin, occurrence records for Rio Grande shiner contained within the Biodiversity Center Fish Collection at the University of Texas at Austin (green and blue dots represent reliable records; red and yellow dots are considered suspect), and analysis of spatial and temporal trends for the species, which indicate declines in detections per HUC sampled (DPHS) and a shift and reduction in the occupied range to the middle basin (Cohen et al. 2018).

coupled with species distribution models yield important information about how community ecology, demographic changes, habitat loss, the spread of invasive exotics, and impacts of climate change affect species status. Those insights can then support conservation planning and policy decisions by TPWD and others. As described below, data and information from the collection also provided foundational science for recommended revisions to the list of freshwater fish SGCN (Cohen et al. 2018) and the lists of STE freshwater fishes.

Adopting a Standardized Species Conservation Status Assessment Methodology

In 2018, TPWD established a multidisciplinary STE Listing Work Group with representatives from the Coastal Fisheries, Inland Fisheries, and Wildlife divisions of TPWD. The TPWD STE Listing Work Group was tasked with coordinating development or adoption of consistent methodologies for assessing conservation status of Texas fish, wildlife, and plants and for coordinating development of science-based and data-driven recommendations for revision of STE species lists. To determine the relative degree of conservation concern, and ultimately whether to designate species as STE, the TPWD STE Listing Work Group adopted the Nature-Serve Rank Calculator as a standardized methodology (Faber-Langendoen et al. 2012, Master et al. 2012). This methodology was developed to provide a consistent approach because NatureServe and its network of state-based natural heritage programs periodically assess conservation status of species and ecosystems across North America. As the state-based natural heritage program for Texas, TPWD is an active cooperator within the NatureServe network. The NatureServe Rank Calculator methodology and associated tools provide a data-driven and regionally consistent approach to evaluate extirpation risk of species at national or state scales, extinction risk of species at global scales, and elimination risk of ecosystems at global scales. Furthermore, the methodology was designed to be compatible with international efforts to assess conservation status of species and contribute to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, which is intended to serve as a tool to inform and catalyze action for global biodiversity conservation (IUCN 2019).

As an initial step to inform potential revisions to the set of freshwater fishes contained on the lists of Texas STE species, the NatureServe Rank Calculator methodology and the Biodiversity Center Fish Collection data were used to assess the conservation status of 91 Texas SGCN freshwater fishes (Figure 2) and also to map the locations of these fishes by number and by sub-watershed locations (Figure 3). These species were recommended by Cohen et al. (2018) as SGCN for the forthcoming 2023 revision of the State Wildlife Action Plan for Texas and were recently adopted by TPWD as focal species for implementation of a statewide network of Native Fish Conservation Areas (Birdsong et al. 2019, Garrett et al. 2019). For each species, scores were assigned to each of 10 individual core factors (i.e., population size, range extent, area of occupancy, number of occurrences, number of occurrences with good viability, environmental specificity, scope, severity, and timing of threats, intrinsic vulnerability, and long-term and short-term trends), which serve as indicators of species rarity, threats, and trends (See Table 1 in Master et al. 2012). Scores assigned to each factor were scaled and weighted according to the perceived level of contribution of each factor to overall species imperilment and risk of extinction (See Table 9 in Faber-Langendoen et al. 2012). Weighted scores were then combined across factors to calculate a final conservation status score for each species and assigned a corresponding conservation status rank (Tables 2 and 3). If data and information used as the basis for scoring of a specific factor were lacking or uncertain, factor scores were assigned a wider range of values, which introduced greater levels of uncertainty into the final conservation status score. Depending on the degree of uncertainty, the NatureServe Rank Calculator assigned either an individual conservation status rank (e.g., Imperiled [S2]), which indicated low levels of uncertainty, or a dual rank (e.g., Imperiled/Vulnerable [S2S3]), which recognized higher levels of uncertainty within one or more factor scores (Table 3).

