Year 1 report for 'Conserving Texas Biodiversity: Status, Trends, and Conservation Planning for Fishes of Greatest Conservation Need'

PI – Dean A. Hendrickson, Curator of Ichthyology, University of Texas Austin, Department of Integrative Biology, Biodiversity Collections (Texas Natural History Collections - TNHC), 10100 Burnet Rd., PRC176EAST/R4000, Austin, Texas 78758-4445; tel: 512-471-9774; email: deanhend@austin.utexas.edu; co-authors - Gary P. Garrett; Ben J. Labay; Adam E. Cohen, Melissa Casarez (all same affiliation as PI)

TPWD Project Leader: Timothy Birdsong, Habitat Conservation Branch – Inland Fisheries Division, 4200 Smith School Road, Austin, TX 78744. Timothy.Birdsong@tpwd.texas.gov. Phone 512 389-4744.

Funded by: Texas Parks and Wildlife Department through U.S. Fish and Wildlife Service State Wildlife Grant Program, grant TX T-106-1 (CFDA# 15.634)

Contract/Project Number: Contract No. 459125 UTA14-001402

Reporting Period: September 1, 2014 through August 31, 2015

Submitted: December 31, 2015

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Activity 1. Coordinate and Facilitate Science and Conservation Actions for Conserving Texas Biodiversity

Year 1 Outcomes

1. Expand and strengthen UT-TPWD coordination.

Multiple meetings to coordinate data sharing and collaboration were arranged with staff from various Divisions at Texas Parks and Wildlife, with outcomes summarized in #3 and #4 below.

2. Establish the collaborative relationship between UT and TPWD

An improved collaborative relationship between UT and TPWD was facilitated and beneficial outcomes to both entities are detailed in #3 and #4 below and Activity 3.

3. Provide data-supported recommendations to TPWD for fishes in the anticipated updates to the Texas Conservation Action Plan (supports activities 2, 3 and 4).

Fishes of Texas staff analyzed occurrences held in the Fishes of Texas database to assess distributional change over time for the native fishes of Texas and developed initial recommendations for conservation status. Feedback on these recommendations was then solicited from research biologists with familiarity of Texas fishes. Upon integration with our recommendations, we met with representatives from TPWD to develop expert opinions on ultimate inclusion or exclusion from the Species of Greatest Conservation Need list.

The resulting list (Appendix 1) contains our recommendations to remove Texas Shiner (*Notropis amabilis*) from the list. Our data shows a broad, stable distribution and there is no evidence of population losses across the range. We recommend an additional 21 taxa be added to the list. Some of these are newly-recognized species, but many are there due to range reductions, declines in population size, habitat fragmentation and habitat loss.

We also recommend that Devils River Pupfish (*Cyprinodon eximius* ssp.) not be recognized as a unique subspecies until a more thorough review of their genetic status can be accomplished. For now, it should be listed as a disjunct population of Conchos Pupfish (*Cyprinodon eximius*).

4. Integrate specimens, datasets and feedback from resource managers and other FoTX stakeholders to increase overall size of FoTX database, especially with newer records, and facilitate improved data flow between FoTX and TPWD.

Fishes of Texas staff are now working with the TPWD in numerous ways. The Bioblitz efforts (Task 4) have allowed us regular contact, in an informal setting, with River Studies Staff, to develop a working relationship which has facilitated numerous discussions regarding how we might further work together and what our goals are. During these field trips we've been working to drive home the message that the Texas Natural History Collections (TNHC) is willing to accept specimens they wish to deposit and that those vouchers will be permanently archived and at their disposal for future research. And by depositing specimens at the TNHC they also facilitate a large diversity of research possibilities since those specimens are available to reserachers around the world for many different types of research (evolution,

morphology, natural history, ecology, and archeology). Furthermore those data will be available on-line and help to improve our own species distribution models and other data products which they might access at some point.

We are working with Inland Fisheries staff to receive recommendations about features they would like to see integrated into the website. As part of that effort we are now in the process of modifying the website to provide geospatial tools which will essentailly become a platform that new GIS layers can be easily added depending on the needs of TPWD or other users. For example we could easily provide layers relevant to regulation and permiting (water rights, outfalls, non-native species, development etc) and those layers would allow users to query the occurrence data in new ways.

We're working with Inland Fisheries and Wildlife Division staff to digitize (where needed) Federal Aid reports (dating back to 1954), Section 6 reports, and State Wildlife Grant reports. Occurrences derived from these reports will be integrated into the Fishes of Texas database to supplement the existing data, thus eventually leading to improved species distribution models, watershed-based spatial prioritization assessments, native fish conservation planning frameworks, etc., that will contribute to implementation of the Texas Conservation Action Plan as well as conservation of freshwater fishes in general. We worked with Megan Bean and Kevin Mayes to scan and provide these reports online. Currently we are providing the Federal Aid Reports via our new "Sandbox" experimental website (http://sandbox.fishesoftexas.org) where we are also providing various other datasets and resources that we are developing. We continue collaborating with Kevin Mayes to quality control a partial database of occurences that he and TPWD staff have derived from those reports. We will eventually provide (at first via the "Sandbox" site) mapable and searchable species occurrences derived from those reports. We will soon be working with Chris Maldonado to do the same with Scientific Research Permit Reports.

We are also working on providing agency database occurrence data via FoTX. All parties now agree to how these data should be provided and we are soon to provide the bulk of the data held in the GoFish Database via FoTX. Those data will be provided online in our Sandbox site (http://sandbox.fishesoftexas.org) as we decide how to best incorporate them into the FoTX website.

We are working with the Texas Natural Diversity Database staff to integrate FoTX data and species distribution models into the TXNDD database, which severely lacks fish occurrence data. We're further working with them to develop, for Texas species, state status (S rankings) that are currently out of date and in need of updating. Updating those rankings will cause changes in G rankings as well. Both S and G rankings will be propagated to to NatureServe's database and thus impact conservation analyses and decision making processes that utlize these rankings.

We are working very closely with Cullen Hanks (TPWD, Wildlife Division, Nature Tracker program) who is actively promoting iNaturalist as a tool for citizen scientists to record photographic observations that can then be used for science and conservation. Along with the iNaturalist projects he already manages for TPWD, he is now helping us manage our own Fishes of Texas iNaturalist project to facilitate more and better observations. He has also been involved with the Bioblitzing efforts discussed in this report (Task 4). We have worked with him outside of this project in two other Austin-area bioblitzes (Berry Creek in Georgetown and Slaughter Creek in south Austin) and we will be further working with him on a Waller Creek bioblitz also unrelated to this project.

Internally, Fishes of Texas Project staff and TNHC staff continue work on Fish Collection expansion including cataloging new specimens and basic data management. We are working steadily to streamline the work flow from processing of incoming fish specimens through identification and cataloging to serving the collection's data via major biodiversity database portals including GBIF and the Fishes of Texas Project's online database. During the reporting period we have cataloged 1,844 new lots (equalling 21,438 individual specimens) from 435 sites. Many of these specimens come from the Bioblitzing efforts described in this report (see Task 4), which has so far generated 358 lots (equaling 4,387 specimens) from 27 sites and many of those remain to be cataloged. A complete record of specimens cataloged during the year covered by this report is provided in Appendix 6. The recently cataloged records will go into FoTX as part of our track 3 dataset (for which we already have data from 10 museums, 5 entirely new to the project).

We've also continuted improving the data held in our TNHC museum database. We have implemented new procedures for specimen digitization and measuring to our standard protocol, which now requires photography and measuring (smallest and largest specimens) for every new lot (jar) before being permanetly shelved. During the reporting period we have photographed approximately 800 specimen lots (jars) and measured and counted the largest and smallest specimens from every jar. Those images will soon be imported into our internal database and most of them are now available on the Fishes of Texas website or will go up shortly. Measurements are already in our TNHC database and will assist users of our data in specimen selection as well as potentially allow us to model species using size class as a variable. We've also improved the data held in our TNHC database by incorporating georeferences from our recent georeferencing projects (75% of TNHC specimen records are now georeferenced).

In an effort to greatly increase the number of data records we provide, we have contacted the decision makers of three fishing phone apps (FishBrain, FishingScout, and iFish) in hopes of collaborating to make available their data for scientific research. They are for-profit busnisess designed to allow anglers to show off their catches, and collectively learn from other anglers. Over the last few years they have exploded and contain a large number of occurrence records along with photos, allowing for verification, in particular for species relatively poorly represented in the museum archives. Since they are for-profit ventures, and their success hinges on their data, they are reluctant to share, however FishBrain has responded to our request and we are currently negotiating with them to provide their data in some form. Once we have the data we will initially provide it on our "Sandbox" site and eventually (depending on what they finally provide) would like to provide it alongside our museum data. We plan to analyse these data by comparing them to our other data sources (museum specimens, iNaturalist, state agency databases, and literature accounts) to develop an understaning of how data from different sources, each biased or lacking in some way, can be used to completment each other and be used for understanding species distributions over time.

In addition we have renewed our efforts to acquire specimens and data held by TPWD as well as as from various researchers in government and universities. During the reporting period of this report we have received specimens from 16 donors that we estimate will produce 3,128 lots, including ~26 lots from TPWD employees as work done outside the collaborative work reported here, ~2,202 lots from 10 universities, ~31 lots from USGS, ~19 lots from City of Austin and another ~2,126 lots from our own

collections and from private donors. However, many of these have not yet been formally cataloged since we've been primarily focused on cataloging specimens derived from fieldwork relating to this project.

5. Continue cleaning and normalizing FoTX Project online database records

We continue to seek out and analyze "suspect" records, correct specimen identifications, identify new species, refine locality and collection dates, integrate fieldnotes and images, and continue to further normalize the FoTX database. At this time we are accepting comments from our users about any aspect of the data held in our database (especially errors) via the comment fields associated with each specimen page.

Dr. Gary Garrett, our TPWD liaison and one of the state's most prolific fish collectors, performed a meticulous verification process comparing his field notes to the data held in FoTX and made corrections to 26 records (via specimen page comment forms) and uploaded 197 field notes.

We visited Texas A&M Univiersity's fish collection to examine and photograph 16 suspect lots. We also examined 412 lots housed at TNHC. Many of those were of the genus Mugil (Mullets) among which we found a surprisingly high error rate (20%). Other specimens were identified as part of an effort to better learn how to differentiate among (*Moxostoma albidum*, *M. austrinum*, and *M. congestum*) As part of this effort we recently identified a new species for the state – *Moxostoma duquesnii* from a tributary of the Red River collected in 1993 (TNHC 32541).

Activity 2. Identify Priority Geographic Management Units for Conserving Fishes of Greatest Conservation Need

Year 1 Outcomes

1. Identify and propose Native Fish Conservation Areas for the portions of Texas where spatial prioritization analysis has not yet been conducted.

Outcomes for this activity included creation of spatial planning (GIS) and mainstreamed products including:

i. New species distribution models for SGCN taxa

ii. A spatial prioritization assessment that identifies focal areas for conservation based on representation

iii. A spatial framework for landscape-scale resource management via identification of high-priority management units (Native Fish Conservation Areas, NFCAs) based on distance and compositional similarity of prioritized areas.

The process we followed to determine NFCAs is illustrated graphically in Figure 1, with indication of the three outcomes listed above. Much more detailed descriptions of the concepts and methods used for creation of these results and products are presented in Labay and Hendrickson 2014, Final Report: Conservation assessment and mapping products for GPLCC priority fish taxa, available at the University of Texas Digital Repository (http://repositories.lib.utexas.edu/handle/2152/27744). Thus, methods will be only briefly discussed here.

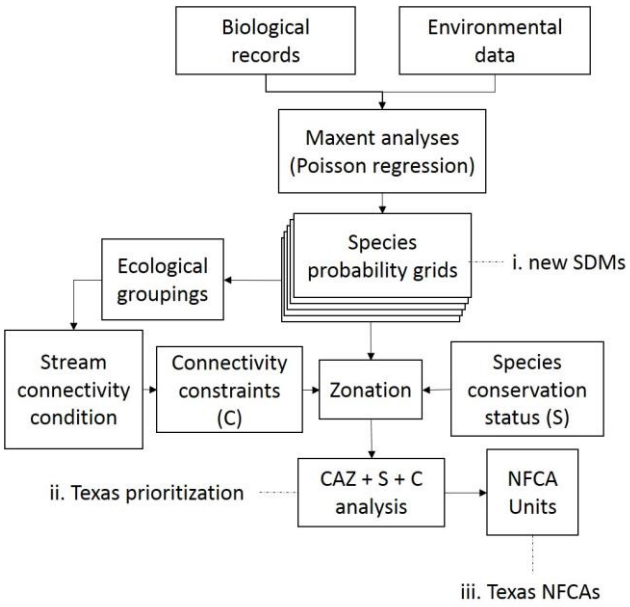


Figure 1. Schematic of the prioritization analysis sequence with indication of three primary outcomes for this report: i. new SDMs for Texas SGCN taxa, ii. A spatial prioritization, and iii. Identification of NFCAs.

2. New species distribution models for SGCN taxa

We used species distribution models (SDMs) to convert point occurrence data into range-wide continuous probability coverages (Guisan et al., 2013). Fish species were chosen for modeling and inclusion into the prioritization analyses on the basis of their potential inclusion in a revised list of Species of Greatest Conservation Need for the state (Appendix 5, Table 1), which is actively being developed as part of this grant deliverable. Museum specimen-vouchered occurrence data sources included the Fishes of Texas database as well as two studies (Hendrickson et al., 2010; Cohen et al., 2013) that compiled, reviewed and partially normalized existing aquatic resource occurrence data from the Global Biodiversity Information Facility (http://www.gbif.org/), FishNet2 (http://www.fishnet2.net/) and numerous other data sources. Selection criteria for inclusion of records into the analysis included restricting to those records with less than a five kilometer estimate on georeferenced locality. Environmental variables used in SDM construction (Appendix 5, Table 2) were selected in part based on expert evaluation of models created from subsets of variables for a set of species with well-known distributions (see Labay et al., 2011). Additional hydrologic-based variables (see Appendix 5, Table 2) were added from the newly released National Hydrography Dataset Plus Version 2 (NHDplus V2; http://www.horizon-systems.com/nhdplus/NHDPlusV2_home.php; assessed 5/15/2015). Climatic, hydrologic, and topographic variables were used to account for broad-scale physiological constraints as determinants of distribution (Graham and Hijmans, 2006), and a hydrology-based geographic variable controlled for historical zoogeography by categorically constraining predictions of species occurrence to watersheds from which they are documented. Hydrologic variables derived from the NHDplus V2 were converted to 30 arc-second grids using the NHDplus V2 catchment unit. Species distribution models were constructed using the maximum entropy algorithm encoded in the Maxent software package (Version 3.3.4; Phillips et al., 2006), with model construction and validation methods described in Labay and Hendrickson (2014). The extent used for SDM construction included NHDplusV2 data regions 11 (Ark-Red-White), 12 (Texas), and 13 (Rio Grande). Additionally, we employed a method to account for the survey sampling bias fishes in our study area. We constructed a bias file that approximates biases in survey data and procedures. This grid was created by using all available fish occurrence data for our study region, and represents relative survey effort across the landscape. This bias file is used by the modeling software to create a similarly biased set of background, or pseudo-absence, occurrence points for model training, and avoids comparing presence data with habitat greatly outside of a species' known conditions. Elith et al. (2011) and Phillips et al. (2009) explain, in detail, implications of sample bias and application of bias grids within the Maxent modeling software.

Information from SDMs were restricted to the political boundary of Texas for assessment analyses and all spatial data analyses were conducted at a 30-arc-second (1 km^2 at the equator) grid resolution. Individual species models in GIS-ready formats can be download via the Fishes of Texas model download portal (http://www.fishesoftexas.org/models/). Additionally details regarding model production methodology is also available there.

3. Prioritization assessment for SGCN fishes in Texas

For spatial prioritization of core habitat for SGCN fishes in Texas we use the planning software Zonation (Moilanen et al., 2005). The primary function of the software is to produce a landscape ranking based on conservation value defined by spatially explicit levels of species, habitat, or ecosystem occurrence. It does

this in our case by initially considering the entire landscape being analyzed and iteratively removing spatial grid cells that result in the smallest loss of conservation value, as defined by SDM estimation of relative probability of occurrence. Zonation allows alternative implementation of the cell removal process and what type of conservation value it emphasizes. The removal rule used in this study is one that emphasizes species rarity (Core-Area Zonation, CAZ; Moilanen et al., 2005), which aims to identify 'core' priority landscapes for each species regardless of overall species richness. In other words, the CAZ approach can potentially consider two streams equally important even if one contains substantially more priority species. The intent with the CAZ approach is to identify the set of core areas most relevant for conservation of all priority species.

Utilizing various Zonation features to 'direct' the cell removal process we produced a series of analyses to provide differing conservation area perspectives. After species distribution models were produced, a primary prioritization referred to as CAZ + S + C, utilized the core area removal process and incorporated species-specific weighting, connectivity constraints, ecological groupings, and a stream connectivity condition factor to produce the landscape rankings depicted in Figure 2. See Labay and Hendrickson (2014) for methods regarding each step in the analysis sequence.

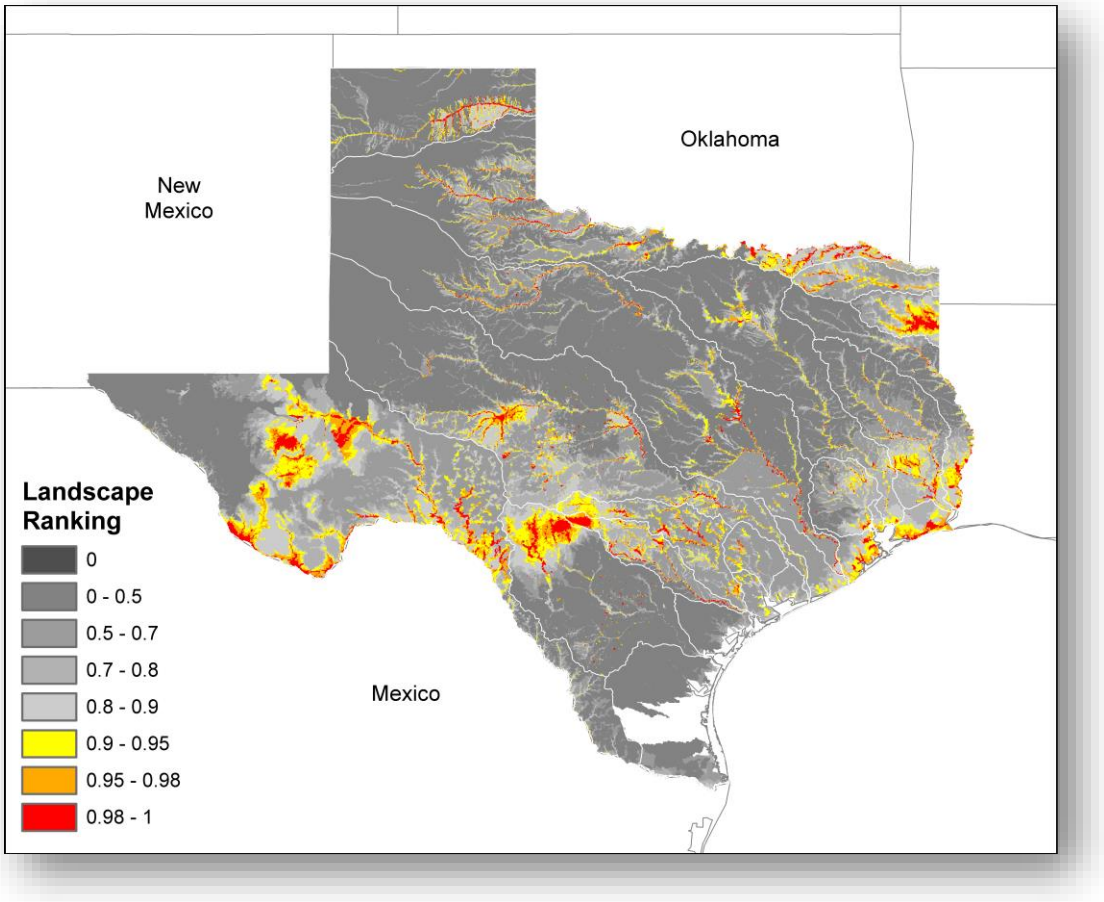


Figure 2. Primary prioritization with core-area function zonation analysis, species-specific rankings, connectivity constraints, ecological groupings and stream connectivity condition factor (CAZ + S + C) for the 70 Species of Greatest Conservation Need in Texas used in the prioritization analysis.

4. Native Fish Conservation Areas

Zonation allows for the identification of distinct species-based geographic units (here called NFCAs) based on the distance and compositional similarity between priority areas. This is done using four user-specified parameters: i.) percentage of the landscape to consider for inclusion in the management units, ii.) minimum inclusion top fraction for each unit (what top fraction must be present in each separate unit), iii.) a maximum distance between units, and iv.) a maximum difference in compositional similarity between units. To identify NFCAs for Texas streams we used the "CAZ + S + C" primary prioritization (Figure 2) as the starting point and chose i.) to consider the top 10% of the landscape ranking, ii.) a minimum inclusion of the top 2% (meaning each unit had to contain a portion of the top 2% of the ranking), iii.) 25 grid cells (approximately 20 kilometers) for the maximum distance allowed between spatially discrete patches that are included in the same management unit, and iv.) a maximum difference in species composition so that two units were determined different if 2 species out of ten (20%) had a 1-log difference in their probability density (SDM value) between the two areas (Figure 3). This initial result of NFCAs for Texas is to be considered preliminary in that it now requires expert opinion to group and adjust the area designations in ways that are more logical in either an administrative, geographic, or hydrologic sense. For example, the San Gabriel River, a tributary of the Brazos watershed is grouped into the NFCA along with the lower Guadalupe and Colorado Rivers. There might be sufficient reason to group the San Gabriel along with the neighboring NFCA of the Lower Brazos River.

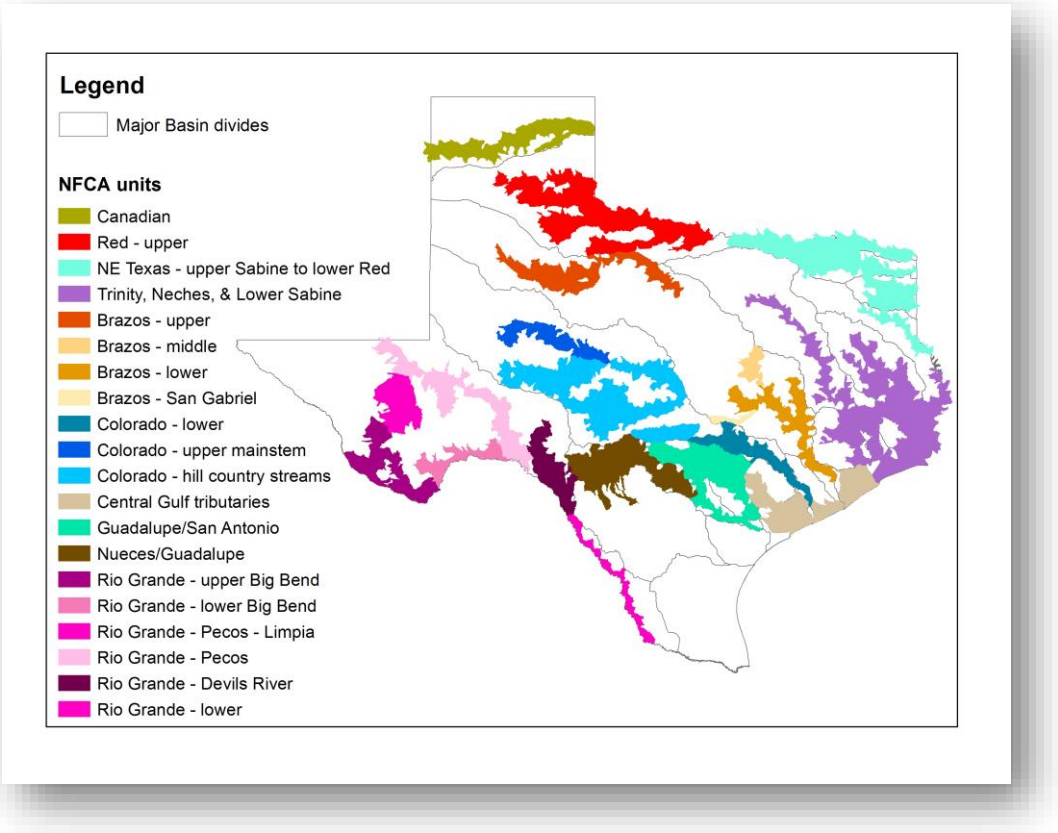


Figure 3. Broad-scale Native Fish Conservation Areas (NFCAs) identified according to distance and compositional similarity among highly ranked regions of the CAZ + S + C analysis (Figure 2). NFCA units are depicted as groupings of 12-digit Hydrologic Units (HUCs)

Activity 3. Develop Monitoring and Conservation Plans for Native Fish Conservation Areas

Year 1 Outcomes

1. Monitoring and conservation plans for Native Fish Conservation Areas

Conservation activities and monitoring guidelines were developed for the previously identified NFCAs in the southern Great Plains (Canadian, upper Red and upper Brazos), Edwards Plateau (Colorado - hill country streams, Guadalupe/San Antonio and Nueces/Medina), and Chihuahuan Desert (Rio Grande – Big Bend, Rio Grande – Pecos and Rio Grande – Devils) ecoregions. These activities and guidelines were constructed to help identify threats and limiting factors as well as directly benefit focal species and the water quality, water quantity and habitats they depend upon. Focal species are defined as those that are indicators of habitat quality and/or in need of conservation actions.Each plan contains i) a brief description of the ecoregion, ii) a summary of conservation and monitoring objectives, iii) a checklist of species found in each NFCA and iv) a brief species account for each of the focal species. The plans are designed to aid TPWD staff in establishing conservation, restoration and monitoring protocols as well as developing constituent groups and examples of conservation management practices. Ideally each plan will evolve as more information is obtained, approaches are refined and objectives are achieved.

Great Plains

Monitoring and conservation plans for NFCAs in this region are described in Appendix 2 - Conservation Plans for Great Plains NFCAs

Edwards Plateau

Monitoring and conservation plans for NFCAs in this region are described in Appendix 3 - Conservation Plans for Edwards Plateau NFCAs

Chihuahuan Desert

Monitoring and conservation plans for NFCAs in this region are described in Appendix 4 - Conservation Plans for Chihuahuan Desert NFCAs

Activity 4. Conduct Field-Based Surveys Detailed Biodiversity Assessments (i.e. Bioblitzing), and Citizen-Based Monitoring

For year one of the project, three focal watersheds were selected from within the above identified NFCAs to conduct three-part biological assessments. The three watersheds surveyed are as follows: Frio and Dry Frio River near the border of Uvalde and Real County (Figure 4), Big Cypress Bayou from above Caddo Lake to Lake O' the Pines (Figure 5), and Village Creek watershed, a tributary of the Neches River (Figure 6). Within each of these watersheds, one site was chosen for bioassessment and citizen-based data collection (except in the case of the Big Cypress Bayou for which 4 sites were chosen). We attempted to inlude the public and parties with vested interest for the bioassessment sites. At these sites we employed SVAP methodology (see Task 4.2 for details) to describe to describe and assess the condition of the stream and riparian area and collected fish. In additional goal was to include local citizens as much possible engaging them with iNaturalist to record photographic observations suitable for scientific research. Our hope was that they might continue to record observations after the events. Our most successful of these events was the Village Creek State Park Bioblitz (http://www.inaturalist.org/projects/village-creek-bioblitz). That project now has 1,055 observations, 218 species and 24 people contributing. We sampled many other sites ("supplemental sites") for fishes with the primary intent being to fill in spatial and temporal data gaps in the Fishes of Texas database. For these sites we had the sole goal of sampling for fish diversity and recorded little other environmental data. The method ensures sampling many sites with many gear types. In addition to whole fish specimens, we collected tissues on occasion and herpetological specimens when easily collected. Both herp and fish specimens (including tissues) were deposited in the TNHC where they will be permamently archived so that researchers can verify our identifications and perform continued research on those specimens well into the future. TPWD Rivers Study Staff took the lion's share of responsibility for organizing these sampling events and also wrote (or is writing) summary reports for each of these events, but we provide basic summary information here.

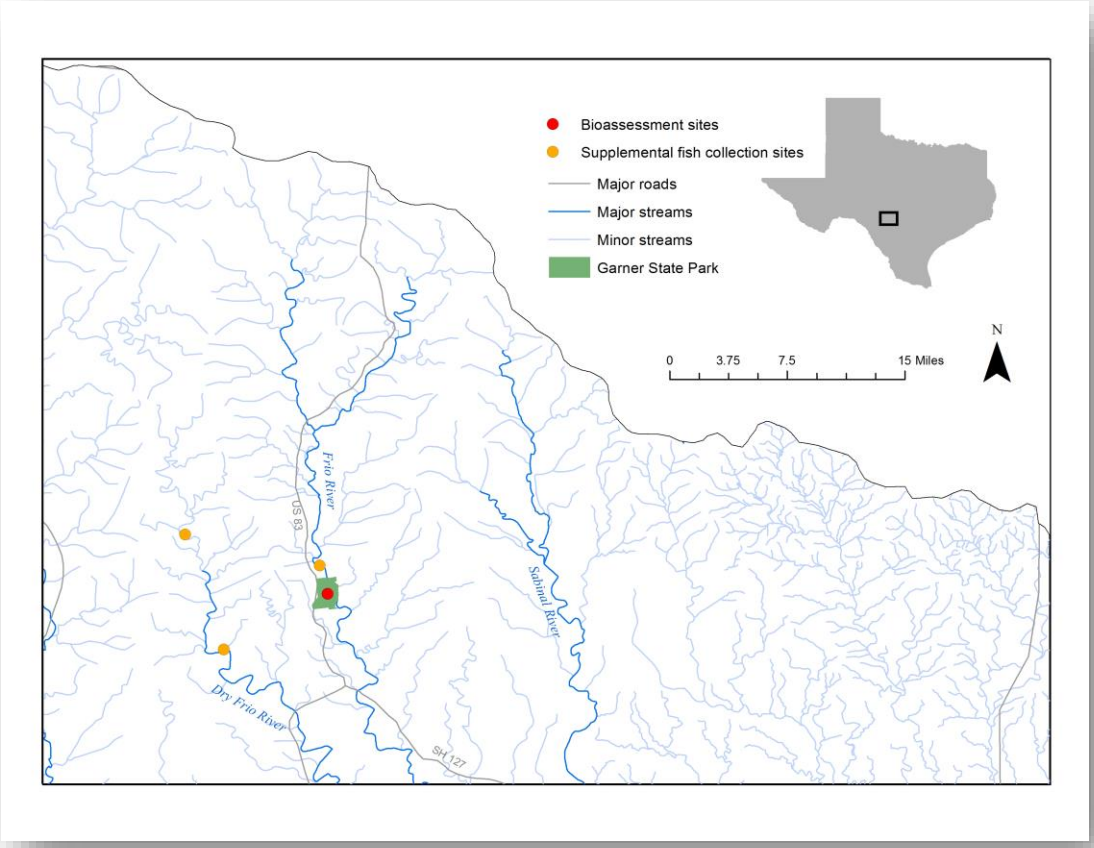


Figure 4 Upper Frio River survey map

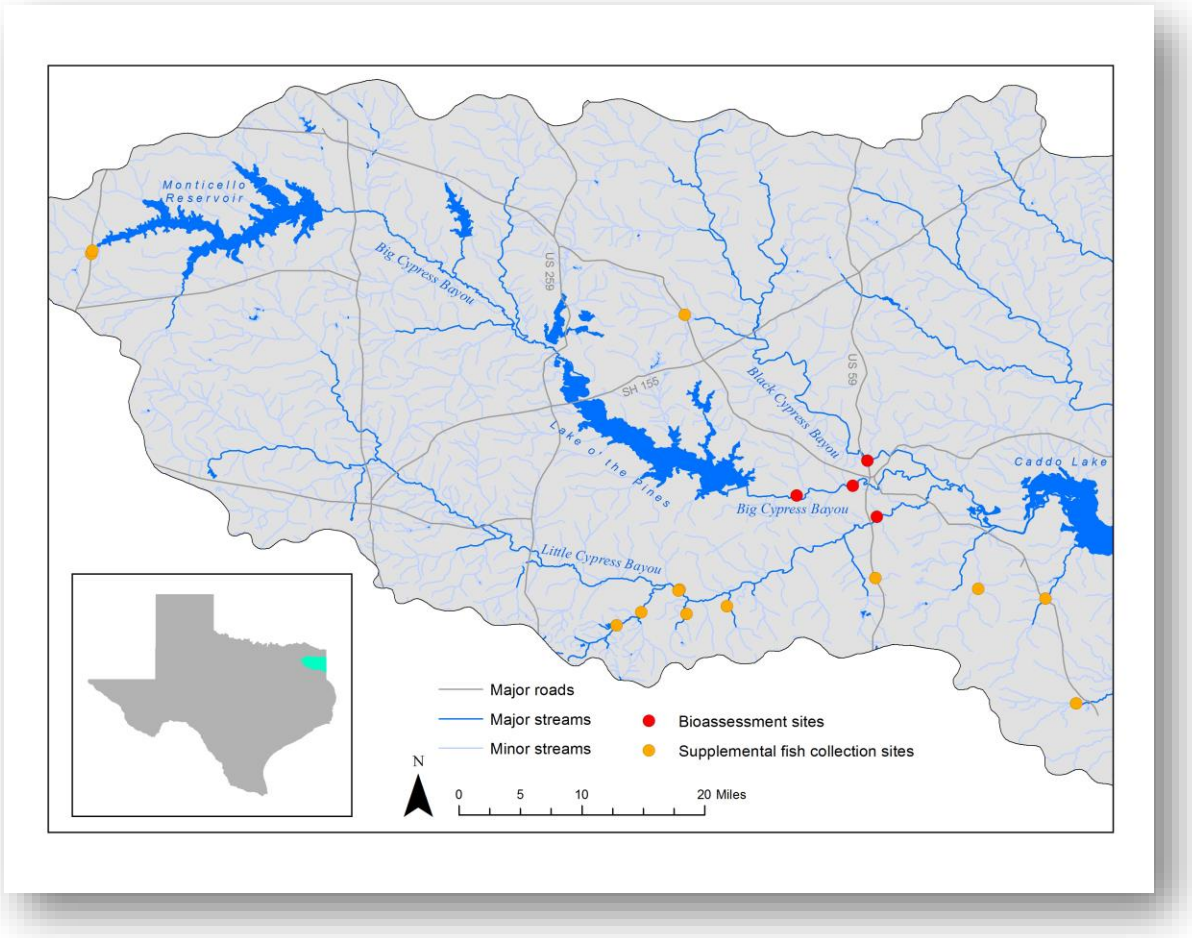


Figure 5. Big Cypress basin survey map

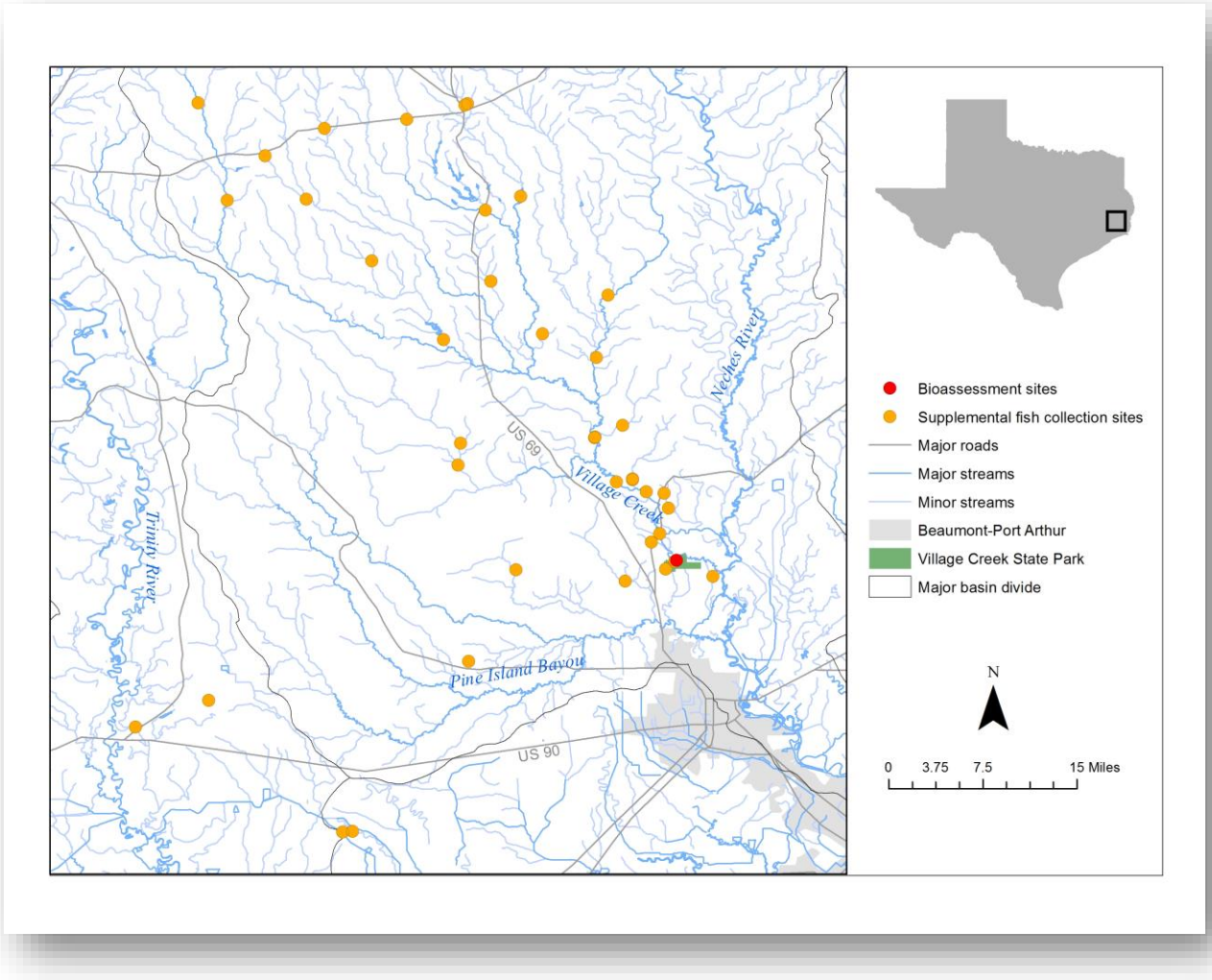


Figure 6 Village Creek basin survey map

Year 1 Outcomes

4.1. Field-Based Surveys

Fish sampling in under-sampled areas indicated by FoTX database analyses

Upper Frio River Basin

On May 16, 2014 the first survey, by Texas Natural History Collections, Ichthyology Collection staff and Texas Parks and Wildlife River Studies division, took place at four locations in the upper Frio River Basin. Two sites were on the main Frio River and two on the Dry Frio (Figure 4). A total of 1386 specimens, representing 17 species were documented and collected. Sampling included seining, backpack electroshocking, frame netting, and boat shocking. Voucher specimens of all fish species were collected by both University of Texas and TPWD staff for identification, analysis, and deposition into our institutional research collection (TNHC - https://integrativebio.utexas.edu/biodiversity-collections/ collections/ichthyology-fish). Specimens collected at the 3 supplemental collection sites (i.e. non-bioblitz sites) have been processed and catalogued into the museum database and those data are available in

Appendix 6 – Field Based Survey Data. Specimens from the main bioblitz site (Frio River at Garner State Park) went with TPWD personnel and will eventually come to the museum for cataloguing and permanent storage, and those data are not provided in Appendix 6. All records will be made available via the Fishes of Texas Project's online database, as well as other major online biodiversity information providers (GBIF - http://www.gbif.org, VertNet - http://www.vertnet.org, Fishnet2 – www.fishnet2.net).

Big Cypress Basin

Survey work for the Big Cypress Basin was split between two trips in September and October, 2014. A total of 18 sites were sampled (4 bioblitz sites and 14 supplemental fish collection sites, Figure 5), yielding 3541 specimens representing 57 species. An emphasis was placed Big Cypress Bayou between Caddo Lake and Lake O' the Pines. Within this segment, 10 supplemental fish collection sites and all four bioblitz events were carried out. Some of the basis for narrowing the scope of the survey area was to serve an additional objective of providing data to the Caddo Lake Institute for their Cypress Basin Flows Project (http://www.caddolakeinstitute.us/flows.html). We note that two of the supplemental collection sites (Harrison Bayou and Paw Paw Bayou) are not part of the Big Cypress watershed proper, but serve to fill data gaps in fish collections for the greater river basin. Sampling included seining, backpack electroshocking, boat shocking, frame netting, and gill nets. As with the previous survey, voucher specimens were documented and collected by both TNHC and TPWD personnel. Specimens from 2 bioblitz sites (Black Cypress Bayou at US 59 and Little Cypress Bayou at US 59) and 13 supplemental fish collection sites have been catalogued into the TNHC database and can be viewed in Appendix 6. Specimens from the remaining 3 sites, 2 bioblitz locations (Big Cypress at Sanders Ranch and Big Cypress at French Creek) and one supplemental collection site, are currently with TPWD River Studies biologists and will later be deposited in the UT TNHC Fish Collection.

Village Creek Basin

This most recent survey was also our most effort intensive since it covered the entirety of the Village Creek watershed. We performed fieldwork over 3 trips in May, July, and August of this year. A total of 41 sites were sampled between the three, 3-day trips (Figure 6). Specimens from the first trip, May 1-3, have been processed and catalogued into our own TNHC Fish Collection.

Appendix 6 – Field Based Survey Data. All specimens from the latter 2 trips are currently being examined and housed at TNHC, with the exception of specimens from the bioassessment event (Village Creek at Village Creek State Park, August 4), which were split between TNHC and TPWD. Seven sites sampled were outside the Village Creek watershed, but either filled holes in data gaps for the greater Neches basin or were targeted collections in search of *Heterandria formosa,* a species apparently expanding its range in Texas which we are attempting to define. This diminutive species was collected from an unnamed roadside ditch at Sour Lake, (Figure 6), adding a new county record and extending the known range of the species approximately 30 km to the north and into the Neches Basin. Our efforts to find the species in the Trinity basin proved unfruitful. Sampling gears for all trips included seining, backpack electroshocking, gill netting, dip netting, frame netting, trot lines, and boat shocking. As with all three field surveys, records will be made available via the Fishes of Texas Project and other major online biodiversity information providers (GBIF - http://www.gbif.org, VertNet - http://www.vertnet.org, Fishnet2 – www.fishnet2.net).