Listing thresholds established by the TPWD STE Listing Work Group centered on these updated state-based species conservation status ranks. Species assigned a state-based rank of Critically Imperiled (S1), Imperiled (S2), or the dual ranks of Critically Imperiled/Imperiled (S1S2) or Imperiled/Vulnerable (S2S3) were included in subsequent phases of the species conservation status assessment process (Figure 2). For species endemic to Texas, updated state-based conservation status ranks assembled through this process are expected to be adopted by NatureServe as the updated global conservation status ranks for those species. For the subset of freshwater fishes with native ranges that extend beyond the borders of Texas, our updated state-based ranks are expected to inform forthcoming updates to the NatureServe global conservation status ranks.

Global species conservation status ranks use the same methodology, but with consideration of data and information from throughout a species' native and occupied range (Faber-Langendoen et al. 2012). Although not a primary consideration in the development of our STE species listing recommendations, global ranks were reviewed by TPWD for non-endemic species with attention given to the extent of the occupied range that occurs outside the state, recognition of whether Texas exists on the periphery



Figure 2. Flow chart illustrating the steps taken by TPWD to revise the lists of State Threatened or Endangered freshwater fishes.



Figure 3. Number of freshwater fishes identified by Cohen et al. (2018) as Species of Greatest Conservation Need that occur within each sub-watershed of Texas.

 Table 2. Definitions of NatureServe state-based conservation status ranks, status rank codes, and their corresponding range of conservation status scores (adapted from Faber-Langendoen et al. 2012).

Conservation status rank	Conservation status rank code	Range of conservation status scores	Conservation status rank definition
State extirpated	SX	N/A	Extirpated from the state
Possibly extirpated	SH	N/A	Known only from historical records but some hope for rediscovery
Critically imperiled	S1	≤ 1.5	Very high risk of extirpation due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors
Imperiled	S2	1.6–2.5	High risk of extirpation
Vulnerable	\$3	2.6-3.5	Moderate risk of extirpation
Apparently secure	S4	3.6-4.5	Considered stable but with some cause for concern from recent localized declines or threats
Secure	S5	4.6-5.5	Extensive range, abundant populations or occurrences, limited concern with declines or threats

Table 3. Freshwater fishes recognized as State Threatened or State Endangered in Texas (revised 2020) with associated NatureServe state-based conservation status ranks (revised 2019), state listing status prior to 2020, and current federal listing status. NatureServe State Rank: see Table 2. Listing status: State Threatened (ST), State Endangered (SE), Federally Threatened (FT), Federally Endangered (FE), Threatened due to similarity of appearance (SAT).