4.2. Detailed Biodiversity Assessments (i.e., Bioblitzing)

In addition to general fish collection, at least one site from each selected watershed (4 for the Big Cypress) was singled out for a comprehensive biodiversity assessment or 'bioblitz'. Additional data collected for these sites includes the following:

- A visual riparian and instream habitat assessment performed using the USDA Natural Resource Conservation Service's (NRCS) Stream Visual Assessment Protocol (SVAP; Bjorkland et al. 2001) as modified by TPWD personnel for Texas Streams (Tom Heger, personal communication). In addition to fulfilling basic rapid bioassessment criteria, the SVAP protocol was chosen to provide opportunities to inform/influence NRCS land conservation priorities through communication of SVAP scores and identification of specific conservation needs of priority stream segments.
- Water quality assessment performed by the collection of temperature, specific conductance, dissolved oxygen, and pH using a YSI multiparameter water quality sonde (data following TCEQ QA/QC procedures; TCEQ 2007).
- Fish surveys following TCEQ protocol (TCEQ 2007), which includes use of backpack electrofishing, seining, and boat electrofishing. For large fish, total lengths will be recorded and
- A voucher photograph taken before release. All other fish captured will be preserved in 10% formalin and taken to the TNHC for enumeration, species identification, and further curation. Once all fish are identified, a regional index of biotic integrity will be calculated (Linam et al. 2002).
- Mussels surveys using timed snorkeling in multiple mesohabitat types following Strayer and Smith (2003).

Bioblitz within the Nueces River headwaters

The first bioblitz occurred on May 16, 2015 at the segment of the Frio River that runs through Garner State Park (Figure 4). Participants included members of TPWD's Inland Fisheries Division, TNHC, The Nature Conservancy, Garner State Park staff, and private citizens. Of the six species classified as Fishes of Greatest Conservation need for the Nueces River headwaters, four were observed (*Cyprinella lepida*, *Dionda serena*, *Ictalurus lupus*, and *Notropis amabilis*). Overall, bioassessment work indicates a high quality functioning ecosystem and aquatic life use, as well as, a diverse fish assemblage. Additional findings and conservation management recommendations are detailed in the TPWD River Studies report Upper Frio River Basin Bioassessment: Dry Frio and Frio Rivers in Real and Uvalde Counties, Texas (https://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_t3200_1809.pdf). Observations for the event can also be viewed at http://www.inaturalist.org/projects/garner-state-park-frio-river-bioblitz.

Bioblitz within the Big Cypress Creek basin

For the Big Cypress Bayou bioblitz, four different sites were chosen for bioassessment work in an effort to provide more comprehensive data to examine the effects of a recently deployed 5-year flow agreement aimed at reinstating native fish assemblage. In addition to TNHC and TWPD Inland Fisheries teams, Dr.s' Lance Williams and Neil Ford (UT Tyler), the Nature Conservancy, local TPWD biologists, UT Tyler students, private citizens, and Joe Trungale, a private consultant working with the Cypress Basin Flows Project, participated in the events. Of the seven Fishes of Greatest Conservation Need for the area, one species was observed at 2 of the bioblitz sites (*Percina maculata*). However, 2 additional SGCN species were observed within the basin at supplemental collection sites (*Notropis atrocaudalis* and *Erimyzon*

claviformes). A report for Big Cypress Bayou is in development and will be released in the near future. Observations from the bioblitz events can be viewed at: http://www.inaturalist.org/projects/cypress-creek-drainage-in-texas-bioblitz-fall-2014.

Bioblitz within the Village Creek basin

The most recent bioblitz was conducted at Village Creek State Park and split between 2 events. A public event, in collaboration with TPWD's River Studies and Wildlife Diversity biologists, University of Houston – Clear Lake, local area Master Naturalists, Village Creek SP staff, Big Thicket NPS, East Texas Herpetological Society, and the Native Plant Society of Texas, occurred over a 3-day period from May 1-3, documenting all taxa for the area. Observations from the event can be viewed at: http://www.inaturalist.org/projects/village-creek-bioblitz. Fish collection for the public event was limited due restrictions from flooding in the area. The bioassessment event was conducted on August 4th and was a collaborative effort by TPWD Inland Fisheries, TNHC, Village Creek SP, Big Thicket NPS, and University of Houston – Clear Lake. Specimens are still in process. Observations from the bioassessment event can be viewed at the Fishes of Texas iNaturalist Project: http://www.inaturalist.org/projects/fishes-of-texas.

4.3 Citizen-Based Monitoring

Develop guidelines and best practices for citizen-based monitoring to ensure that data are provided in a format that supports species identification, scientists trained to use iNaturalist and in fish ID.

One of the primary goals of using iNaturalist to collect biodiversity occurrence data is to educate TPWD personnel, volunteers, collaborators, and partners about iNaturalist as a tool to quickly add valuable observational data into TPWD-associated iNaturalist projects such as, Fishes of Texas, Herps of Texas, Mammals of Texas, or to the scientific community in general. The flyer that was distributed to publicize this event (Figure 8) serves as a guideline to sharing observations via iNaturalist and provides information that facilitates bioblitz events:

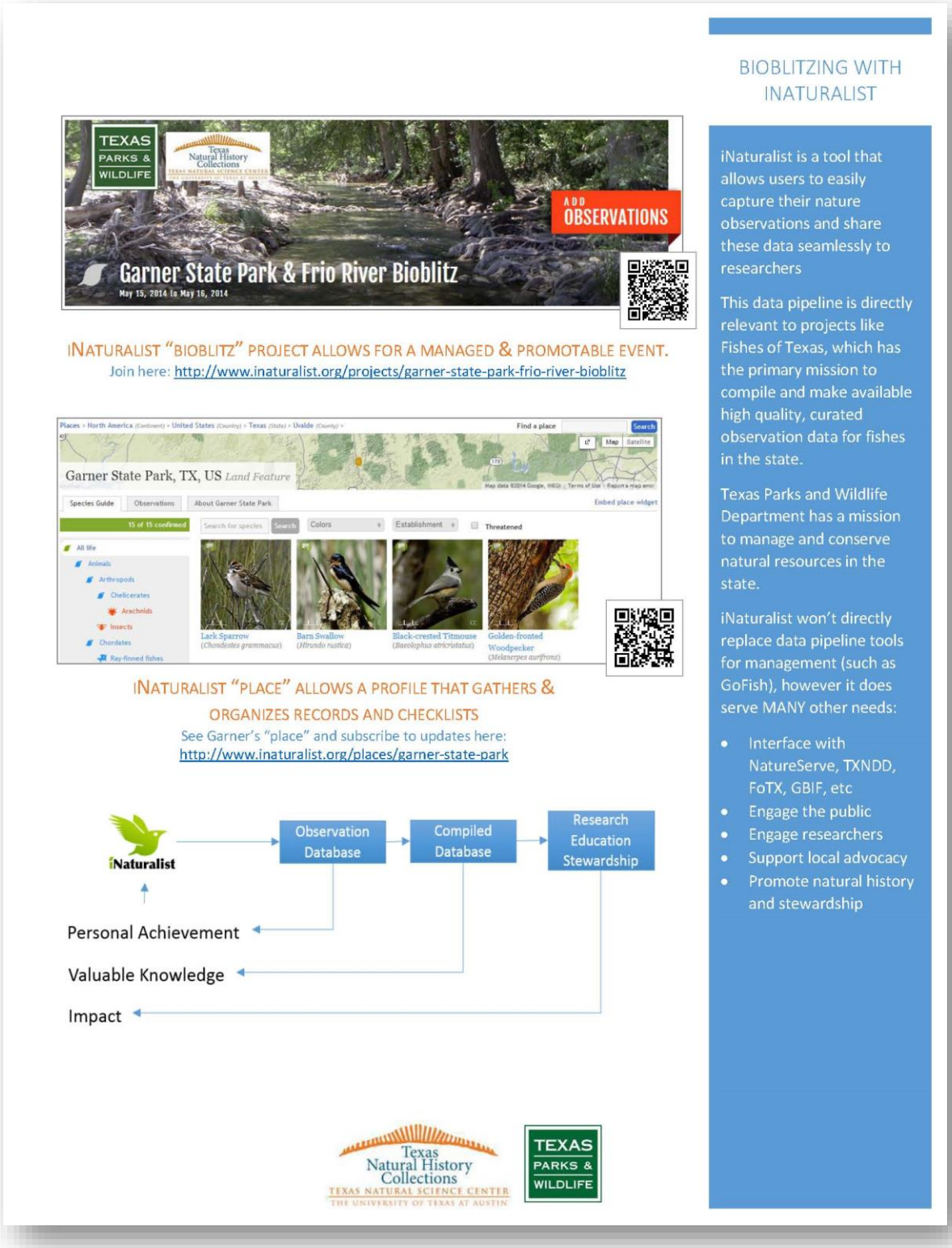


Figure 7 Flyer produced for this project and distributed within (and beyond) TPWD offices statewide to promote broader use of organized bioblitzes and use of iNaturalist to capture and share occurrence observations

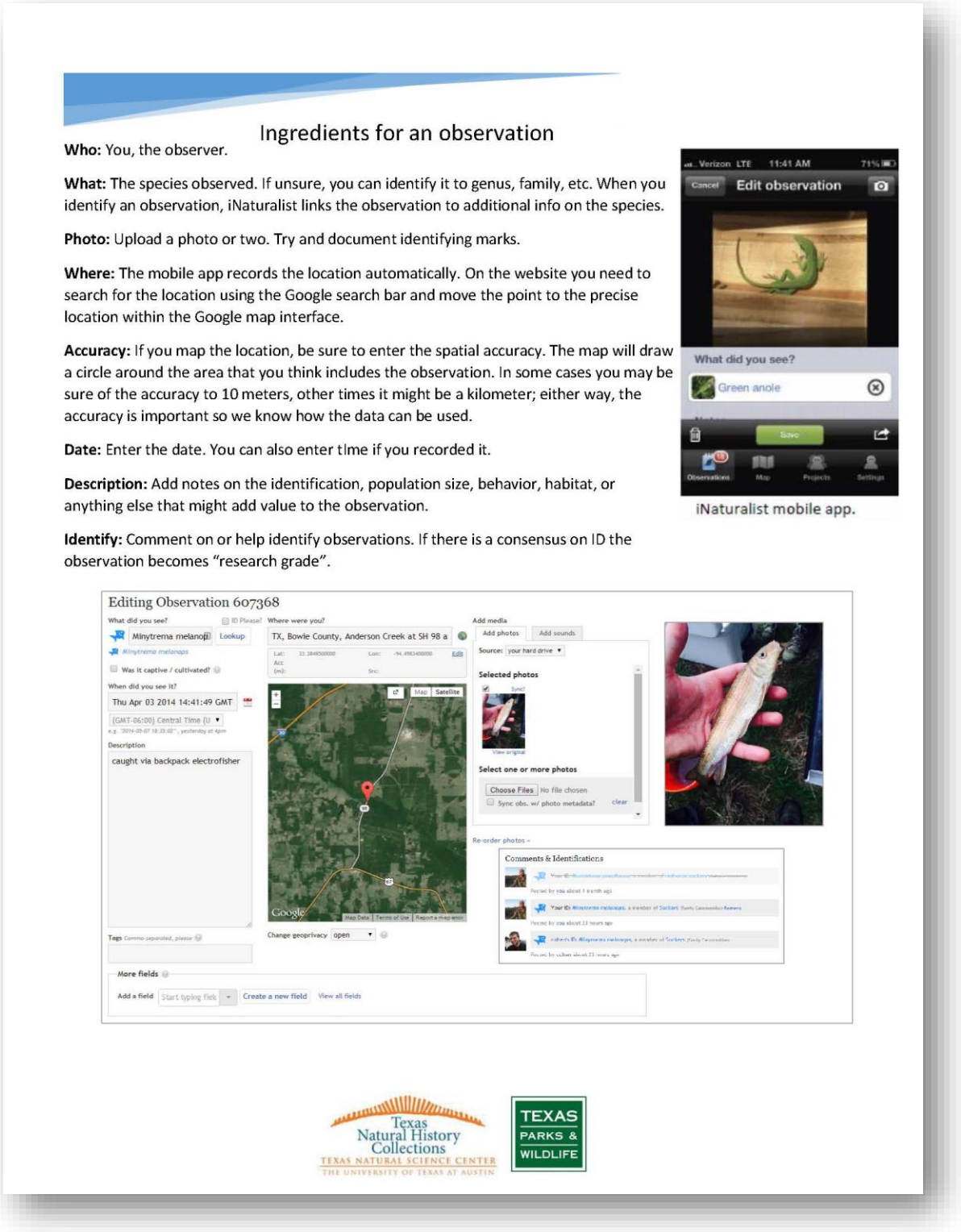


Figure 8 Flyer produced for this project and distributed within (and beyond) TPWD offices statewide to provide basic instructions for recording occurrence observation data in iNaturalist to help improve data quality

Promote citizen-based monitoring via iNaturalist forums, expert workshops, Master Naturalists, etc.

For promotion of citizen-science monitoring via iNaturalist, Fishes of Texas teamed up with TPWD's Wildlife Diversity Program staff, who have established a well-rooted working relationship with the public through their various outreach programs. More specifically we worked closely with Cullen Hanks, a TPWD Wildlife Diversity Biologist, who has been working with the naturalist community on using iNaturalist through the team's Texas Nature Trackers Program. The program includes coverage of a range of target taxa iNaturalist projects (ex: Herps of Texas, Mammals of Texas) to which the Fishes of Texas Project has been added. Our first official collaborative event with Wildlife Diversity, occurred at the Village Creek Bioblitz. Various local naturalist groups, such as Master Naturalist chapters, were in attendance and joined us as co-sponsors for the event (see Figure 9 for complete list of sponsors from this one event). All of this project's bioblitzes were widely publicized by TPWD and others, all linking to our event pages in iNaturalist.

Promotion of iNaturalist has become a routine part of any field work where other organizations or groups are involved. Some examples include TPWD meetings, collections with University of Texas Vertebrate Natural History classes, Austin Youth River Watch field events, and assistance in student research collections. Most recently, we have participated in local area Texas Amphibian Watch groups.

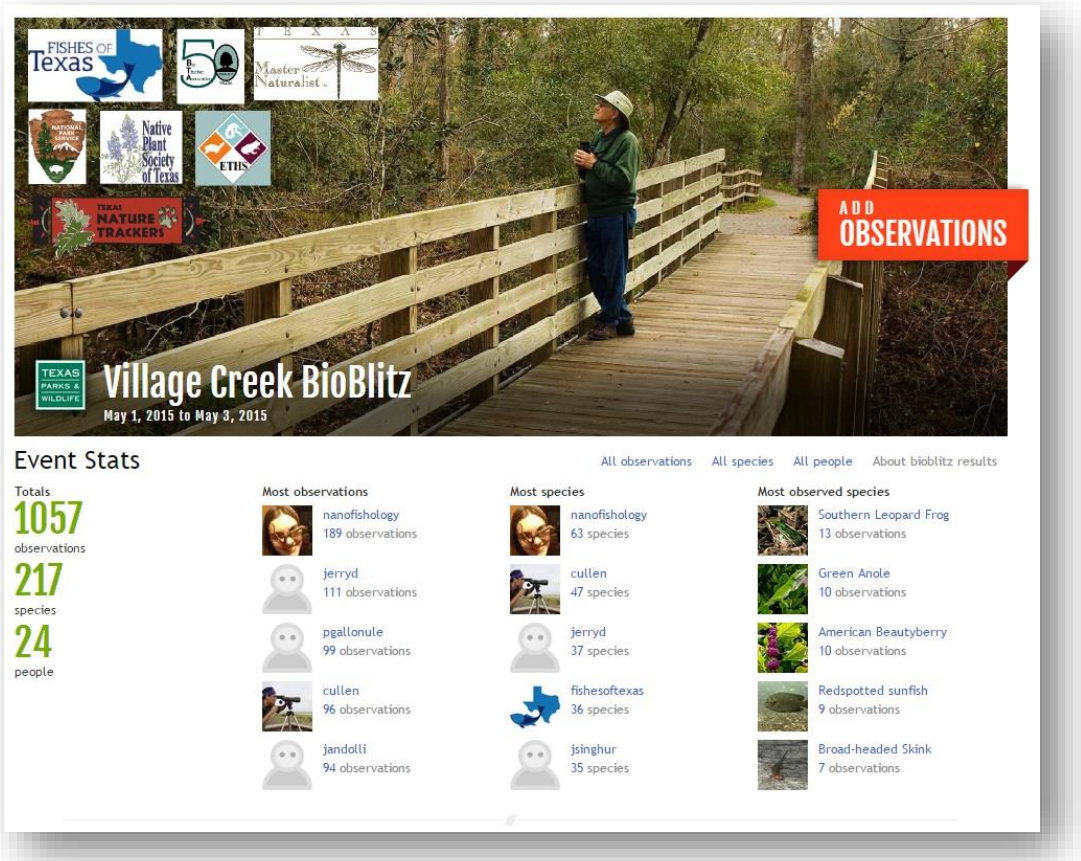
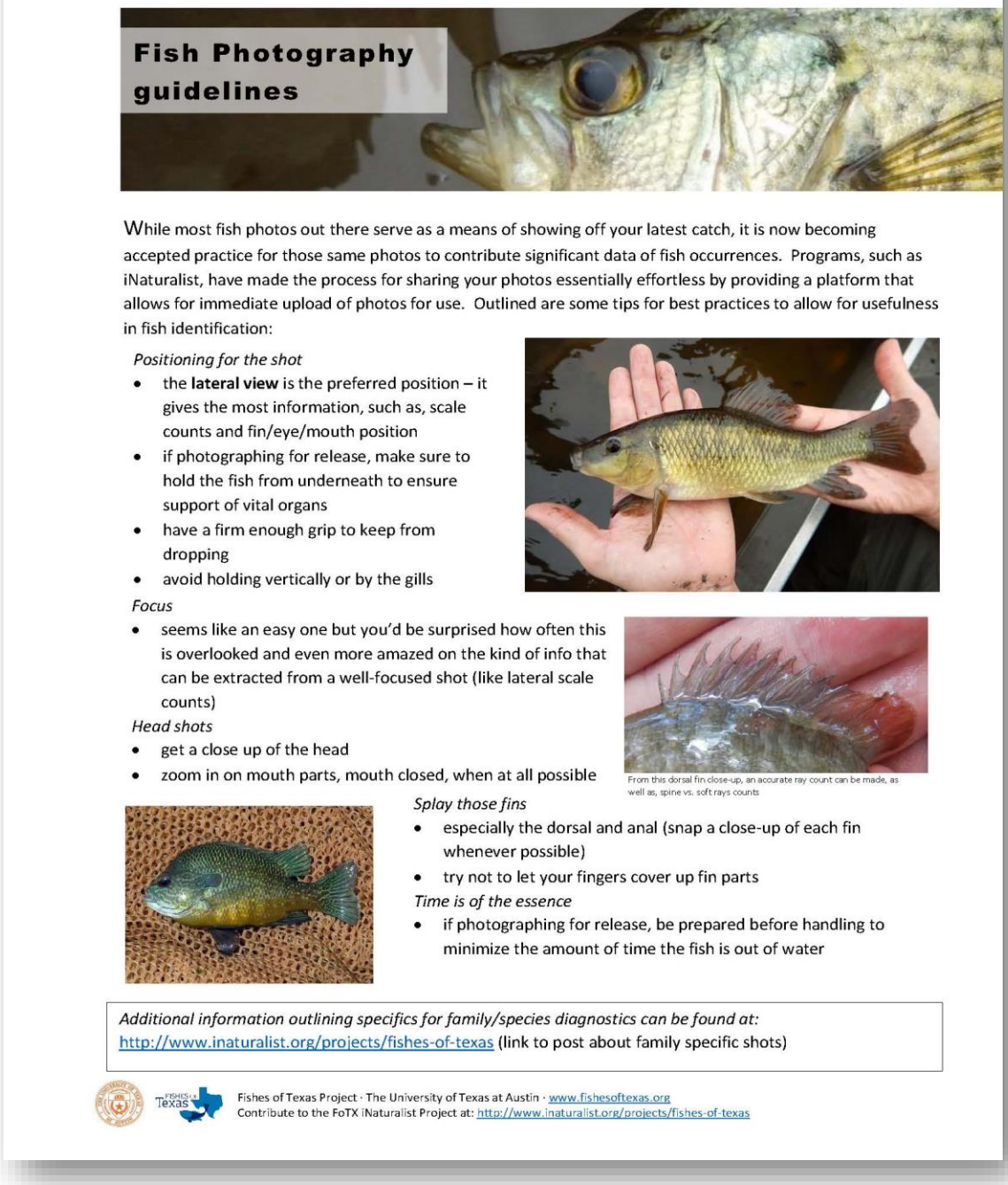


Figure 9 iNaturalist Village Creek Bioblitz event page

Develop a fact sheet with guidance on processing photographic observations into iNaturalist.

Guidelines and proper handling tips for photographing fish observations and uploading observations to iNaturalist were broadly disseminated via a flyer (Figure 10). More detailed information with details for identifying specimens to families was posted to the Fishes of Texas iNaturalist project's journal (http://www.inaturalist.org/projects/village-creek-bioblitz/journal).