Family Scienti		Common name	NatureServe state rank	State listing status		
	Scientific name			Previous listing status	Updated listing status	Federal listing status
Acipenseridae	Scaphirhynchus platorynchus	shovelnose sturgeon	S1	ST	ST	SAT
Polyodontidae	Polyodon spathula	paddlefish	S1	ST	ST	_
Cyprinidae C	Campostoma ornatum	Mexican stoneroller	S2	ST	ST	_
	Cyprinella lepida	plateau shiner	S2	-	ST	_
	Cyprinella proserpina	proserpine shiner	S2S3	ST	ST	_
	Dionda diaboli	Devils River minnow	S1	ST	ST	FT
	Dionda episcopa	roundnose minnow	S1	_	ST	_
	Dionda nigrotaeniata	Medina roundnose minnow	S1	_	ST	_
	Dionda serena	Nueces roundnose minnow	S2	_	ST	_
	Gila pandora	Rio Grande chub	S1	ST	ST	_
	Hybognathus amarus	Rio Grande silvery minnow	SX	SE	SE	FE
	Macrhybopsis aestivalis	speckled chub	S1S2	_	ST	_
Macrhybopsis australis Macrhybopsis tetranema Notropis braytoni Notropis buccula Notropis chihuahua	Macrhybopsis australis	prairie chub	S1	_	ST	_
	Macrhybopsis tetranema	peppered chub	S1	-	ST	_
	Notropis braytoni	Tamaulipas shiner	S1S2	-	ST	_
	Notropis buccula	smalleye shiner	S1S2	-	SE	FE
	, Notropis chihuahua	Chihuahua shiner	S1	ST	ST	_
	, Notropis girardi	Arkansas River shiner	S1	ST	ST	FT
	Notropis jemezanus	Rio Grande shiner	S1	_	ST	_
	Notropis oxyrhynchus	sharpnose shiner	S1S2	_	SE	FE
	Notropis potteri	chub shiner	S2	_	ST	_
Notopis poten Notropis simus pecosensis Pteronotropis hubbsi	Notropis simus pecosensis	Pecos bluntnose shiner	SX	ST	ST	FT
	Pteronotropis hubbsi	bluehead shiner	S2	ST	ST	_
Catostomidae Cyc Erii	Cycleptus elongatus	blue sucker	S1	ST	ST	_
	Erimyzon claviformis	creek chubsucker	S2	ST	ST	_
lctaluridae	lctalurus lupus	headwater catfish	S1S2	_	ST	-
	Prietella phreatophila	Mexican blindcat	S1	_	SE	FE
Satan eurystomus Trogloglanis patterso	Satan eurystomus	widemouth blindcat	S1	ST	ST	_
	Trogloglanis pattersoni	toothless blindcat	S1	ST	ST	-
Poeciliidae Gambusia clarkhul Gambusia gaigei Gambusia georgei Gambusia heteroch Gambusia nobilis Gambusia senilis	Gambusia clarkhubbsi	San Felipe gambusia	S1	ST	ST	_
	Gambusia gaigei	Big Bend gambusia	S1	SE	SE	FE
	Gambusia georgei	San Marcos gambusia	SX	SE	SE	FE
	Gambusia heterochir	Clear Creek gambusia	S1	SE	SE	FE
	Gambusia nobilis	Pecos gambusia	S1	SE	SE	FE
	Gambusia senilis	blotched gambusia	S1	ST	ST	-
Cyprinodontidae	Cyprinodon bovinus	Leon Springs pupfish	S1	SE	SE	FE
Cyphilodonidae	Cyprinodon elegans	Comanche Springs pupfish	S1	SE	SE	FE
	Cyprinodon eximius	Conchos pupfish	S1	ST	ST	_
	Cyprinodon pecosensis	Pecos pupfish	S1	ST	ST	_
	Cyprinodon rubrofluviatilis	Red River pupfish	S2	_	ST	_
Percidae	Etheostoma fonticola	fountain darter	<u>Ş1</u>	SF	SF	FF
reiciuae	Etheostoma orahami	Rio Grande darter	S1	ST	ST	-
	Percina apristis	Guadalupe darter	S1	_	ST	_
	Percina maculata	blackside darter	S1	ST	ST	_

or is core to the species range, and how recently the last global species conservation status assessment was completed by Nature-Serve. Other criteria considered in the development of STE listing recommendations included the scope of voluntary-based conservation measures directed at individual species, and the potential role or implications of STE listing in addressing specific conservation challenges and needs of that species. The TPWD STE Listing Work Group also decided that STE listing of freshwater fishes (and marine fishes) would be limited to species currently recognized by the American Fisheries Society (Page et al. 2013). Similar requirements were established for other groups of taxa with corresponding professional societies which maintain lists of recognized species. Furthermore, the STE Listing Work Group determined that SE status would be reserved for species currently listed as endangered under the ESA, ensuring consistency and alignment between the two protected species lists.

Ensuring Transperency and Incorporating Input from Subject-Matter Experts

Subject-matter experts from the TPWD Inland Fisheries and Wildlife divisions, universities, and non-governmental organizations were invited to participate in a series of three introductory webinars and an in-person workshop used to obtain input into recommended revisions to the lists of Texas STE freshwater fishes. An open invitation to participate was broadly disseminated by TPWD to professionals actively involved in native fish research and conservation in the state. Webinars were designed to familiarize participants with 1.) state-based conservation measures available for the restoration and protection of native freshwater fishes, 2.) conservation implications for listing of a species as STE, 3.) the species conservation status assessment methodology adopted by TPWD to identify species recommended for listing, and 4.) the process that would be used to facilitate additional input from subject-matter experts. During the webinars, these experts were invited to participate in one or more of four regional assessment teams (i.e., Chihuahuan Desert, East Texas and Coastal Plains, Edwards Plateau, and Southern Great Plains). The primary role of each regional assessment team was to review the state-based species conservation status ranks assigned to each species in those regions. The regional teams were asked to 1.) determine whether they agreed with the updated state-based conservation status ranks, 2.) provide supporting observations or evidence for their responses, 3.) provide additional data on the status and trends of the species assessed in their regions, and 4.) provide specific case studies of diminished or value-added protections potentially occurring because of listing of a specific species as STE. Input from each team was collated in advance of the in-person workshop, with a regional