Fish Photography guidelines

While most fish photos out there serve as a means of showing off your latest catch, it is now becoming accepted practice for those same photos to contribute significant data of fish occurrences. Programs, such as iNaturalist, have made the process for sharing your photos essentially effortless by providing a platform that allows for immediate upload of photos for use. Outlined are some tips for best practices to allow for usefulness in fish identification:

Positioning for the shot

- the **lateral view** is the preferred position – it gives the most information, such as, scale counts and fin/eye/mouth position
- if photographing for release, make sure to hold the fish from underneath to ensure support of vital organs
- have a firm enough grip to keep from dropping
- avoid holding vertically or by the gills

Focus

- seems like an easy one but you'd be surprised how often this is overlooked and even more amazed on the kind of info that can be extracted from a well-focused shot (like lateral scale counts)

Head shots

- get a close up of the head
- zoom in on mouth parts, mouth closed, when at all possible

From this dorsal fin close-up, an accurate ray count can be made, as well as, spine vs. soft rays counts

Splay those fins

- especially the dorsal and anal (snap a close-up of each fin whenever possible)
- try not to let your fingers cover up fin parts

Time is of the essence

- if photographing for release, be prepared before handling to minimize the amount of time the fish is out of water

Additional information outlining specifics for family/species diagnostics can be found at:
http://www.inaturalist.org/projects/fishes-of-texas (link to post about family specific shots)

Fishes of Texas Project · The University of Texas at Austin · www.fishesoftexas.org
Contribute to the FoTX iNaturalist Project at: http://www.inaturalist.org/projects/fishes-of-texas

Figure 10 Flyer describing best practices for proper photographic observations that facilitate accurate specimen identification.

Provide identification verification and other recommendations on data provided through online collaboration with iNaturalist users

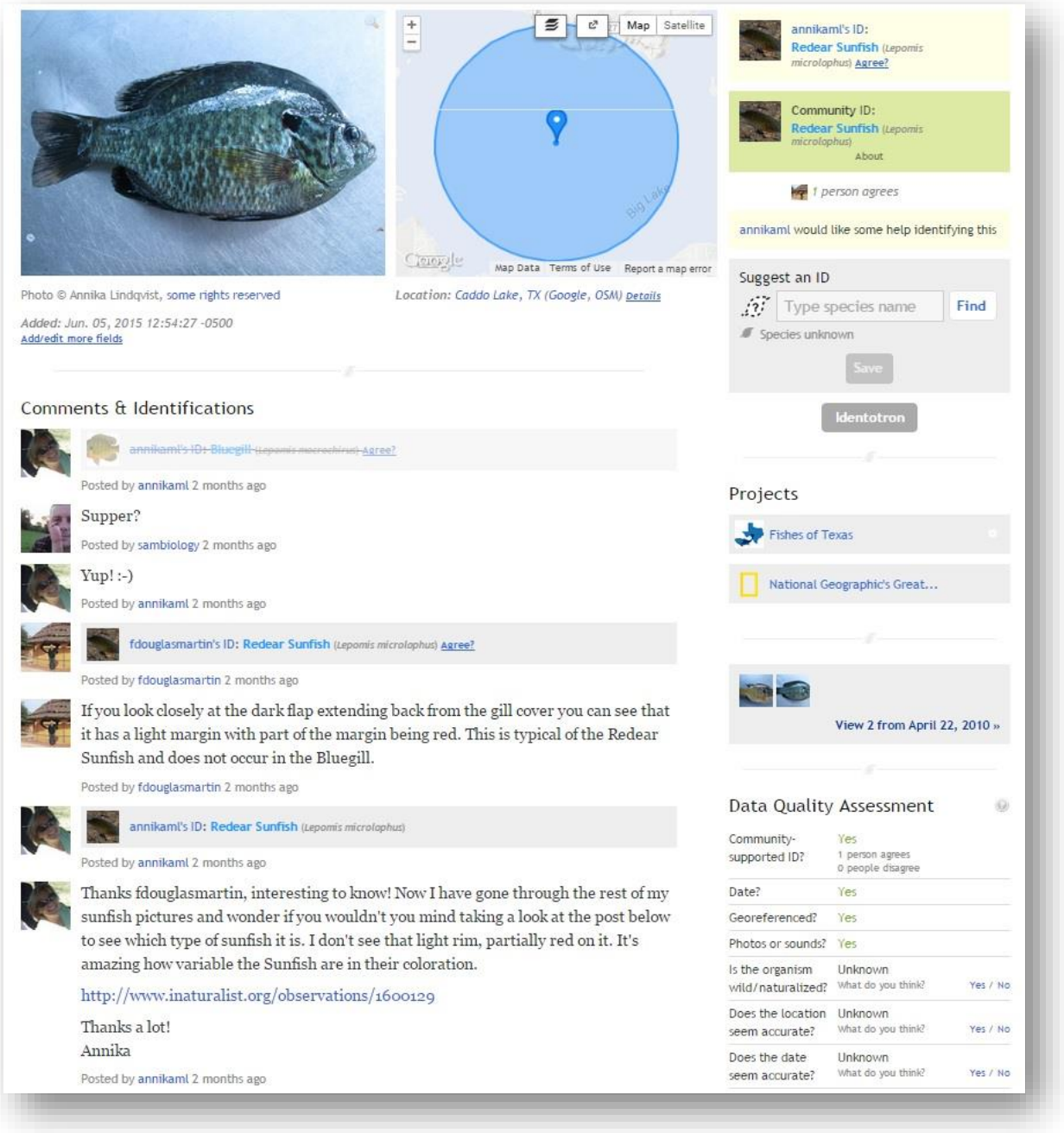


Figure 11 Example of inter-actions between FoTX staff (Dr. F. Douglas Martin) and site users regarding identifications.

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Appendix 1 - Species of Greatest Conservation Need – updated

All content of this Appendix is also available in the attached Excel spreadsheet – SGCN_fishes_appendix1.xlsx

KEY TO CODES

	included in both current and past SGCN versions
	name changes, suggested additions (marked with a check), recommended deletions (X)
✓	included in SGCN list
X	removal from SGCN list recommended
red font	extirpated/extinct

LISTING STATUS

E	Endangered (USFWS)
Extinct	Presumed globally extinct
Extirpated	Presumed extirpated from Texas
sT	State Threatened
T	Threatened (USFWS)

CONSERVATION NEEDS

1	Establish, improve and maintain riparian zones
2	Improve or maintain water quality
3	Improve or maintain watershed connectivity
4	Improve or maintain appropriate hydrologic conditions for the support of biota in aquatic systems
5	Establish, improve or maintain appropriate sediment flows
6	Maintain and restore physical habitat in freshwater systems
7	Restore or improve ecological balance in habitats negatively affected by nonindigenous invasive or problem species
8	Conserve, restore, and create coastal estuarine and marine habitats

ECOREGION

CHIH	CHIHUAHUAN DESERT
CGPL	CENTRAL GREAT PLAINS
CRTB	CROSS TIMBERS

ECPL	EAST CENTRAL TEXAS PLAINS
EDPT	EDWARDS PLATEAU
GCPM	GULF COAST PRAIRIES AND MARSHES
HIPL	HIGH PLAINS
STPL	SOUTH TEXAS PLAINS
SWTB	SOUTHWEST TABLELANDS
TBPR	TEXAS BLACKLAND PRAIRIES
WGCP	WESTERN GULF COASTAL PLAINS

Texas native freshwater fishes	**new TCAP**	**2011 TCAP**	**2005 TWAP**	**listing status**	**justification**	**conservation needs**							
						1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Ichthyomyzon castaneus - Chestnut Lamprey		☐	☐										
Ichthyomyzon gagei - Southern Brook Lamprey		☐	☐										
Scaphirhynchus platorynchus - Shovelnose Sturgeon / esturión	✓	✓	✓	sT	flow alterations; habitat fragmentation		x	x	x	x	x		
Polyodon spathula - Paddlefish	✓	✓	✓	sT	abundance and range substantially reduced		x	x	x	x	x		
Atractosteus spatula - Alligator Gar / catán	✓	✓	☐		habitat loss; over-exploitation			x	x		x		
Lepisosteus oculatus - Spotted Gar / catán pinto		☐	☐										
Lepisosteus osseus - Longnose Gar / catán aguja		☐	☐										
Lepisosteus platostomus - Shortnose Gar		☐	☐										
Amia calva - Bowfin		☐	☐										

Hiodon alosoides - Goldeye	✓	✓	✓		loss of natural flow regime; habitat fragmentation; loss of habitat			x	x		x		
Anguilla rostrata - American Eel / anguila americana	✓	✓	✓		catadromous; dams impede migration; habitat loss	x		x	x		x		
Dorosoma cepedianum - Gizzard Shad / sardina molleja		□	□										
Dorosoma petenense - Threadfin Shad / sardina maya		□	□										
Campostoma anomalum - Central Stoneroller / rodapiedras del centro		□	□										
Campostoma ornatum - Mexican Stoneroller / rodapiedras mexicano	✓	✓	✓	sT	loss of natural flow regime; reduced stream flow; competition with introduced Plains Killifish		x		x	x	x	x	
Campostoma spadiceum - Highland Stoneroller	✓	□	□		rare and restricted range in US & Texas		x		x	x	x	x	
Cyprinella lepida - Plateau Shiner	✓	✓	✓		reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Cyprinella sp. - Nueces River Shiner	✓	✓	✓		reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Cyprinella lutrensis - Red Shiner / carpita roja		□	□										
Cyprinella lutrensis blairi - Maravillas Red Shiner		□	□	Extinct									
Cyprinella proserpina - Proserpine Shiner / carpita del Norte	✓	✓	✓	sT	loss of natural flow regime		x	x	x		x		

Cyprinella venusta - Blacktail Shiner / carpita colinegra		□	□										
Dionda argentosa - Manantial Roundnose Minnow / carpa de manantial	✓	✓	✓		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda diaboli - Devils River Minnow / carpa diabla	✓	✓	✓	T	limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda episcopa - Roundnose Minnow / carpa obispa	✓	✓	✓		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda flavipinnis - (Guadalupe) Roundnose Minnow	✓	□	□		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda nigrotaeniata - (Medina) Roundnose Minnow	✓	✓	✓		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda serena - (Frio) Roundnose Minnow	✓	✓	✓		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda sp. 1 - (Conchos) Roundnose Minnow	✓	□	□		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda sp. 3 - (Colorado) Roundnose Minnow	✓	□	□		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Dionda texensis - (Nueces) Roundnose Minnow	✓	□	□		limited distribution; reduced spring flows; habitat fragmentation; habitat loss		x	x	x		x		
Gila pandora - Rio Grande Chub	✓	✓	✓	sT	limited distribution; reduced spring flows; habitat loss		x	x	x		x		

Hybognathus amarus - Rio Grande Silvery Minnow / carpa Chamizal	✓	✓	✓	E	loss of natural flow regime; reduced stream flow; habitat fragmentation; habitat loss; interactions with non-native species		x	x	x	x	x		
Hybognathus hayi - Cypress Minnow		□	□										
Hybognathus nuchalis - Mississippi Silvery Minnow	✓	□	□		flood-pulse broadcast spawner			x	x	x	x		
Hybognathus placitus - Plains Minnow	✓	□	□		flood-pulse broadcast spawner			x	x	x	x		
Hybopsis amnis - Pallid Shiner	✓	□	□		reductions in abundance and distribution		x	x	x	x	x		
Luxilus chrysocephalus - Striped Shiner	□	□	□										
Lythrurus fumeus - Ribbon Shiner	□	□	□										
Lythrurus umbratilis - Redfin Shiner	□	□	□										
Macrhybopsis aestivalis - Speckled Chub / carpa pecosa	✓	✓	✓		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Macrhybopsis australis - Prairie Chub	✓	✓	✓		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Macrhybopsis hyostoma - Shoal Chub	✓	□	□		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		

Macrhybopsis marconis - Burrhead Chub	✓	□	✓		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Macrhybopsis storeriana - Silver Chub	✓	✓	✓		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Macrhybopsis tetranema - Peppered Chub	✓	✓	✓		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notemigonus crysoleucas - Golden Shiner		□	□										
Notropis amabilis - Texas Shiner / carpita texana	X	✓	□		broad and stable distribution; no evidence of declines in abundance or range								
Notropis sp. West Texas Shiner	✓	□	□		newly described species; limited/uncertain distribution; habitat loss		x	x	x	x	x		
Notropis atherinoides - Emerald Shiner		□	□										
Notropis atrocaudalis - Blackspot Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss								
Notropis bairdi - Red River Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis blennius - River Shiner	✓	□	□		loss of natural flow regime; habitat fragmentation; habitat loss								

Notropis braytoni - Tamaulipas Shiner / carpita tamaulipeca	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis buccula - Smalleye Shiner	✓	✓	✓	E	loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis buchanani - Ghost Shiner / carpita fantasma		☐	☐										
Notropis chalybaeus - Ironcolor Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss; small disjunct population in the San Marcos River headwaters		x	x	x	x	x		
Notropis chihuahua - Chihuahua Shiner / carpita chihuahuense	✓	✓	✓	sT	loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis girardi - Arkansas River Shiner	✓	✓	✓	T	loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis jemezanus - Rio Grande Shiner / carpita del Bravo	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis maculatus - Taillight Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss								
Notropis orca - Phantom Shiner / carpita de El Paso		☐	☐	Extinct									
Notropis oxyrhynchus - Sharpnose Shiner	✓	✓	✓	E	loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		

Notropis potteri - Chub Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis sabinae - Sabine Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss; broadcast spawner that utilizes downstream drift hatching and dispersal		x	x	x	x	x		
Notropis shumardi - Silverband Shiner	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis simus pecosensis - Pecos Bluntnose Shiner	✓	✓	✓	sT	loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Notropis simus simus - Rio Grande Bluntnose Shiner / carpita chata		☐	☐	Extinct									
Notropis stramineus - Sand Shiner / carpita arenera		☐	☐										
Notropis texanus - Weed Shiner		☐	☐										
Notropis volucellus - Mimic Shiner		☐	☐										
Opsopoeodus emiliae - Pugnose minnow		☐	☐										
Phenacobius mirabilis - Suckermouth Minnow	✓	☐	☐		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Pimephales promelas - Fathead Minnow / carpita cabezona		☐	☐										

Pimephales vigilax - Bullhead Minnow / carpita cabeza de toro		□	□										
Platygobio gracilis - Flathead Chub / carpita cabeza plana	✓	□	□		flood-pulse broadcast spawner; loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Pteronotropis hubbsi - Bluehead Shiner	✓	✓	✓	sT	limited range; habitat losss	x	x	x	x	x	x		
Rhinichthys cataractae - Longnose Dace / carpita rinconera	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss		x	x	x	x	x		
Semotilus atromaculatus - Creek Chub		□	□										
Carpiodes carpio - River Carpsucker / matalote chato		□	□										
Carpiodes sp. 1	✓	□	□		undescribed species in Llano River; limited/unknown distribution		x	x	x	x	x		
Cycleptus elongatus - Blue Sucker / matalote azul	✓	✓	✓	sT	habitat loss; fragmentation; loss of natural flow regime; reduced water quality		x	x	x	x	x		
Cycleptus sp. - Rio Grande Blue Sucker	✓	✓	□		habitat loss; fragmentation; loss of natural flow regime; reduced water quality		x	x	x	x	x		
Erimyzon claviformis - Western Creek Chubsucker	✓	✓	✓	sT	previously *Erimyzon oblongus*; habitat loss; fragmentation; loss of natural flow regime; reduced water quality		x	x	x	x	x		
Erimyzon sucetta - Lake Chubsucker		□	□										

Ictiobus bubalus - Smallmouth Buffalo / matalote boquín		□	□										
Ictiobus cyprinellus - Bigmouth Buffalo		□	□										
Ictiobus niger - Black Buffalo / matalote negro		□	□										
Minytrema melanops - Spotted Sucker		□	□										
Moxostoma albidum - Longlip Jumprock / matalote blanco	✓	□	□		limited and uncertain distribution; habitat loss; fragmentation; loss of natural flow regime; reduced water quality		x	x	x	x	x		
Moxostoma austrinum - Mexican Redhorse / matalote chuime	✓	✓	✓		limited and uncertain distribution; habitat loss; fragmentation; loss of natural flow regime; reduced water quality		x	x	x	x	x		
Moxostoma congestum - Gray Redhorse / matalote gris		□	□										
Moxostoma erythrurum - Golden Redhorse		□	□										
Moxostoma poecilurum - Blacktail Redhorse		□	□										
Astyanax mexicanus - Mexican Tetra / sardinita mexicana		□	□										
Ameiurus melas - Black Bullhead / matalote negro		□	□										
Ameiurus natalis - Yellow Bullhead / bagre torito amarillo		□	□										

Ictalurus furcatus - Blue Catfish / bagre azul		☐	☐										
Ictalurus furcatus sp. - Rio Grande Blue Catfish	✓	☐	☐		limited and uncertain distribution; habitat loss; rare		x	x	x	x	x	x	
Ictalurus lupus - Headwater Catfish / bagre lobo	✓	✓	✓		loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish		x	x	x	x	x	x	
Ictalurus punctatus - Channel Catfish / bagre de canal		☐	☐										
Ictalurus sp. - Chihuahua Catfish	✓	✓	✓		habitat loss; hybridization with Channel Catfish		x	x	x	x	x	x	
Noturus gyrinus - Tadpole Madtom		☐	☐										
Noturus nocturnus - Freckled Madtom		☐	☐										
Pylodictis olivaris - Flathead Catfish / bagre piltonte		☐	☐										
Satan eurystomus - Widemouth Blindcat	✓	✓	✓	sT	aquifer depletion; pollution		x		x		x		
Trogloglanis pattersoni - Toothless Blindcat	✓	✓	✓	sT	aquifer depletion; pollution		x		x		x		
Esox americanus vermiculatus - Grass Pickerel		☐	☐										
Esox niger - Chain Pickerel		☐	☐										
Oncorhynchus clarkii virginalis - Rio Grande Cutthroat Trout	✓	✓	✓	Extirpated	habitat loss; competition and hybridization with Rainbow Trout		x		x		x	x	

Aphredoderus sayanus - Pirate Perch		□	□										
Agonostomus monticola - Mountain Mullet / trucha de tierra caliente	✓	□	□		threats similar to American Eel; catadromous; dams impede migration; habitat loss		x	x	x		x		x
Mugil cephalus - Striped Mullet / lisa rayada		□	□										
Labidesthes sicculus - Brook Silverside		□	□										
Membras martinica - Rough Silverside		□	□										
Menidia beryllina - Inland Silverside / plateadito salado		□	□										
Fundulus blairae - Western Starhead Topminnow		□	□										
Fundulus chrysotus - Golden Topminnow		□	□										
Fundulus grandis - Gulf Killifish / sardinilla del Pánuco		□	□										
Fundulus kansae - Northern Plains Killifish		□	□										
Fundulus notatus - Blackstripe Topminnow		□	□										
Fundulus olivaceus - Blackspotted Topminnow		□	□										
Fundulus zebrinus - Plains Killifish		□	□										
Lucania parva - Rainwater Killifish / sardinilla de lluvia		□	□										

Gambusia affinis - Western Mosquitofish / guayacón mosquito		☐	☐										
Gambusia amistadensis - Amistad Gambusia		☐	☐	Extinct									
Gambusia gaigei - Big Bend Gambusia	✓	✓	✓	E	habitat loss; spring flow reductions; exotic species	x	x		x		x	x	
Gambusia geiseri - Largespring Gambusia		☐	☐										
Gambusia georgei - San Marcos Gambusia		☐	✓	E	extinct								
Gambusia heterochir - Clear Creek Gambusia	✓	✓	✓	E	diminished spring flows; hybridization with Western Mosquitofish	x	x		x		x	x	
Gambusia krumholzi - Spotfin Gambusia / guayacón del Nava	✓	✓	✓	sT	previously *Gambusia clarkhubbsi*; habitat modification; water quality from urban pollution	x	x		x		x	x	
Gambusia nobilis - Pecos Gambusia	✓	✓	✓	E	groundwater pumping; habitat loss; pollution; hybridization with introduced Largespring Gambusia	x	x		x		x	x	
Gambusia senilis - Blotched Gambusia / guayacón del Bravo	✓	✓	✓	sT	habitat loss	x	x		x		x	x	
Gambusia speciosa - Tex-Mex Gambusia / guayacón de Nuevo León		☐	☐										
Heterandria formosa - Least Killifish		☐	☐										
Poecilia formosa - Amazon Molly / topote amazona		☐	☐										

Poecilia latipinna - Sailfin Molly / topote velo negro		□	□										
Cyprinodon bovinus - Leon Springs Pupfish	✓	✓	✓	E	groundwater pumping; habitat loss; pollution; hybridization with Sheepshead Minnow	x			x		x	x	
Cyprinodon elegans - Comanche Springs Pupfish	✓	✓	✓	E	groundwater pumping; habitat loss; pollution; hybridization with Sheepshead Minnow	x			x		x	x	
Cyprinodon eximius - Conchos Pupfish / cachorrito del Conchos	✓	✓	✓	sT	reductions in stream flow; habitat loss; hybridization with Sheepshead Minnow	x			x		x	x	
Cyprinodon pecosensis - Pecos Pupfish	✓	✓	✓	sT	groundwater pumping; hybridization with Sheepshead Minnow	x			x		x	x	
Cyprinodon rubrofluviatilis - Red River Pupfish	✓	✓	✓		habitat loss; hybridization with Sheepshead Minnow	x			x		x	x	
Cyprinodon variegatus - Sheepshead Minnow / bolín		□	□										
Morone chrysops - White Bass		□	□										
Morone mississippiensis - Yellow Bass		□	□										
Centrarchus macropterus - Flier		□	□										
Lepomis cyanellus - Green Sunfish / pez sol		□	□										
Lepomis gulosus - Warmouth / mojarra golosa		□	□										
Lepomis humilis - Orangespotted Sunfish		□	□										
Lepomis macrochirus - Bluegill / mojarra oreja azul		□	□										

Lepomis marginatus - Dollar Sunfish		□	□										
Lepomis megalotis - Longear Sunfish / mojarra gigante		□	□										
Lepomis microlophus - Redear Sunfish / robalo de oreja roja		□	□										
Lepomis miniatus - Redspotted Sunfish		□	□										
Lepomis symmetricus - Bantam Sunfish		□	□										
Micropterus punctulatus - Spotted Bass		□	□										
Micropterus salmoides - Largemouth Bass / lobina negra		□	□										
Micropterus salmoides nuecensis - Rio Grande Largemouth Bass	✓	□	✓		limited/uncertain distribution; habitat loss; hybridization		x		x		x	x	
Micropterus treculii - Guadalupe Bass	✓	✓	✓		reductions in stream flow; habitat loss; fragmentation; hybridization with Smallmouth Bass		x		x		x	x	
Pomoxis annularis - White Crappie		□	□										
Pomoxis nigromaculatus - Black Crappie / mojarra negra		□	□										
Ammocrypta clara - Western Sand Darter	✓	✓	✓		loss of natural flow regime; habitat loss		x	x	x	x	x		
Ammocrypta vivax - Scaly Sand Darter		□	□										

Etheostoma artesiae - Redspot Darter		□	□										
Etheostoma asprigene - Mud Darter		□	□										
Etheostoma chlorosoma - Bluntnose Darter		□	□										
Etheostoma fonticola - Fountain Darter	✓	✓	✓	E	loss of natural flow regime; habitat loss		x	x	x	x	x		
Etheostoma fusiforme - Swamp Darter		□	□										
Etheostoma gracile - Slough Darter		□	□										
Etheostoma grahami - Rio Grande Darter / perca del Bravo	✓	✓	✓	sT	loss of natural flow regime; habitat loss		x	x	x	x	x		
Etheostoma histrio - Harlequin Darter		□	□										
Etheostoma lepidum - Greenthroat Darter		□	□										
Etheostoma parvipinne - Goldstripe Darter		□	□										
Etheostoma proeliare - Cypress Darter		□	□										
Etheostoma pulchellum - Plains Orangethroat Darter		□	□		previously *Etheostoma spectabile*								
Etheostoma radiosum - Orangebelly Darter	✓	✓	✓		loss of natural flow regime; habitat loss		x	x	x	x	x		
Etheostoma thompsoni - Gumbo Darter	✓	□	□		newly described species limited to Neches and Sabine river basins		x	x	x	x	x		
Percina apristis - Guadalupe Darter	✓	✓	□		loss of natural flow regime; habitat loss		x	x	x	x	x		

Percina caprodes - Logperch		☐	☐										
Percina carbonaria - Texas Logperch		☐	☐										
Percina macrolepida - Bigscale Logperch / perca escamona		☐	☐										
Percina maculata - Blackside Darter	✓	✓	✓	sT	loss of natural flow regime; habitat loss		x	x	x	x	x		
Percina phoxocephala - Slenderhead Darter		☐	☐										
Percina sciera - Dusky Darter		☐	☐										
Percina shumardi - River Darter	✓	☐	☐		reduction in East TX distribution; disjunct populations in Guadalupe and San Antonio river systems		x	x	x	x	x		
Aplodinotus grunniens - Freshwater Drum / roncador de agua dulce		☐	☐										
Elassoma zonatum - Banded Pygmy Sunfish		☐	☐										
Herichthys cyanoguttatus - Rio Grande Cichlid / mojarra del Norte		☐	☐										

Texas native freshwater fishes	**drainage**	**ecoregion**
Ichthyomyzon castaneus - Chestnut Lamprey		
Ichthyomyzon gagei - Southern Brook Lamprey		

Scaphirhynchus platorynchus - Shovelnose Sturgeon / esturión	Red River (Rio Grande?)	ECPL, WGCP
Polyodon spathula - Paddlefish	Trinity, Neches, Sabine, Cypress, Sulphur, Red	TBPR, ECPL, WGCP, CRTB, GCPM-UP
Atractosteus spatula - Alligator Gar / catán	coastal streams from the Rio Grande to Red River	CHIH, TBPR, ECPL, WGCP, GCPM, STPL
Lepisosteus oculatus - Spotted Gar / catán pinto		
Lepisosteus osseus - Longnose Gar / catán aguja		
Lepisosteus platostomus - Shortnose Gar		
Amia calva - Bowfin		
Hiodon alosoides - Goldeye	Red River	ECPL, WGCP, CRTB
Anguilla rostrata - American Eel / anguila americana	Rio Grande to Red River	CHIH, TBPR, ECPL, WGCP, CRTB, CGPL, EDPT
Dorosoma cepedianum - Gizzard Shad / sardina molleja		
Dorosoma petenense - Threadfin Shad / sardina maya		
Campostoma anomalum - Central Stoneroller / rodapiedras del centro		
Campostoma ornatum - Mexican Stoneroller / rodapiedras mexicano	Rio Grande	CHIH
Campostoma spadiceum - Highland Stoneroller	eastern Oklahoma, western Arkansas and NE Texas (Aiken Creek, Sulphur River trib)	
Cyprinella lepida - Plateau Shiner	Frio, Sabinal	EDPT, STPL
Cyprinella sp. - Nueces River Shiner	Nueces River	EDPT, STPL

Cyprinella lutrensis - Red Shiner / carpita roja		
Cyprinella lutrensis blairi - Maravillas Red Shiner		
Cyprinella proserpina - Proserpine Shiner / carpita del Norte	lower Pecos & Devils rivers, Las Moras, Pinto, & San Felipe creeks	CHIH, EDPT
Cyprinella venusta - Blacktail Shiner / carpita colinegra		
Dionda argentosa - Manantial Roundnose Minnow / carpa de manantial	lower Pecos & Devils rivers, San Felipe & Sycamore creeks	CHIH, EDPT
Dionda diaboli - Devils River Minnow / carpa diabla	Devils River, San Felipe, Pinto & Sycamore creeks	CHIH, EDPT
Dionda episcopa - Roundnose Minnow / carpa obispa	Pecos River	CHIH
Dionda flavipinnis - (Guadalupe) Roundnose Minnow	Guadalupe and southern Colorado drainages	EDPT
Dionda nigrotaeniata - (Medina) Roundnose Minnow	Medina River	EDPT
Dionda serena - (Frio) Roundnose Minnow	Frio River	EDPT
Dionda sp. 1 - (Conchos) Roundnose Minnow	Rio Grande tribs in Big Bend region	CHIH
Dionda sp. 3 - (Colorado) Roundnose Minnow	northern Colorado River	EDPT
Dionda texensis - (Nueces) Roundnose Minnow	Nueces River	EDPT
Gila pandora - Rio Grande Chub	Little Aguja Creek	CHIH

Hybognathus amarus - Rio Grande Silvery Minnow / carpa Chamizal	Rio Grande	CHIH, GCPM-LWR, STPL
Hybognathus hayi - Cypress Minnow		
Hybognathus nuchalis - Mississippi Silvery Minnow	Brazos River eastward and northward to the Red River	CRTB, TBPR, ECPL, WGCP
Hybognathus placitus - Plains Minnow	Colorado and Brazos basins northward to the Red River	EDPT, CRTB, TBPR, ECTP, WGCP, GCPM
Hybopsis amnis - Pallid Shiner	Guadalupe River to Red River	EDPT, CRTB, TBPR, ECTP, WGCP, GCPM
Luxilus chrysocephalus - Striped Shiner		
Lythrurus fumeus - Ribbon Shiner		
Lythrurus umbratilis - Redfin Shiner		
Macrhybopsis aestivalis - Speckled Chub / carpa pecosa	Rio Grande	CHIH
Macrhybopsis australis - Prairie Chub	upper Red River	CGPL
Macrhybopsis hyostoma - Shoal Chub	Sabine River to Lavaca River	CGPL, CRTB, TBPR, ECTP, WGCP
Macrhybopsis marconis - Burrhead Chub	San Antonio, Guadalupe & Colorado rivers	EDPT, TBPR, ECTP, GCPM
Macrhybopsis storeriana - Silver Chub	Red River & lower Brazos River	TBPR, ECPL, CRTB, CGPL
Macrhybopsis tetranema - Peppered Chub	upper South Canadian River	SWTB
Notemigonus crysoleucas - Golden Shiner		

Notropis amabilis - Texas Shiner / carpita texana	Edwards Plateau streams to Pecos River	EDPT
Notropis sp. West Texas Shiner	lower Pecos & Devils rivers, San Felipe & Sycamore creeks	CHIH, EDPT
Notropis atherinoides - Emerald Shiner		
Notropis atrocaudalis - Blackspot Shiner	lower Brazos north and eastward to Red River	TBPR, ECPL, WGCP, GCPM
Notropis bairdi - Red River Shiner	Red River	TBPR, ECPL, WGCP, CRTB, CGPL
Notropis blennius - River Shiner	Red River	CGPL, ECPL, WGCP
Notropis braytoni - Tamaulipas Shiner / carpita tamaulipeca	Rio Grande & lower Pecos River	CHIH, GCPM-LWR, STPL
Notropis buccula - Smalleye Shiner	Brazos River	TBPR, ECPL
Notropis buchanani - Ghost Shiner / carpita fantasma		
Notropis chalybaeus - Ironcolor Shiner	Red, Sabine & San Marcos rivers	TBPR, ECPL, WGCP
Notropis chihuahua - Chihuahua Shiner / carpita chihuahuense	Rio Grande	CHIH
Notropis girardi - Arkansas River Shiner	Canadian River	SWTB
Notropis jemezanus - Rio Grande Shiner / carpita del Bravo	Rio Grande & Pecos River	CHIH, STPL
Notropis maculatus - Taillight Shiner	Sulphur River & Cypress Bayou	WGCP

Notropis orca - Phantom Shiner / carpita de El Paso		
Notropis oxyrhynchus - Sharpnose Shiner	Brazos River	SWTB, TBPR, ECPL, CRTB, CGPL
Notropis potteri - Chub Shiner	Red, lower Trinity, San Jacinto and Brazos rivers	SWTB, TBPR, ECPL, WGCP, CRTB, CGPL
Notropis sabinae - Sabine Shiner	San Jacinto River to Sabine River	WGCP
Notropis shumardi - Silverband Shiner	Coastal Plain streams from Lavaca River to Red River	TBPR, ECPL, WGCP, GCPM
Notropis simus pecosensis - Pecos Bluntnose Shiner	Pecos River	CHIH
Notropis simus simus - Rio Grande Bluntnose Shiner / carpita chata		
Notropis stramineus - Sand Shiner / carpita arenera		
Notropis texanus - Weed Shiner		
Notropis volucellus - Mimic Shiner		
Opsopoeodus emiliae - Pugnose minnow		
Phenacobius mirabilis - Suckermouth Minnow	Canadian, Red, Sabine, Trinity & Colorado rivers	SWTB, CGPL, CRTB, TBPR, ECTP, WGCP
Pimephales promelas - Fathead Minnow / carpita cabezona		
Pimephales vigilax - Bullhead Minnow / carpita cabeza de toro		
Platygobio gracilis - Flathead Chub / carpita cabeza plana	Canadian River	SWTB

Pteronotropis hubbsi - Bluehead Shiner	Cypress Bayou	WGCP
Rhinichthys cataractae - Longnose Dace / carpita rinconera	Rio Grande	CHIH, STPL
Semotilus atromaculatus - Creek Chub		
Carpiodes carpio - River Carpsucker / matalote chato		
Carpiodes sp. 1	Llano River	EDPT
Cycleptus elongatus - Blue Sucker / matalote azul	major streams of Texas excluding the Rio Grande	TBPR, ECPL, WGCP, CRTB, GCPM-UP, GCPM-MID
Cycleptus sp. - Rio Grande Blue Sucker	Rio Grande	CHIH, GCPM-LWR, STPL
Erimyzon claviformis - Western Creek Chubsucker	Red River southward to San Jacinto River	ECPL, WGCP
Erimyzon sucetta - Lake Chubsucker		
Ictiobus bubalus - Smallmouth Buffalo / matalote boquín		
Ictiobus cyprinellus - Bigmouth Buffalo		
Ictiobus niger - Black Buffalo / matalote negro		
Minytrema melanops - Spotted Sucker		
Moxostoma albidum - Longlip Jumprock / matalote blanco	Rio Grande, Devils River	CHIH, EDPT

Moxostoma austrinum - Mexican Redhorse / matalote chuime	Rio Grande	CHIH
Moxostoma congestum - Gray Redhorse / matalote gris		
Moxostoma erythrurum - Golden Redhorse		
Moxostoma poecilurum - Blacktail Redhorse		
Astyanax mexicanus - Mexican Tetra / sardinita mexicana		
Ameiurus melas - Black Bullhead / matalote negro		
Ameiurus natalis - Yellow Bullhead / bagre torito amarillo		
Ictalurus furcatus - Blue Catfish / bagre azul		
Ictalurus furcatus sp. - Rio Grande Blue Catfish	Rio Grande in Big Bend region	CHIH
Ictalurus lupus - Headwater Catfish / bagre lobo	Rio Grande, Pecos, upper Nueces, San Antonio, Guadalupe and Colorado rivers	CHIH, CRTB, CGPL, EDPT
Ictalurus punctatus - Channel Catfish / bagre de canal		
Ictalurus sp. - Chihuahua Catfish	Rio Grande	CHIH
Noturus gyrinus - Tadpole Madtom		
Noturus nocturnus - Freckled Madtom		
Pylodictis olivaris - Flathead Catfish / bagre piltonte		

Satan eurystomus - Widemouth Blindcat	San Antonio Pool of the Edwards Aquifer	TBPR
Trogloglanis pattersoni - Toothless Blindcat	San Antonio Pool of the Edwards Aquifer	TBPR
Esox americanus vermiculatus - Grass Pickerel		
Esox niger - Chain Pickerel		
Oncorhynchus clarkii virginalis - Rio Grande Cutthroat Trout	Limpia & McKittrick creeks	CHIH
Aphredoderus sayanus - Pirate Perch		
Agonostomus monticola - Mountain Mullet / trucha de tierra caliente	Rio Grande to Sabine River	WGCP, TBPR, ECTP, GCPM
Mugil cephalus - Striped Mullet / lisa rayada		
Labidesthes sicculus - Brook Silverside		
Membras martinica - Rough Silverside		
Menidia beryllina - Inland Silverside / plateadito salado		
Fundulus blairae - Western Starhead Topminnow		
Fundulus chrysotus - Golden Topminnow		
Fundulus grandis - Gulf Killifish / sardinilla del Pánuco		
Fundulus kansae - Northern Plains Killifish		
Fundulus notatus - Blackstripe Topminnow		

Fundulus olivaceus - Blackspotted Topminnow		
Fundulus zebrinus - Plains Killifish		
Lucania parva - Rainwater Killifish / sardinilla de lluvia		
Gambusia affinis - Western Mosquitofish / guayacón mosquito		
Gambusia amistadensis - Amistad Gambusia		
Gambusia gaigei - Big Bend Gambusia	springs in the Boquillas Crossing & Rio Grande Village, Big Bend National Park	CHIH
Gambusia geiseri - Largespring Gambusia		
Gambusia georgei - San Marcos Gambusia		
Gambusia heterochir - Clear Creek Gambusia	Clear Creek, tributary to the San Saba River	EDPT
Gambusia krumholzi - Spotfin Gambusia / guayacón del Nava	San Felipe Creek; ríos San Diego & Nava, Mexico	STPL
Gambusia nobilis - Pecos Gambusia	Balmorhea springs complex & Diamond Y Springs	CHIH
Gambusia senilis - Blotched Gambusia / guayacón del Bravo	Devils River	CHIH, STPL
Gambusia speciosa - Tex-Mex Gambusia / guayacón de Nuevo León		
Heterandria formosa - Least Killifish		
Poecilia formosa - Amazon Molly / topote amazona		

Poecilia latipinna - Sailfin Molly / topote velo negro		
Cyprinodon bovinus - Leon Springs Pupfish	Diamond Y Springs	CHIH
Cyprinodon elegans - Comanche Springs Pupfish	Balmorhea springs complex	CHIH
Cyprinodon eximius - Conchos Pupfish / cachorrito del Conchos	Alamito Creek, Devils River	CHIH, EDPT
Cyprinodon pecosensis - Pecos Pupfish	Pecos River	CHIH
Cyprinodon rubrofluviatilis - Red River Pupfish	upper Brazos & Red rivers	SWTB, CGPL
Cyprinodon variegatus - Sheepshead Minnow / bolín		
Morone chrysops - White Bass		
Morone mississippiensis - Yellow Bass		
Centrarchus macropterus - Flier		
Lepomis cyanellus - Green Sunfish / pez sol		
Lepomis gulosus - Warmouth / mojarra golosa		
Lepomis humilis - Orangespotted Sunfish		
Lepomis macrochirus - Bluegill / mojarra oreja azul		
Lepomis marginatus - Dollar Sunfish		
Lepomis megalotis - Longear Sunfish / mojarra gigante		

Lepomis microlophus - Redear Sunfish / robalo de oreja roja		
Lepomis miniatus - Redspotted Sunfish		
Lepomis symmetricus - Bantam Sunfish		
Micropterus punctulatus - Spotted Bass		
Micropterus salmoides - Largemouth Bass / lobina negra		
Micropterus salmoides nuecensis - Rio Grande Largemouth Bass	Rio Grande, Devils River	CHIH, EDPT
Micropterus treculii - Guadalupe Bass	streams of the northern and eastern Edwards Plateau	TBPR, CRTB, EDPT
Pomoxis annularis - White Crappie		
Pomoxis nigromaculatus - Black Crappie / mojarra negra		
Ammocrypta clara - Western Sand Darter	Neches, Sabine & Red rivers	WGCP
Ammocrypta vivax - Scaly Sand Darter		
Etheostoma artesiae - Redspot Darter		
Etheostoma asprigene - Mud Darter	Sulphur River & Cypress Bayou	
Etheostoma chlorosoma - Bluntnose Darter		
Etheostoma fonticola - Fountain Darter	upper San Marcos & Comal rivers	TBPR
Etheostoma fusiforme - Swamp Darter	San Jacinto & Sabine rivers	WGCP

Etheostoma gracile - Slough Darter		
Etheostoma grahami - Rio Grande Darter / perca del Bravo	Rio Grande, lower Pecos & Devils rivers; Dolan, San Felipe & Sycamore creeks	CHIH, EDPT
Etheostoma histrio - Harlequin Darter		
Etheostoma lepidum - Greenthroat Darter		
Etheostoma parvipinne - Goldstripe Darter		
Etheostoma proeliare - Cypress Darter		
Etheostoma pulchellum - Plains Orangethroat Darter		
Etheostoma radiosum - Orangebelly Darter	Red River	ECPL, WGCP
Etheostoma thompsoni - Gumbo Darter	Neches & Sabine rivers	WGCP
Percina apristis - Guadalupe Darter	Guadalupe, San Marcos & Comal rivers	TBPR, ECPL, EDPT
Percina caprodes - Logperch		
Percina carbonaria - Texas Logperch		
Percina macrolepida - Bigscale Logperch / perca escamona		
Percina maculata - Blackside Darter	Red River in the northeast Texas	WGCP
Percina phoxocephala - Slenderhead Darter		
Percina sciera - Dusky Darter		

Percina shumardi - River Darter	Red, Sulphur, Cypress, Sabine, Neches, Guadalupe, San Antonio	ECPL, WGCP
Aplodinotus grunniens - Freshwater Drum / roncador de agua dulce		
Elassoma zonatum - Banded Pygmy Sunfish		
Herichthys cyanoguttatus - Rio Grande Cichlid / mojarra del Norte		

Appendix 2 - Conservation Plans for Great Plains NFCAs

Conservation Activities and Monitoring Guidelines for the Southern Plains Native Fish Conservation Areas

The NFCAs of the Southern Plains region are comprised of the upper watersheds of the Canadian, Red and Brazos rivers. Aquifer pumping for agriculture and mismanagement of surface flows through retention and diversion have negatively impacted the natural flow regime and diminished surface waters. These problems have been exacerbated by the proliferation of the non-native saltcedar (*Tamarix* spp.). As a result, the majority of the indigenous, aquatic fauna is imperiled. Causes for fish species declines include habitat fragmentation, dewatering, flow regime alteration, water pollution, and introduction of non-native species.

A multi-species, ecosystem approach to species conservation provides an improved method for addressing the common nature and magnitude of threats facing ecosystems and their component species. It is also improves efficiency, cost effectiveness and is more likely to succeed. This plan is designed to coordinate projects to improve water quality, increase water quantity, restore natural habitats, reduce impacts of non-native species, diminish stream system fragmentation, and restore proper function of springs, creeks, rivers, and riparian areas. It will only be effective if it is able to inform and influence water management, land-use planning and zoning, and land-management decisions that will determine current and future conditions of rivers and streams and the associated habitat quality for native fishes. Additionally, to provide long-term benefits to focal species populations, conservation actions must be coordinated at sufficient scales to meet all life history stages of these species and must adopt conservation approaches that are cost-effective and sustainable over time.