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summary of recommendations presented at the workshop by each regional assessment team. A facilitated discussion then occurred at the workshop, with all workshop attendees invited to offer input, feedback, and ask questions on the recommendations of each regional assessment team. Regional recommendations were finalized at the workshop and then combined and formatted into a proposed statewide revision to the lists of STE species.

Summary of Changes to the State Threatened or Endangered Species Lists

The proposed statewide revision of freshwater fishes was combined with recommended statewide revisions by TPWD for other taxonomic groups within the resource management purview of the agency. The combined lists of SE species and ST species were presented to the TPWD STE Listing Work Group and TPWD senior leadership for review and then presented to the Texas Parks and Wildlife Commission at their August 2019 meeting. The proposed revisions were subsequently published in the Texas Register, which serves as the journal of state agency rulemaking. At the January 2020 Texas Parks and Wildlife Commission Meeting, TPWD staff summarized public comments received in response to the notice in the Texas Register and then offered a proposal for rulemaking, which was unanimously adopted by the Texas Parks and Wildlife Commission. Following adoption, this rulemaking action was codified in Texas Administrative Code in April 2020. Revisions made to the STE species lists as a result of this process expanded state-based protections for 16 species of freshwater fishes (Table 3; Figure 4), including recognition of an additional 13 species as ST and three species as SE. Three new species listed as SE were previously listed as endangered under the ESA. Two shiners have experienced substantial range reductions, with their current occupied range limited to the Brazos River upstream of Possum Kingdom Lake; both were listed in 2014 (USFWS 2014b). Mexican blindcat (Prietella phreatophila), a species thought to be limited in range to areas of northern Coahuila, Mexico, was recently documented in Texas within a cave located at the Amistad National Recreation Area (Cohen et al. 2018). Through an international agreement with Mexico, the species was listed as endangered under the ESA in 1970 (USFWS 1970).

Through this species conservation status assessment process, an additional six species of Texas freshwater fish met the ST criteria and were proposed for listing; however, these species had not yet been formally recognized as valid species by the American Fisheries Society Names of Fishes Committee (Page et al. 2013). Four of these six species were previously thought to be populations of already described species but were recently determined to be unique, genetically distinct species, most with extremely limited



Figure 4. Number of freshwater fishes identified as Texas State Threatened or Endangered that occur within each sub-watershed of Texas.

ranges confined to individual river systems. TPWD will revisit the consideration for listing these six species upon inclusion of these species in future publications of the American Fisheries Society Names of Fishes Committee. Conservation status of six additional species of freshwater fish also met basic criteria to be considered for listing as ST, but subject-matter experts recommended that additional data were needed to accurately assess their conservation status globally and in Texas. These species subsequently were adopted as research priorities of TPWD, with the expectation that their listing status will be reassessed during the next revision of the lists of STE species. Lastly, the potential existed for delisting of STE freshwater fishes with conservation status ranks that did not meet or exceed the listing threshold established by the TPWD STE Listing Work Group (i.e., species with conservation status ranks of Vulnerable [S3], Apparently Secure [S4], or Secure [S5]). While none of the freshwater fishes previously contained on the lists of STE species were assigned a conservation status score below the listing threshold, several terrestrial and marine species within the

resource management purview of the TPWD Coastal Fisheries and Wildlife divisions received scores (and affirmation from subject-matter experts) that resulted in their delisting.