To accomplish this goal, it is necessary to develop a holistic, habitat-oriented approach to conservation of focal species, restore and protect habitat, restore habitat connectivity and reduce deleterious effects of non-native species. Threat factors need to be delineated and prioritized based on threat level and what can be managed. Currently known threats in the Southern Plains NFCAs are identified in the species accounts at the end of this document and include:

a. habitat fragmentation
b. barriers to migration
c. loss of natural flow regime
d. reduced stream flow
e. spring flow declines
f. habitat loss
g. non-native species – habitat modification, hybridization, competition and predation

Objective 1: Protect and maintain intact, healthy habitats

- Determine locations and extent of healthy habitats.
- Assess degree of threats and limiting factors present in healthy habitats.

- Develop a priority list of stream segments for protection actions.
- Organize Technical Advisory Teams for individual stream segments to analyze current data, define challenges, determine conservation methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
    - Maintain floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
    - Maintain appropriate sediment transport and avoid channel narrowing.
    - Maintain native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.
    - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.
    - Seek appropriate easements, water rights acquisitions and flow agreements to maintain appropriate hydrologic conditions.
    - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor conservation efforts and assess benefits to focal species populations

Objective 2: Restore impacted habitats

- Determine locations, extent and type of impacted habitats.
- Assess degree of threats and limiting factors present in impacted habitats.
- Develop a priority list of stream segments for restoration actions.
- Organize Technical Advisory Teams for individual stream segments to analyze data, define challenges, determine restoration methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
    - Where feasible, restore floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
    - Restore appropriate sediment transport and reduce channel narrowing.
    - Restore native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.

  - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.
  - Seek appropriate easements, water rights acquisitions and flow agreements to improve appropriate hydrologic conditions.
  - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor restoration efforts and assess benefits to focal species populations.

Objective 3: Restore stream and habitat connectivity

- Inventory fish passage barriers and delineate impacts on ecology of focal species.
- Where feasible, diminish or remove fish passage barriers and restore aquatic connectivity.

Objective 4: Mitigate effects of invasive species

- Assess current status of focal species affected by invasive species.
- Develop methods for reducing non-native species in targeted areas.
- Develop methods to prevent introductions of invasive species and minimize impacts of existing invasive species.
- Restore or improve the ecological balance in habitats negatively affected by non-native, invasive or problem species.
- Reestablish genetic integrity of hybridized populations in targeted areas.

Objective 5: Organize networks of public and private landowners

- Provide technical guidance workshops, newsletters, social media, etc. to facilitate development and expansion of local citizen-based partnerships.
- Landowner networks should be committed to the cooperative conservation of land and water resources within the watershed.
- Landowner networks should promote values of functional upland, riparian, and stream systems and emphasize the conservation of native fish communities and supporting habitats.
- Landowner networks should work to reduce or eliminate activities on the landscape that degrade water quality, reduce water quantity, degrade riparian systems, favor non-native species, or fragment stream systems.
- Landowner networks should encourage an array of sustainable land-use activities that are compatible with aquatic resource conservation.
- Landowner networks promote collaboration across jurisdictional and land ownership boundaries.

Objective 6: Develop conservation demonstration areas

- Provide fishing, paddling, and hiking opportunities.

- Promote sustainable public use of rivers.
- Describe benefits to other native species.
- Demonstrate best management practices.
- Highlight restoration actions through educational kiosks.

Objective 7: Conduct research to fill critical information gaps

- Identify knowledge gaps critical to restoration and conservation of the focal species.
- Design and conduct research as needed to enhance conservation efforts outlined in Objectives 1-4.
- Initial sampling at representative locations within each NFCA should be quarterly and include:
    - Biological characteristics of focal species: population size, population structure (genetics & demographics), fecundity, food habits, habitat selectivity, flow-ecology relationships, associated species
    - Habitat structure: flow and discharge rates, channel width, channel morphology, substrate types, depth, cover, trends in surrounding land use
    - Water quality: temperature, pH, dissolved oxygen, conductivity, total dissolved solids, alkalinity, hardness, chemical and biological oxygen demand
- Threats and limiting factors for the focal species will determine the scale at which the monitoring is designed. As baseline data are developed, monitoring parameters can be modified and streamlined to address critical issues and needs for the focal species.

Objective 8: Adaptive management and reporting

- Develop annual and long-term reporting requirements to document acquired data, departures from plan and evaluations necessary for adaptive management.
- Determine research needs for refining restoration and management actions.
- Periodically modify strategies based on monitoring, evaluation and research results.
- Share information with the public in an easy to use and understandable format.

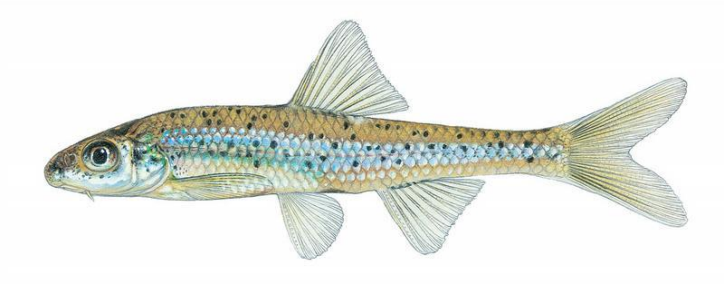
Fishes of the (upper) Brazos River NFCA

List of modeled species used in construction of Brazos River NFCA. Focal species are highlighted in blue and non-native species are in red.

Lepisosteus oculatus (Spotted Gar)	*Pylodictis olivaris* (Flathead Catfish)
Lepisosteus osseus (Longnose Gar)	*Labidesthes sicculus* (Brook Silverside)
Dorosoma cepedianum (Gizzard Shad)	*Menidia beryllina* (Inland Silverside)
Dorosoma petenense (Threadfin Shad)	*Fundulus grandis* (Gulf Killifish)
Campostoma anomalum (Central Stoneroller)	*Fundulus notatus* (Blackstripe Topminnow)
Carassius auratus (Goldfish)	*Fundulus zebrinus* (Plains Killifish)
Cyprinella lutrensis (Red Shiner)	*Gambusia affinis* (Western Mosquitofish)
Cyprinella venusta (Blacktail Shiner)	*Cyprinodon rubrofluviatilis* (Red River Pupfish)
Cyprinus carpio (Common Carp)	*Morone chrysops* (White Bass)
Hybognathus placitus (Plains Minnow)	*Morone saxatilis* (Striped Bass)
Macrhybopsis hyostoma (Shoal Chub)	*Lepomis auritus* (Redbreast Sunfish)
Notemigonus crysoleucas (Golden Shiner)	*Lepomis cyanellus* (Green Sunfish)
Notropis buccula (Smalleye Shiner)	*Lepomis gulosus* (Warmouth)
Notropis buchanani (Ghost Shiner)	*Lepomis humilis* (Orangespotted Sunfish)
Notropis oxyrhynchus (Sharpnose Shiner)	*Lepomis macrochirus* (Bluegill)
Notropis potteri (Chub Shiner)	*Lepomis megalotis* (Longear Sunfish)
Notropis shumardi (Silverband Shiner)	*Lepomis microlophus* (Redear Sunfish)
Notropis stramineus (Sand Shiner)	*Lepomis miniatus* (Redspotted Sunfish)
Notropis volucellus (Mimic Shiner)	*Micropterus punctulatus* (Spotted Bass)
Pimephales promelas (Fathead Minnow)	*Micropterus salmoides* (Largemouth Bass)
Pimephales vigilax (Bullhead Minnow)	*Micropterus treculii* (Guadalupe Bass)
Carpiodes carpio (River Carpsucker)	*Pomoxis annularis* (White Crappie)
Ictiobus bubalus (Smallmouth Buffalo)	*Pomoxis nigromaculatus* (Black Crappie)
Moxostoma congestum (Gray Redhorse)	*Etheostoma pulchellum*
Ameiurus melas (Black Bullhead)	*Percina carbonaria* (Texas Logperch)
Ameiurus natalis (Yellow Bullhead)	*Percina macrolepida* (Bigscale Logperch)
Ictalurus furcatus (Blue Catfish)	*Percina sciera* (Dusky Darter)
Ictalurus punctatus (Channel Catfish)	*Herichthys cyanoguttatus* (Rio Grande Cichlid)
Noturus gyrinus (Tadpole Madtom)	*Oreochromis aureus* (Blue Tilapia)
Noturus nocturnus (Freckled Madtom)	

Macrhybopsis hyostoma

Shoal Chub



Status: SGCN

Threats in Brazos River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Relatively large, oval eyes set high on head, cross-eyed appearance when viewed from above; one or two pairs of maxillary barbels; translucent pale green or gray dorsally, silvery white ventrally, with broad silver lateral stripe; small to large pigmentations on dorsal and lateral regions; pigmentation on fins variable, usually along rays of pectoral, pelvic, dorsal, anal and caudal fins (Eisenhour 2004).

Range in Texas: Sabine, Red, Brazos and Colorado rivers (Underwood et al. 2003).

Habitat: Prefers streams with well-defined pools and riffles/runs, braided channels, and shifting sand/gravel bars. Considered a habitat specialist in habitats with clean sand or pea-size gravel substrates and moderate current velocities (Luttrell et al. 2002).

Biology: Feeds on aquatic insects, small crustaceans, and plant material (Starrett 1950). Likely similar to Peppered Chub (*Macrhybopsis tetranema*), which is a flood-pulse spawner (Bottrell et al. 1964; Miller and Robison 2004).

Notropis buccula

Smalleye Shiner

Status: federally endangered; state endangered; SGCN

Threats in Brazos River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Black pigments outlining dorsal scales, especially posterior to dorsal fin; dorsal stripe conspicuously interrupted in base of dorsal fin, producing a dark dash at base of dorsal fin (Hubbs et al. 2008).

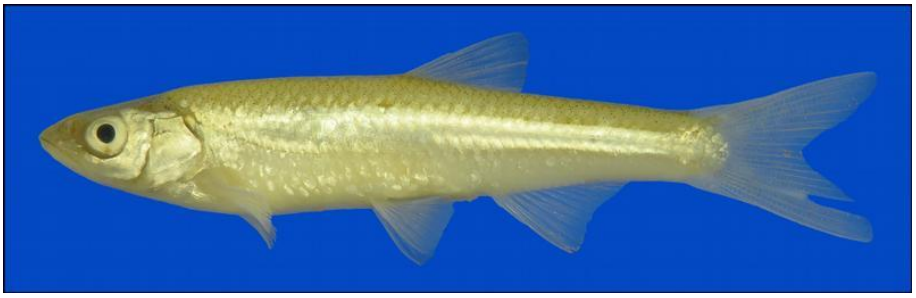
Range: Endemic to the Brazos River watershed; presumed to have been introduced into the Colorado River (Hubbs et al. 2008).

Habitat: Common in river channels or periphery of channels in water with moderate depth and current velocities; substrate usually sand or silt (Moss and Mayes 1993).

Biology: Opportunistic invertivore consuming aquatic insects, primarily dipterans, terrestrial insects, detritus, and plant material (Moss and Mayes 1993; Marks et al. 2001). Pelagic, broadcast spawner, producing multiple cohorts of semi-buoyant eggs within a spawning season; may spawn synchronously during pulse flows (Durham 2007, Wilde and Urbanczyk 2013).

Notropis oxyrhynchus

Sharpnose Shiner



Status: federally endangered; state endangered; SGCN

Threats in Brazos River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Slightly falcate anal fin, dorsal fin begins well behind insertion of the pelvic fin (Hubbs et al. 2008).

Range: Endemic to Brazos River watershed. Thought to be introduced in the Colorado River drainage (Conner and Suttkus 1986).

Habitat: Usually found over sand substrate in moderate current velocities and depths (Ostrand and Wilde 2002; Durham 2007).

Biology: Generalist drift invertivore, consuming aquatic and terrestrial invertebrates, detritus, plant material and sand (Moss and Mayes 1993; Marks 1999; Marks et al. 2001). Pelagic, broadcast spawner during mid-May through September with multiple peaks (Durham 2007, Wilde and Urbanczyk 2013).

Notropis potteri

Chub Shiner

Status: SGCN

Threats in Brazos River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Moderately dusky above and silvery below, with little pigment below the region of the lateral line; melanophores scattered evenly on upper parts of the head and body; dark lateral band moderately developed on the caudal peduncle, ending just before the weak and diffuse basicaudal spot (Hubbs and Bonham 1951).

Range: Red, lower Trinity, San Jacinto and Brazos rivers (Hubbs et al. 2008).

Habitat: Flowing water with silt or sand substrate (Gilbert 1980; Perkin et al. 2009).

Biology: Invertivore and piscivore; pelagic, broadcast spawner (Perkin et al. 2009).

Notropis shumardi

Silverband Shiner

Status: SGCN

Threats in Brazos River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Dorsal scales lightly outlined with black pigments; upper and lower lips with dark pigment (Robison and Buchanan 1988).

Range in Texas: Lavaca River to Red River (Hubbs et al. 2008).

Habitat: Main channel with moderate to swift current velocities and moderate to deep depths; associated with turbid water over silt, sand and gravel (Gilbert 1980, Robison and Buchanan 1988, Cross 1995).

Biology: Breeds May through mid-fall (Edwards 1999). Pelagic spawner over hard sand to fine gravel substrates in water 1-2 m deep in strong current (Conner 1977).

Cyprinodon rubrofluviatilis

Red River Pupfish

Status: SGCN

Threats in Brazos River NFCA: habitat loss; hybridization with Sheepshead Minnow

Description: Juveniles, females, non-breeding males with a lateral and dorso-lateral series of brownish irregularly shaped blotches; females with spot at base of dorsal fin that is lacking in mature males; breeding males have bright blue iridescence in upper body, most intense in nape region; caudal fin bordered posteriorly with an intense black band; abdomen naked anterior to pelvic fins (Echelle 1973; Hubbs et al. 2008).

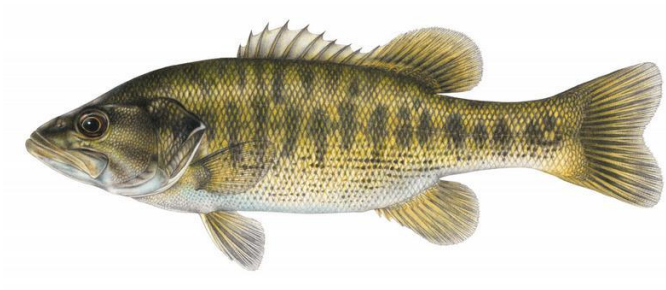
Range: Endemic to the upper Red and Brazos basins, introduced in the Canadian and Colorado basins (Echelle et al. 1977; Page and Burr 1997; Hubbs et al. 2008).

Habitat: River edges, channels, backwaters, over sand bottoms; euryhaline and eurythermal (Minckley et al. 1991).

Biology: High salinity tolerance, up to 150‰ (Echelle et al. 1972; Higgins and Wilde 2005). Primarily a bottom-feeding omnivore (Echelle 1973) feeding on midge and other insect larvae (Miller and Robison 2004). Spawns February through November in territories maintained by individual males (Echelle 1973).

Micropterus treculii

Guadalupe Bass



Status: SGCN; State Fish of Texas

Threats in Brazos River NFCA: reductions in stream flow; habitat loss; fragmentation; hybridization with Smallmouth Bass

Description: Distinctive black, diamond-shaped pattern along sides and rows of spots that form stripes on its belly; jaw does not extend beyond eye; glossohyal teeth present on tongue (Hubbs and Bailey 1942; Garrett 1991).

Range: Endemic to the streams of the northern and eastern Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio basins; species also found outside of the Edwards Plateau streams in decreased abundance, primarily in the lower Colorado River; two introduced populations have been established in the Nueces River system (Garrett 1991; Hubbs et al. 2008).

Habitat: Prefers small lentic environments in flowing water; absent from extreme headwaters; smaller fish occur in rapids, often near eddies; large individuals found mainly in riffle tail races; uses large rocks, cypress knees, stumps and similar types of cover for refuge (Hubbs et al. 1953; Edwards 1980; Garrett 1991; Edwards 1999).

Biology: Food preferences include larval ephemeropterans, fishes, aquatic dipteran larvae and terrestrial hymenopterans (Hurst et al. 1975; Edwards 1980). Males tend to build nests near a source of slow to moderately moving water from early March through May or June (Hurst et al 1975; Edwards 1980; Garrett 1991; Edwards 1999), with an apparent secondary spawning period in the late summer and fall (Edwards 1980; Edwards 1999).

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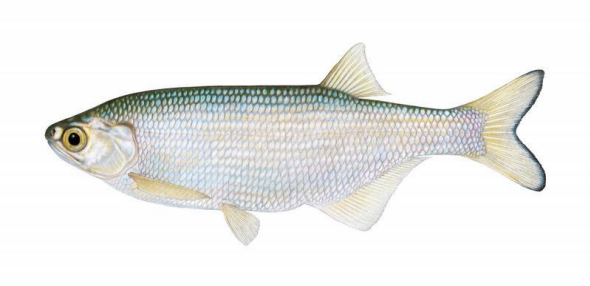
Fishes of the Red River NFCA

Focal species are highlighted in blue and non-native species are in red.

Lepisosteus osseus ((Longnose Gar)	*Ameiurus natalis* (Yellow Bullhead)
Hiodon alosoides (Goldeye)	*Ictalurus punctatus* (Channel Catfish)
Dorosoma cepedianum (Gizzard Shad)	*Pylodictis olivaris* (Flathead Catfish)
Campostoma anomalum (Central Stoneroller)	*Menidia beryllina* (Inland Silverside)
Cyprinella lutrensis (Red Shiner)	*Fundulus notatus* (Blackstripe Topminnow)
Cyprinella venusta (Blacktail Shiner)	*Fundulus zebrinus* (Plains Killifish)
Cyprinus carpio (Common Carp)	*Gambusia affinis* (Western Mosquitofish)
Hybognathus placitus (Plains Minnow)	*Cyprinodon rubrofluviatilis* (Red River Pupfish)
Macrhybopsis australis (Prairie Chub)	*Morone chrysops* (White Bass)
Macrhybopsis storeriana (Silver Chub)	*Lepomis cyanellus* (Green Sunfish)
Notemigonus crysoleucas (Golden Shiner)	*Lepomis gulosus* (Warmouth)
Notropis atherinoides (Emerald Shiner)	*Lepomis humilis* (Orangespotted Sunfish)
Notropis bairdi (Red River Shiner)	*Lepomis macrochirus* (Bluegill)
Notropis blennius (River Shiner)	*Lepomis megalotis* (Longear Sunfish)
Notropis buchanani (Ghost Shiner)	*Lepomis microlophus* (Redear Sunfish)
Notropis potteri (Chub Shiner)	*Micropterus punctulatus* (Spotted Bass)
Notropis stramineus (Sand Shiner)	*Micropterus salmoides* (Largemouth Bass)
Phenacobius mirabilis (Suckermouth Minnow)	*Pomoxis annularis* (White Crappie)
Pimephales promelas (Fathead Minnow)	*Etheostoma pulchellum*
Pimephales vigilax (Bullhead Minnow)	*Percina caprodes* (Logperch)
Carpiodes carpio (River Carpsucker)	*Sander canadensis* (Sauger)
Ictiobus bubalus (Smallmouth Buffalo)	*Aplodinotus grunniens* (Freshwater Drum)
Ameiurus melas (Black Bullhead)	

Hiodon alosoides

Goldeye



Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; loss of habitat

Description: Fleshy keel along belly extends from pectoral fin base to anal fin (Page and Burr 1997). During the breeding season, males have anterior rays of the anal fin elongated forming a distinct lobe (Battle and Sprules 1960).

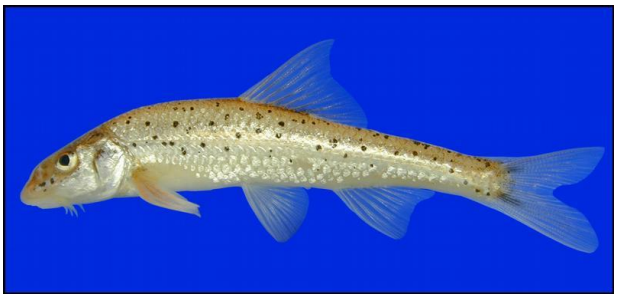
Range in Texas: Restricted to the Red River basin and is especially abundant in Lake Texoma (Hubbs et al. 2008).

Habitat: Moderate to fast current, as well as quiet pools; tolerant of highly turbid conditions (Gilbert 1980; Wallus et al. 1990).

Biology: Invertivore feeding at surface and water column (Gilbert 1980; Goldstein and Simon 1999). Nonguarder, rock and gravel spawner with pelagic free embryos (Balon 1981; Simon 1999).

Macrhybopsis australis

Prairie Chub



Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Broad, poorly defined mid-lateral stripe; small melanophores scattered over dorsolateral surface of body; lips very fleshy and thickened posteriorly (Eisenhour 2004).

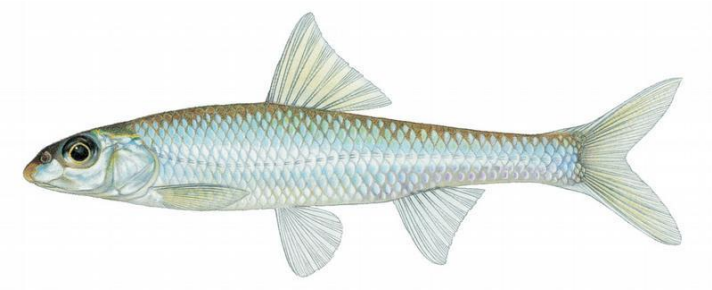
Range: Endemic to the upper Red River basin (Eisenhour 2004; Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in streams; occupies intermittent streams that may dry to isolated, salt-encrusted pools (Winston et al. 1991; Eisenhour 2004). Distribution is correlated with high levels of dissolved salts (Taylor et al. 1993; Eisenhour 2004; Higgins and Wilde 2005), with salinities over 19‰ (Echelle et al. 1972; Eisenhour 2004).

Biology: Primarily taste-feeders, swimming over the bottom with pectoral fins spread widely and barbels in contact with the sand substrate until cutaneous taste buds on the barbels, fins and body detect food items (Davis and Miller 1967).

Macrhybopsis storeriana

Silver Chub



Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Faint, dusky lateral stripe usually present; caudal fin lightly pigmented, except the lower 3-4 rays, which are completely unpigmented (Becker 1983).

Range in Texas: Red River (Warren et al. 2000) and the lower Brazos River (Hubbs et al. 2008).

Habitat: Ranges over gravel to silt substrates, but found more commonly over silt or mud bottom (Kinney 1954; Linam et al. 1994).

Biology: Planktivore/invertivore (Simon 1999). Rock and gravel spawners with pelagic free embryos (Simon 1999).

Notropis bairdi

Red River Shiner

Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Middorsal stripe conspicuously interrupted at base of dorsal fin, producing a dark dash at base of dorsal fin (Hubbs et al. 2008).

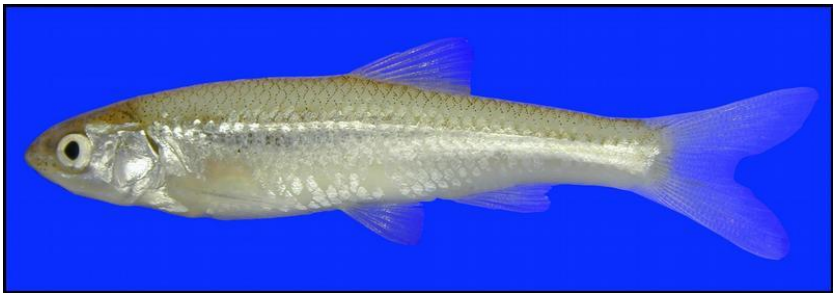
Range: Endemic to Red River basin (Hubbs 1957; Gilbert 1980; Hubbs et al. 2008).

Habitat: Turbid waters of broad, shallow channels of main stream, over bottom mostly of silt and shifting sand (Gilbert 1980). Species is tolerant of high salinities (Taylor et al. 1993; Higgins and Wilde 2005).

Biology: Feeds on benthic invertebrates (Echelle et al. 1972). Life history unknown, but likely similar to the Arkansas River Shiner (*Notropis girardi*).

Notropis blennius

River Shiner



Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Pale-colored with a silvery midlateral stripe; no bright breeding colors (Becker 1983; Miller and Robison 2004).

Range in Texas: Red River (Hubbs et al. 2008).

Habitat: Usually found in turbid waters over substrate of silt, sand and gravel (Gilbert 1980).

Biology: Invertivore, benthic and drift (Goldstein and Simon 1999). Spawns in summer (Cross 1967) over sand and gravel (Trautman 1981).

Notropis potteri

Chub Shiner

Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Moderately dusky above and silvery below, with little pigment below the region of the lateral line; melanophores scattered evenly on upper parts of the head and body; dark lateral band moderately developed on the caudal peduncle, ending just before the weak and diffuse basicaudal spot (Hubbs and Bonham 1951).

Range: Red, lower Trinity, San Jacinto and Brazos rivers (Hubbs et al. 2008).

Habitat: Flowing water with silt or sand substrate (Gilbert 1980; Perkin et al. 2009).

Biology: Invertivore and piscivore; pelagic, broadcast spawner (Perkin et al. 2009).

Phenacobius mirabilis

Suckermouth Minnow

Status: SGCN

Threats in Red River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Dark lateral stripe ending in a spot at base of caudal fin (Sublette et al. 1990). Lower lip thick with fleshy lobe on each side that is partially separated from mandible by a groove (Hubbs et al. 2008).

Range in Texas: Occurs in limited numbers in Canadian, Red, Sabine, Trinity and Colorado drainages (Wilde and Bonner 2000; Hubbs et al. 2008).

Habitat: Predominates in riffles and shallow race ways (Burr and Warren 1986) and may move into shallow gravel riffles at night (Starrett 1950a; Deacon 1961).

Biology: Benthic grazing invertivore; feeds by probing the substrate with its sensitive snout and lips (Starrett 1950b). Spawns in late spring or early summer (Hubbs and Ortenburger 1929; Starrett 1951; Pflieger 1997) in gravelly riffles (Becker 1983).

Cyprinodon rubrofluviatilis

Red River Pupfish

Status: SGCN

Threats in Red River NFCA: habitat loss; hybridization with Sheepshead Minnow

Description: Juveniles, females, non-breeding males with a lateral and dorso-lateral series of brownish irregularly shaped blotches; females with spot at base of dorsal fin that is lacking in mature males; breeding males have bright blue iridescence in upper body, most intense in nape region; caudal fin bordered posteriorly with an intense black band; abdomen naked anterior to pelvic fins (Echelle 1973; Hubbs et al. 2008).

Range: Endemic to the upper Red and Brazos basins, introduced in the Canadian and Colorado basins (Echelle et al. 1977; Page and Burr 1997; Hubbs et al. 2008).

Habitat: River edges, channels, backwaters, over sand bottoms; euryhaline and eurythermal (Minckley et al. 1991).

Biology: High salinity tolerance, up to 150‰ (Hill and Holland 1971; Echelle et al. 1972; Higgins and Wilde 2005). Primarily a bottom-feeding omnivore (Echelle 1973) feeding on midge and other insect larvae (Miller and Robison 2004). Spawns February through November in territories maintained by individual males (Echelle 1973).

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Fishes of the Canadian River NFCA

Focal species are highlighted in blue and non-native species are in red.

Cyprinella lutrensis (Red Shiner)	*Menidia beryllina* (Inland Silverside)
Cyprinus carpio (Common Carp)	*Fundulus kansae* (Northern Plains Killifish)
Hybognathus placitus (Plains Minnow)	*Gambusia affinis* (Western Mosquitofish)
Macrhybopsis tetranema (Peppered Chub)	*Cyprinodon rubrofluviatilis* (Red River Pupfish)
Notemigonus crysoleucas (Golden Shiner)	*Morone chrysops* (White Bass)
Notropis girardi (Arkansas River Shiner)	*Lepomis cyanellus* (Green Sunfish)
Notropis stramineus (Sand Shiner)	*Lepomis humilis* (Orangespotted Sunfish)
Phenacobius mirabilis (Suckermouth Minnow)	*Lepomis macrochirus* (Bluegill)
Pimephales promelas (Fathead Minnow)	*Lepomis megalotis* (Longear Sunfish)

Pimephales vigilax (Bullhead Minnow)	*Lepomis microlophus* (Redear Sunfish)
Platygobio gracilis (Flathead Chub)	*Micropterus salmoides* (Largemouth Bass)
Ameiurus melas (Black Bullhead)	*Sander vitreus* (Walleye)
Ictalurus punctatus (Channel Catfish)	

Macrhybopsis tetranema

Peppered Chub

Status: SGCN

Threats in Canadian River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Pigment nearly confined to dorsal half of body; medium-large melanophores scattered over dorsolateral surface; head conical, flattened ventrally with long and relatively pointed snout; lips fleshy and thickened posteriorly; two distinct pairs of barbels present (Eisenhour 1999).

Range in Texas: Only in portions of the upper South Canadian River (Eisenhour 1999; Luttrell et al. 1999; Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in streams (Eisenhour 2004).

Biology: Generalist, bottom feeder; spawns May- August, multiple times per year (Bottrell et al. 1964; Bonner 2000; Durham and Wilde 2005, 2006). Spawns under both high and low flows, as well as in pools (Bonner 2000). Eggs are broadcast by breeding females in the deeper part of the stream current (Bottrell et al. 1964).

Notropis girardi

Arkansas River Shiner

Status: federally threatened; state threatened; SGCN

Threats in Canadian River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Melanophores form a weak middorsal stripe anterior to the dorsal fin; in clear water, a black chevron is present at the base of the caudal fin (Wilde 2002). Upper sides of body without scattered, large melanophores; no pronounced dark markings on dorsal fin membranes (Hubbs et al. 2008).

Range in Texas: Canadian River (Hubbs et al. 2008).

Habitat: Shallow, slower moving water over mostly silt and shifting sand substrates (Gilbert 1980) in areas having high conductivity and low turbidity (Bonner 2000).

Biology: Generalist invertivore, feeding on organisms exposed by movement of the sand or washed downstream (Gilbert 1980; Wilde et al. 2001). Spawns April - August (Gilbert 1980; Bestgen et al. 1989; Bonner 2000; Wilde 2002; Hoagstrom and Brooks 2005; Durham and Wilde 2005) during high flows in main stream channel, after which eggs travel with current miles downstream (Gilbert 1980; Bestgen et al. 1989).

Phenacobius mirabilis

Suckermouth Minnow

Status: SGCN

Threats in Canadian River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Dark lateral stripe ending in a spot at base of caudal fin (Sublette et al. 1990). Lower lip thick with fleshy lobe on each side that is partially separated from mandible by a groove (Hubbs et al. 2008).

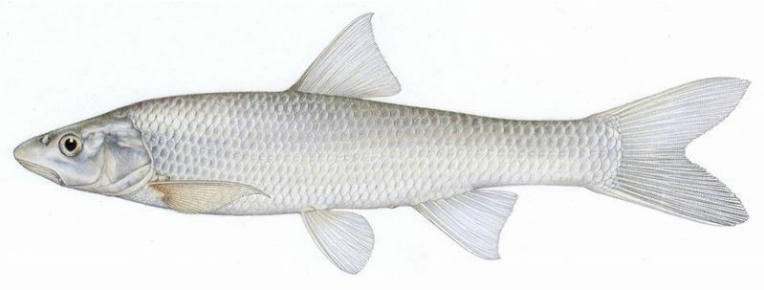
Range in Texas: Occurs in limited numbers in Canadian, Red, Sabine, Trinity and Colorado drainages (Wilde and Bonner 2000; Hubbs et al. 2008).

Habitat: Predominates in riffles and shallow race ways (Burr and Warren1986) and may move into shallow gravel riffles at night (Starrett 1950a; Deacon 1961).

Biology: Benthic grazing invertivore; feeds by probing the substrate with its sensitive snout and lips (Starrett 1950b). Spawns in late spring or early summer (Hubbs and Ortenburger 1929; Starrett 1951; Pflieger 1997) in gravelly riffles (Becker 1983).

Platygobio gracilis

Flathead Chub



Status: SGCN

Threats in Canadian River NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Body always silvery; small barbel present at corners of mouth (Hubbs et al. 2008).

Range in Texas: Canadian River (Hubbs et al. 2008).

Habitat: Found in strong currents over sandy bottoms and in shallow pools (Cross and Collins 1995).

Biology: Invertivore using both sight and taste buds associated with the barbels (Goldstein and Simon 1999). Pelagic, broadcast spawn in response to floods during April – August and needs more than 200 km of unimpounded river for successful reproduction (Bonner and Wilde 2000; Durham and Wilde 2006).

Cyprinodon rubrofluviatilis

Red River Pupfish

Status: SGCN

Threats in Canadian River NFCA: habitat loss; hybridization with Sheepshead Minnow

Description: Juveniles, females, non-breeding males with a lateral and dorso-lateral series of brownish irregularly shaped blotches; females with spot at base of dorsal fin that is lacking in mature males; breeding males have bright blue iridescence in upper body, most intense in nape region; caudal fin bordered posteriorly with an intense black band; Abdomen naked anterior to pelvic fins (Echelle 1973; Hubbs et al. 2008).

Range: Endemic to upper Red and Brazos basins, introduced in the Canadian and Colorado basins (Echelle et al. 1977; Page and Burr 1997; Hubbs et al. 2008).

Habitat: River edges, channels, backwaters, over sand bottoms; euryhaline and eurythermal (Minckley et al. 1991).

Biology: High salinity tolerance, up to 150‰ (Hill and Holland 1971; Echelle et al. 1972; Higgins and Wilde 2005). Primarily a bottom-feeding omnivore (Echelle 1973) feeding on midge and other insect larvae (Miller and Robison 2004). Spawns February through November in territories maintained by individual males (Echelle 1973).

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Appendix 3 - Conservation Plans for Edwards Plateau NFCAs

Conservation Activities and Monitoring Guidelines for the Edwards Plateau Native Fish Conservation Areas

The NFCAs of the Edwards Plateau traverse the most geologically, hydrologically and biologically diverse region of Texas. Terrestrial landscapes are comprised of a mixture of grasslands, savannas, shrublands and woodlands with steep hills and riparian corridors throughout. The karst geology of the region created one of the most important features relative to the biological diversity and endemism, the Edwards, Edwards-Trinity, and Trinity aquifers. The primary threat is groundwater extraction and the resultant reduction or loss of spring flows.

This is also one of the fastest developing regions in the United States. The complexities at the interface of conservation and human population growth makes resource management even more challenging than usual. Areas being actively managed for conservation include the Llano River, Pedernales River and Blanco River, all through the Native Black Bass Initiative.

A multi-species, ecosystem approach to species conservation provides an improved method for addressing the common nature and magnitude of threats facing ecosystems and their component species. It is also improves efficiency, cost effectiveness and is more likely to succeed. This plan is designed to coordinate projects to improve water quality, increase water quantity, restore natural habitats, reduce impacts of non-native species, diminish stream system fragmentation, and restore proper function of springs, creeks, rivers, and riparian areas. It will only be effective if it is able to inform and influence water management, land-use planning and zoning, and land-management decisions that will determine current and future conditions of rivers and streams and the associated habitat quality for native fishes. Additionally, to provide long-term benefits to focal species populations, conservation actions must be coordinated at sufficient scales to meet all life history stages of these species and must adopt conservation approaches that are cost-effective and sustainable over time.

To accomplish this goal, it is necessary to develop a holistic, habitat-oriented approach to conservation of focal species, restore and protect habitat, restore habitat connectivity and reduce deleterious effects of non-native species. Threat factors need to be delineated and prioritized based on threat level and what can be managed. Currently known threats in the Edwards Plateau NFCAs are identified in the species accounts at the end of this document and include:

h. habitat fragmentation

i. barriers to migration

j. loss of natural flow regime

k. reduced stream flow

l. spring flow declines

m. habitat loss

n. non-native species – habitat modification, hybridization and competition

Objective 1: Protect and maintain intact, healthy habitats

- Determine locations and extent of healthy habitats.
- Assess degree of threats and limiting factors present in healthy habitats.
- Develop a priority list of stream segments for protection actions.
- Organize Technical Advisory Teams for individual stream segments to analyze current data, define challenges, determine conservation methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
    - Maintain floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
    - Maintain appropriate sediment transport.
    - Maintain native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.
    - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.
    - Seek appropriate easements, water rights acquisitions and flow agreements to maintain appropriate hydrologic conditions.
    - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor conservation efforts and assess benefits to focal species populations

Objective 2: Restore impacted habitats

- Determine locations, extent and type of impacted habitats.
- Assess degree of threats and limiting factors present in impacted habitats.
- Develop a priority list of stream segments for restoration actions.
- Organize Technical Advisory Teams for individual stream segments to analyze data, define challenges, determine restoration methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
    - Where feasible, restore floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
    - Restore appropriate sediment transport.

  - Restore native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.
  - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.
  - Seek appropriate easements, water rights acquisitions and flow agreements to improve appropriate hydrologic conditions.
  - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor restoration efforts and assess benefits to focal species populations.

Objective 3: Restore stream and habitat connectivity

- Inventory fish passage barriers and delineate impacts on ecology of focal species.
- Where feasible, diminish or remove fish passage barriers and restore aquatic connectivity.

Objective 4: Mitigate effects of invasive species

- Assess current status of focal species affected by invasive species.
- Develop methods for reducing non-native species in targeted areas.
- Develop methods to prevent introductions of non-native species and minimize impacts of existing invasive species.
- Restore or improve the ecological balance in habitats negatively affected by non-native, invasive or problem species.
- Reestablish genetic integrity of hybridized populations in targeted areas.

Objective 5: Organize networks of public and private landowners

- Provide technical guidance workshops, newsletters, social media, etc. to facilitate development and expansion of local citizen-based partnerships.
- Landowner networks should be committed to the cooperative conservation of land and water resources within the watershed.
- Landowner networks should promote values of functional upland, riparian, and stream systems and emphasize the conservation of native fish communities and supporting habitats.
- Landowner networks should work to reduce or eliminate activities on the landscape that degrade water quality, reduce water quantity, degrade riparian systems, favor non-native species, or fragment stream systems.
- Landowner networks should encourage an array of sustainable land-use activities that are compatible with aquatic resource conservation.
- Landowner networks promote collaboration across jurisdictional and land ownership boundaries.

Objective 6: Develop conservation demonstration areas

- Provide fishing, paddling, and hiking opportunities.
- Promote sustainable public use of rivers.
- Describe benefits to other native species.
- Demonstrate best management practices.
- Highlight restoration actions through educational kiosks.

Objective 7: Conduct research to fill critical information gaps

- Identify knowledge gaps critical to restoration and conservation of the focal species.
- Design and conduct research as needed to enhance conservation efforts outlined in Objectives 1-4.
- Initial sampling at representative locations within each NFCA should be quarterly and include:
    - Biological characteristics of focal species: population size, population structure (genetics & demographics), fecundity, food habits, habitat selectivity, flow-ecology relationships, associated species
    - Habitat structure: flow and discharge rates, channel width, channel morphology, substrate types, depth, cover, trends in surrounding land use
    - Water quality: temperature, pH, dissolved oxygen, conductivity, total dissolved solids, alkalinity, hardness, chemical and biological oxygen demand
- Threats and limiting factors for the focal species will determine the scale at which the monitoring is designed. As baseline data are developed, monitoring parameters can be modified and streamlined to address critical issues and needs for the focal species.

Objective 8: Adaptive management and reporting

- Develop annual and long-term reporting requirements to document acquired data, departures from plan and evaluations necessary for adaptive management.
- Determine research needs for refining restoration and management actions.
- Periodically modify strategies based on monitoring, evaluation and research results.
- Share information with the public in an easy to use and understandable format.

Fishes of the Nueces River NFCA

Focal species are highlighted in blue and non-native species are in red.

Lepisosteus oculatus (Spotted Gar)	*Ictalurus punctatus* (Channel Catfish)
Dorosoma cepedianum (Gizzard Shad)	*Oncorhynchus mykiss* (Rainbow Trout)
Dorosoma petenense (Threadfin Shad)	*Menidia beryllina* (Inland Silverside)
Campostoma anomalum (Central Stoneroller)	*Fundulus notatus* (Blackstripe Topminnow)

Cyprinella lepida (Plateau Shiner)	*Gambusia affinis* (Western Mosquitofish)
Cyprinella sp (Nueces River Shiner)	*Gambusia geiseri* (Largespring Gambusia)
Cyprinella venusta (Blacktail Shiner)	*Poecilia latipinna* (Sailfin Molly)
Cyprinus carpio (Common Carp)	*Lepomis auritus* (Redbreast Sunfish)
Dionda serena (Frio & Sabinal) Roundnose Minnow)	*Lepomis cyanellus* (Green Sunfish)
Dionda texensis (Nueces) Roundnose Minnow)	*Lepomis gulosus* (Warmouth)
Notemigonus crysoleucas (Golden Shiner)	*Lepomis macrochirus* (Bluegill)
Notropis amabilis (Texas Shiner)	*Lepomis megalotis* (Longear Sunfish)
Notropis stramineus (Sand Shiner)	*Lepomis microlophus* (Redear Sunfish)
Notropis texanus (Weed Shiner)	*Lepomis miniatus* (Redspotted Sunfish)
Notropis volucellus (Mimic Shiner)	*Micropterus dolomieu* (Smallmouth Bass)
Opsopoeodus emiliae (Pugnose Minnow)	*Micropterus salmoides* (Largemouth Bass)
Pimephales vigilax (Bullhead Minnow)	*Micropterus salmoides nuecensis* (Rio Grande largemouth bass)
Carpiodes carpio (River Carpsucker)	*Micropterus treculii* (Guadalupe Bass)
Moxostoma congestum (Gray Redhorse)	*Pomoxis annularis* (White Crappie)
Astyanax mexicanus (Mexican Tetra)	*Etheostoma lepidum* (Greenthroat Darter)
Ameiurus melas (Black Bullhead)	*Aplodinotus grunniens* (Freshwater Drum)
Ameiurus natalis (Yellow Bullhead)	*Herichthys cyanoguttatus* (Rio Grande Cichlid)
Ictalurus lupus (Headwater Catfish)	*Oreochromis aureus* (Blue Tilapia)

Cyprinella lepida

Plateau Shiner

Status: SGCN

Threats in Nueces NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Head blunt and rounded, upper jaw length greater than snout length; black median chin stripe extends no farther posteriorly than below the eye; interradial membranes of dorsal fin have melanophores (Hubbs et al. 2008).

Range: Endemic to the headwaters of the Frio, Sabinal (Richardson and Gold 1995; Edwards et al. 2004, Carson et al. 2014) and Guadalupe rivers (Mayden 1989).