Discussion

Through this process, a comprehensive, data-driven, inclusive, and transparent review was completed of the conservation status of Texas freshwater fishes. Adoption of the NatureServe Rank Calculator as the standard methodology for evaluation of Texas freshwater fish for listing as STE was advantageous in that it aligned this review with similar species conservation status assessments being undertaken in other states, territories, and provinces throughout North America by natural heritage programs and other cooperators of the NatureServe network. Using a standardized methodology will facilitate communications and coordination among stakeholders involved in range-wide conservation assessment and planning efforts for species with native ranges encompassing multiple jurisdictions (i.e., states, provinces, territories). Adoption of the NatureServe Rank Calculator aligned our review with criteria considered in development of the IUCN Red List of Threatened Species, ensuring that conservation status of Texas freshwater fishes more accurately reflects and considers global biodiversity conservation status assessments and species conservation initiatives. Furthermore, because this risk-based species conservation status methodology was used across all taxonomic groups under the purview of TPWD, it enabled a consistent, equitable, and repeatable approach for consideration of species in need of added protections offered to those contained on the lists of STE species. For these same reasons, use of this methodology should also be considered for adoption by TPWD for the next update of the list of SGCN in 2023, as its prior use for that purpose was previously limited to species within the purview of the TPWD Wildlife Division.

This review of conservation statuses of Texas freshwater fishes included opportunities for stakeholder engagement and input from subject-matter experts actively involved in native fish research and conservation in the state. Use of webinars and an in-person workshop to obtain input from subject-matter experts ensured that the best available science was considered in species conservation status assessments. This stakeholder process also contributed to a more unified and defensible set of recommendations from native fish conservation professionals in the state. The geographic boundaries of the four regional assessment teams established for this stakeholder process directly corresponded to the four fish conservation planning regions previously adopted by TPWD for implementation of a network of Native Fish Conservation Areas in Texas (Birdsong et al. 2019). Those four regions are ecologically meaningful in that they closely align with the biotic provinces of Texas (Blair 1950). It was apparent throughout both planning processes that many of the researchers and conservationists engaged in native fish conservation in Texas were also geographically aligned with those regions (Birdsong et al. 2019, Garrett et al. 2019). Use of these planning regions for the revision of the lists of STE freshwater fishes allowed formation of teams comprising individuals with existing professional relationships who were comfortable interacting and sharing data, observations, ideas, and strategies, and who recognized the direct value of participating in the process to advance the conservation of species and habitats within the geographic focus of their respective programs. These observations underscore the importance of engagement with stakeholders and subject-matter experts at local or regional scales, which proved beneficial and effective for this species conservation status assessment process.

A shortcoming of the stakeholder process was lack of proactive communication and coordination with the regulated community potentially affected by revision of the lists of STE species. Several organizations representative of the regulated community inaccurately interpreted or perceived specific added regulatory burdens from species additions to the lists of STE species, often confusing the lists of STE species with the regulatory protections provided through the ESA. It is recommended that future revisions to the lists of STE species include proactive stakeholder communication and coordination efforts directed explicitly at the regulated community in order to explain regulatory implications of state-based species listings and provide a detailed description of the species conservation status assessment methodology and supporting data used by TPWD to recommend species for listing.

The TPWD should consider establishing a recurring, cyclical schedule for completion of comprehensive species conservation status assessments and necessary revisions to the lists of STE species across taxa. Such a decision should consider the timing and frequency that new data and information become available on status and trends of species. Other potential considerations include the timing and frequency that recurring updates are made to the State Wildlife Action Plan for Texas and associated list of SGCN, and opportunities that exist to integrate the species conservation status assessments used for these two processes. As noted earlier, the TPWD Wildlife Division previously utilized the NatureServe species conservation status ranks to select species for inclusion on the list of SGCN. It is recommended that the Inland Fisheries and Coastal Fisheries divisions also adopt this strategy, with all natural resources divisions cooperating on the development of standard thresholds that consider the NatureServe state-based species conservation status ranks in determination of species to be listed or removed as SGCN. For example, species with conservation status ranks of Vulnerable, Imperiled, and Critically Imperiled might be considered for listing as SGCN. This would enable investments of research and conservation funding available through the State Wildlife Grants Program (and the Recovering America's Wildlife Act, should it be passed by the U.S. Congress) toward all species on the lists of STE species (i.e., typically those ranked as Imperiled or Critically Imperiled) and toward other species considered at moderate risk of statewide extirpation (i.e., typically those ranked as Vulnerable) given rarity, threats, and current population trends (Master et al. 2012).

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