Habitat: Found over gravel and limestone substrates (Page and Burr 1997; Edwards et al. 2004) in clear, cool, spring-fed headwaters (Hubbs 1954; Edwards et al. 2004).

Biology: Unknown, but likely similar to both Proserpine Shiner (*C. proserpina*) and Red Shiner (*C. lutrensis*).

Cyprinella sp

Nueces River Shiner

Status: SGCN

Threats in Nueces NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Head blunt and rounded, upper jaw length greater than snout length; black median chin stripe extends no farther posteriorly than below eye; interradial membranes of dorsal fin have melanophores (Hubbs et al. 2008).

Range: Endemic to the headwaters of the Nueces River (Richardson and Gold 1995; Edwards et al. 2004, Carson et al. 2014).

Habitat: Found over gravel and limestone substrates (Page and Burr 1997; Edwards et al. 2004) in clear, cool, spring-fed headwaters (Hubbs 1954; Edwards et al. 2004).

Biology: Unknown, but likely similar to the Plateau Shiner (*C. lepida*), Proserpine Shiner (*C. proserpina*) and Red Shiner (*C. lutrensis*).

Dionda serena

(Frio) Roundnose Minnow

Status: SGCN

Threats in Nueces NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Cross-hatched scale markings and double dashes along the lateral line; rounded caudal spot (Hubbs and Brown 1956; Edwards 1999). Black band through eye to snout (Hubbs et al. 2008).

Range: Endemic to the headwaters of the Frio and Sabinal rivers (Schönhuth et al. 2012; Carson et al. 2014)

Habitat: Spring-fed headwaters (Edwards 1999; Edwards et al. 2004; Hubbs et al. 2008).

Biology: Unknown, but likely similar to *D. texensis* and *D. diaboli* (Devils River Minnow).

Dionda texensis

(Nueces) Roundnose Minnow

Status: SGCN

Threats in Nueces NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Cross-hatched scale markings and double dashes along the lateral line; rounded caudal spot (Hubbs and Brown 1956; Edwards 1999). Black band through eye to snout (Hubbs et al. 1991).

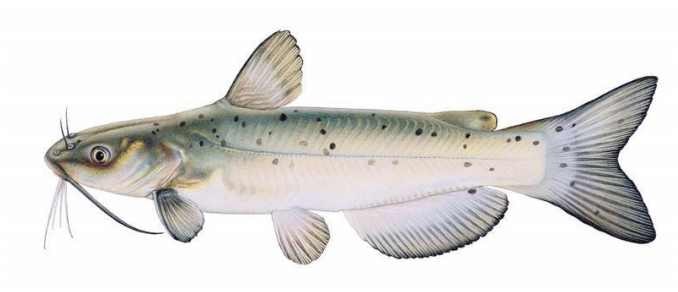
Range: Endemic to the headwaters of the Nueces River (Schönhuth et al. 2012; Carson et al. 2014)

Habitat: Unknown, but likely similar to (*D. serena*) and *D. diaboli* (Devils River Minnow).

Biology: Spawns in spring when water temperatures reach about 17-18°C; eggs heavy and non-adhesive (Hubbs 1951).

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in Nueces NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

Range in Texas: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990). Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also

occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al. 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. It is likely similar to Channel Catfish in most respects.

Micropterus salmoides nuecensis

Rio Grande Largemouth Bass

Status: SGCN

Threats in Nueces NFCA: habitat loss; hybridization with Florida Largemouth Bass

Description: Glossohyal tooth patch (Bailey and Hubbs 1949, Edwards 1980). Genetically distinct based on nuclear microsatellite markers (Lutz-Carrillo et al. 2006).

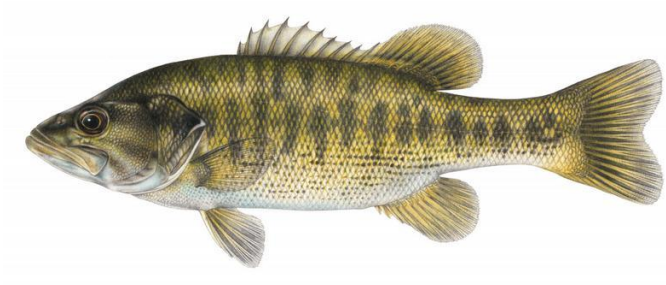
Range: Original distribution thought to be from the Nueces River in Texas to the Río Soto La Marina, Mexico (Bailey and Hubbs 1949, Edwards 1980), currently in the upper Devils River.

Habitat: unknown, but likely similar to *M. salmoides.*

Biology: unknown, but likely similar to *M. salmoides.*

Micropterus treculii

Guadalupe Bass



Status: SGCN; State Fish of Texas

Threats in Nueces NFCA: reductions in stream flow; habitat loss; fragmentation; hybridization with Smallmouth Bass

Description: Distinctive black, diamond-shaped pattern along sides and rows of spots that form stripes on its belly; jaw does not extend beyond eye; glossohyal teeth present on tongue (Hubbs and Bailey 1942; Garrett 1991).

Range: Endemic to the streams of the northern and eastern Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio basins; species also found outside of the Edwards Plateau streams in decreased abundance, primarily in the lower Colorado River; two introduced populations have been established in the Nueces River system (Garrett 1991; Hubbs et al. 2008).

Habitat: Prefers small lentic environments in flowing water; absent from extreme headwaters; smaller fish occur in rapids, often near eddies; large individuals found mainly in riffle tail races; uses large rocks, cypress knees, stumps and similar types of cover for refuge (Hubbs et al. 1953; Edwards 1980; Garrett 1991; Edwards 1997).

Biology: Food preferences include larval ephemeropterans, fishes, aquatic dipteran larvae and terrestrial hymenopterans (Hurst et al. 1975; Edwards 1980). Males tend to build nests near a source of slow to moderately moving water from early March through May or June (Hurst et al 1975; Edwards 1980; Garrett 1991; Edwards 1997), with an apparent secondary spawning period in the late summer and fall (Edwards 1980; Edwards 1997).

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Fishes of the San Antonio/Guadalupe NFCA

Focal species are highlighted in blue and non-native species are in red.

Lepisosteus oculatus (Spotted Gar)	*Trogloglanis pattersoni* (Toothless Blindcat)
Lepisosteus osseus (Longnose Gar)	*Menidia beryllina* (Inland Silverside)
Dorosoma cepedianum (Gizzard Shad)	*Fundulus grandis* (Gulf Killifish)
Campostoma anomalum (Central Stoneroller)	*Fundulus notatus* (Blackstripe Topminnow)
Cyprinella lutrensis (Red Shiner)	*Lucania parva* (Rainwater Killifish)
Cyprinella venusta (Blacktail Shiner)	*Gambusia affinis* (Western Mosquitofish)
Cyprinus carpio (Common Carp)	*Gambusia geiseri* (Largespring Gambusia)
Dionda flavipinnis ((Guadalupe) Roundnose Minnow)	*Poecilia latipinna* (Sailfin Molly)
Dionda nigrotaeniata ((Medina) Roundnose Minnow)	*Lepomis auritus* (Redbreast Sunfish)
Macrhybopsis marconis (Burrhead Chub)	*Lepomis cyanellus* (Green Sunfish)
Notemigonus crysoleucas (Golden Shiner)	*Lepomis gulosus* (Warmouth)
Notropis amabilis (Texas Shiner)	*Lepomis humilis* (Orangespotted Sunfish)
Notropis buchanani (Ghost Shiner)	*Lepomis macrochirus* (Bluegill)
Notropis stramineus (Sand Shiner)	*Lepomis megalotis* (Longear Sunfish)
Notropis texanus (Weed Shiner)	*Lepomis microlophus* (Redear Sunfish)
Notropis volucellus (Mimic Shiner)	*Lepomis miniatus* (Redspotted Sunfish)
Pimephales promelas (Fathead Minnow)	*Micropterus dolomieu* (Smallmouth Bass)
Pimephales vigilax (Bullhead Minnow)	*Micropterus punctulatus* (Spotted Bass)
Carpiodes carpio (River Carpsucker)	*Micropterus salmoides* (Largemouth Bass)
Erimyzon sucetta (Lake Chubsucker)	*Micropterus treculii* (Guadalupe Bass)
Moxostoma congestum (Gray Redhorse)	*Pomoxis annularis* (White Crappie)
Astyanax mexicanus (Mexican Tetra)	*Pomoxis nigromaculatus* (Black Crappie)
Ameiurus melas (Black Bullhead)	*Etheostoma lepidum* (Greenthroat Darter)
Ameiurus natalis (Yellow Bullhead)	*Etheostoma pulchellum*
Ictalurus lupus (Headwater Catfish)	*Percina apristis* (Guadalupe Darter)
Ictalurus punctatus (Channel Catfish)	*Percina carbonaria* (Texas Logperch)
Pylodictis olivaris (Flathead Catfish)	*Herichthys cyanoguttatus* (Rio Grande Cichlid)
Satan eurystomus (Widemouth Blindcat)	

Dionda flavipinnis

(Guadalupe) Roundnose Minnow

Status: SGCN

Threats in San Antonio/Guadalupe NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Dorsal region dusky; black band through eye to snout; black, rounded caudal spot (Cope 1880; Hubbs et al. 2008).

Range: Guadalupe and southern Colorado drainages (Schönhuth et al. 2012).

Habitat: Primarily restricted to clear spring-fed waters that have slight temperature variations (Jurgens 1951; Brown 1953; Hubbs et al. 1953; Kuehne 1955; Tilton 1961; Wayne 1979).

Biology: Vegetation (e.g., green filamentous algae) is the main component of diet (Wayne 1979). Spawns from January – August with peaks occurring April - May and July - August (Wayne 1979; Wayne and Whiteside 1985).

Dionda nigrotaeniata

(Medina) Roundnose Minnow

Status: SGCN

Threats in San Antonio/Guadalupe NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Similar to *D. flavipinnis*. Dorsal region dusky; black band through eye to snout; black, rounded caudal spot. (Cope 1880; Hubbs et al. 2008).

Range: upper Medina River (Schönhuth et al. 2012).

Habitat: Unknown, but likely similar to *D. episcopa* and *D. flavipinnis*.

Biology: Unknown, but likely similar to *D. episcopa* and *D. flavipinnis*.

Macrhybopsis marconis

Burrhead Chub

Status: SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Lateral stripe distinct along side of body; one pair of maxillary barbels; pale olive dorsally and silvery-white ventrally with broad silver lateral stripe; small melanophores on posterior dorsolateral scales

concentrated to form submarginal band on scales appearing as vague diamond pattern (Eisenhour 2004; Hubbs et al. 2008).

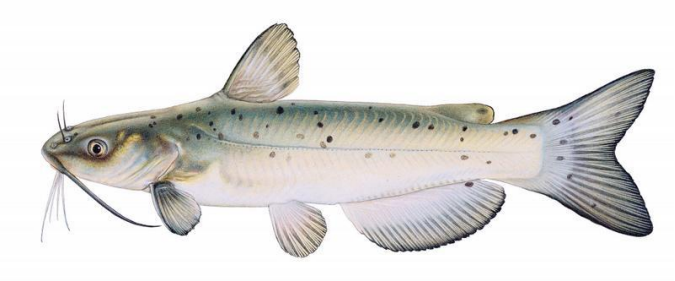
Range: Endemic to the San Antonio and Guadalupe rivers; remnant populations may exist in the Edwards Plateau portion of the Colorado River (Eisenhour 2004; Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in medium to large streams; found to be most abundant in riffles over large gravel and cobble (Eisenhour 2004).

Biology: Likely similar to *M. aestivalis* with a diet consisting of small insects, crustaceans and plant material; sedentary when not seeking food (Miller et al. 2005).

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in San Antonio/Guadalupe NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

Range in Texas: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990) Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al., 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. It is likely similar to Channel Catfish in most respects.

Satan eurystomus

Widemouth Blindcat

Status: state threatened; SGCN

Threats in San Antonio/Guadalupe NFCA: aquifer depletion; pollution

Description: Eyeless; body is white or pink in color (Page and Burr 1997). Well-developed teeth on jaws; lips at corner of mouth thick (Hubbs and Bailey 1947; Hubbs et al. 2008). The swim bladder has been replaced with adipose tissue as an adaptation to the hydrostatic pressure where they live; other adaptations include highly developed sensory systems, lower metabolic rates, smaller body size (50-100 mm) and longer life cycles (Sneegas and Hendrickson 2004).

Range: San Antonio Pool of the Edwards Aquifer (Cooper and Longley 1980; Page and Burr 1997; Warren et al. 2000; Hubbs et al. 2008).

Habitat: Subterranean waters (Page and Burr 1997) at depths of 300 - 600 m (Cooper and Longley 1980; Hubbs et al. 2008);

Biology: Opportunistic predator (Longley and Karnei 1979) feeding on decapods, amphipods and isopods. It also probably preys on the Toothless Blindcat (Sneegas and Hendrickson 2004).

Troglogianis pattersoni

Toothless Blindcat

Status: state threatened; SGCN

Threats in San Antonio/Guadalupe NFCA: aquifer depletion; pollution

Description: Eyeless; body is white or pink in color (Page and Burr 1997). Small body with toothless sucker-mouth (Langecker and Longley 1993).

Range: San Antonio Pool of the Edwards Aquifer (Cooper and Longley 1980; Page and Burr 1997; Warren et al. 2000; Hubbs et al. 2008).

Habitat: Subterranean waters (Page and Burr 1997) at depths of 300 - 600 m (Cooper and Longley 1980; Hubbs et al. 2008);

Biology: Thought to be a detritivore (Langecker and Longley 1993) feeding on dead or dying invertebrates and a fungus commonly found in the Edwards Aquifer (Sneegas and Hendrickson 2004).

Micropterus treculii

Guadalupe Bass

Status: SGCN; State Fish of Texas

Threats in San Antonio/Guadalupe NFCA: reductions in stream flow; habitat loss; fragmentation; hybridization with Smallmouth Bass

Description: Distinctive black, diamond-shaped pattern along sides and rows of spots that form stripes on its belly; jaw does not extend beyond eye; glossohyal teeth present on tongue (Hubbs and Bailey 1942; Garrett 1991).

Range: Endemic to the streams of the northern and eastern Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio basins; species also found outside of the Edwards Plateau streams in decreased abundance, primarily in the lower Colorado River; two introduced populations have been established in the Nueces River system (Garrett 1991; Hubbs et al. 2008).

Habitat: Prefers small lentic environments in flowing water; absent from extreme headwaters; smaller fish occur in rapids, often near eddies; large individuals found mainly in riffle tail races; uses large rocks, cypress knees, stumps and similar types of cover for refuge (Hubbs et al. 1953; Edwards 1980; Garrett 1991; Edwards 1997).

Biology: Food preferences include larval ephemeropterans, fishes, aquatic dipteran larvae and terrestrial hymenopterans (Hurst et al. 1975; Edwards 1980). Males tend to build nests near a source of slow to moderately moving water from early March through May or June (Hurst et al 1975; Edwards 1980; Garrett 1991; Edwards 1997), with an apparent secondary spawning period in the late summer and fall (Edwards 1980; Edwards 1997).

Percina apristis

Guadalupe Darter

Status: SGCN

Threats in San Antonio/Guadalupe NFCA: loss of natural flow regime; habitat loss

Description: Olive colored, with seven distinct rectangular black blocks along the midline; proximal half of the spinous dorsal is black in males and gray in females; distal part is yellow to orange in males and clear to yellow in females, depending on the season; upper jaw extends to a point below the most anterior part of the eye (Hubbs 1954).

Range: Endemic to the Guadalupe River Basin (Hubbs 1954).

Habitat: Gravelly runs and riffles; most common under or around small boulders in the main current; seems to prefer moderately turbid water (Hubbs et al. 1953; Hubbs 1954; Robins and Page 2007).

Biology: Spawns from mid-January to mid-June (Brown 1955; Hubbs 1985).

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Fishes of the Colorado River NFCA

Focal species are highlighted in blue and non-native species are in red.

Lepisosteus osseus (Longnose Gar)	*Ictalurus punctatus* (Channel Catfish)
Anguilla rostrata (American Eel)	*Pylodictis olivaris* (Flathead Catfish)
Dorosoma cepedianum (Gizzard Shad)	*Menidia beryllina* (Inland Silverside)
Dorosoma petenense (Threadfin Shad)	*Fundulus grandis* (Gulf Killifish)
Campostoma anomalum (Central Stoneroller)	*Fundulus notatus* (Blackstripe Topminnow)
Carassius auratus (Goldfish)	*Fundulus zebrinus* (Plains Killifish)
Cyprinella lutrensis (Red Shiner)	*Gambusia affinis* (Western Mosquitofish)
Cyprinella venusta (Blacktail Shiner)	*Gambusia geiseri* (Largespring Gambusia)
Cyprinus carpio (Common Carp)	*Gambusia heterochir* (Clear Creek Gambusia)
Dionda flavipinnis (Guadalupe) Roundnose Minnow)	*Poecilia latipinna* (Sailfin Molly)
Dionda sp 3 (Colorado) Roundnose Minnow)	*Cyprinodon rubrofluviatilis* (Red River Pupfish)
Hybognathus placitus (Plains Minnow)	*Morone chrysops* (White Bass)
Macrhybopsis hyostoma (Shoal Chub)	*Lepomis auritus* (Redbreast Sunfish)
Macrhybopsis marconis (Burrhead Chub)	*Lepomis cyanellus* (Green Sunfish)
Notemigonus crysoleucas (Golden Shiner)	*Lepomis gulosus* (Warmouth)
Notropis amabilis (Texas Shiner)	*Lepomis humilis* (Orangespotted Sunfish)
Notropis buccula (Smalleye Shiner)	*Lepomis macrochirus* (Bluegill)
Notropis buchanani (Ghost Shiner)	*Lepomis megalotis* (Longear Sunfish)
Notropis oxyrhynchus (Sharpnose Shiner)	*Lepomis microlophus* (Redear Sunfish)
Notropis stramineus (Sand Shiner)	*Lepomis miniatus* (Redspotted Sunfish)
Notropis texanus (Weed Shiner)	*Micropterus punctulatus* (Spotted Bass)
Notropis volucellus (Mimic Shiner)	*Micropterus dolomieu* (Smallmouth Bass)

Opsopoeodus emiliae (Pugnose Minnow)	*Micropterus salmoides* (Largemouth Bass)
Phenacobius mirabilis (Suckermouth Minnow)	*Micropterus treculii* (Guadalupe Bass)
Pimephales promelas (Fathead Minnow)	*Pomoxis annularis* (White Crappie)
Pimephales vigilax (Bullhead Minnow)	*Pomoxis nigromaculatus* (Black Crappie)
Carpiodes carpio (River Carpsucker)	*Etheostoma lepidum* (Greenthroat Darter)
Carpiodes cyprinus (Quillback)	*Etheostoma pulchellum*
Ictiobus bubalus (Smallmouth Buffalo)	*Percina carbonaria* (Texas Logperch)
Minytrema melanops (Spotted Sucker)	*Percina macrolepida* (Bigscale Logperch)
Moxostoma congestum (Gray Redhorse)	*Percina sciera* (Dusky Darter)
Astyanax mexicanus (Mexican Tetra)	*Aplodinotus grunniens* (Freshwater Drum)
Ameiurus melas (Black Bullhead)	*Herichthys cyanoguttatus* (Rio Grande Cichlid)
Ameiurus natalis (Yellow Bullhead)	*Oreochromis aureus* (Blue Tilapia)
Ictalurus lupus (Headwater Catfish)	

Anguilla rostrata

American Eel

Status: SGCN

Threats in Colorado NFCA: barriers to migration; habitat loss

Description: Body snakelike, lacking pelvic fins and dorsal fin is continuous with caudal and anal (Page and Burr 1997). Mouth large, slightly oblique; gape extended to posterior margin of eye; teeth in bands on jaws and vomer; scales small, cycloid and embedded (Hardy 1978).

Range: This species is known from most of the Atlantic and Gulf coasts of North America, including the Caribbean coasts of Central and South America to Brazil. Texas records include specimens from the Red River to the Rio Grande in most of the large river systems of the state. Dams impede the upstream migrations of the species and have effectively eradicated the species in the western part of the state (Koster 1957; Hubbs and Echelle 1973; Hubbs et al. 2008).

Habitat: The species is found in a wide range of habitats (Helfman et al. 1987, Warren et al. 2000). Postlarval eels tend to be bottom-dwellers, hiding in burrows, tubes, snags, plant masses, other types of shelter, or the substrate itself (Fahay 1978; Van Den Avyle 1984).

Biology: American Eel is carnivorous, the main food items are fishes and invertebrates (Goldstein and Simon 1999). American Eel exhibits facultative catadromy, has multiple life stages, is semelparous and

panmictic. Sexual maturity is not reached until at least 5 years, and often 20+ years for females (Hardy 1978; Haro et al. 2000); Males reported to mature at about 280 mm, and females at about 460 mm; however females may mature at lesser sizes (Hardy 1978).

Dionda flavipinnis

(Guadalupe) Roundnose Minnow

Status: SGCN

Threats in Colorado NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Dorsal region dusky, black band through eye to snout; black, rounded caudal spot. (Cope 1880; Hubbs et al. 2008).

Range: Endemic to Guadalupe and southern Colorado drainages (Schönhuth et al. 2012).

Habitat: Primarily restricted to clear spring-fed waters that have slight temperature variations (Jurgens 1951; Brown 1953; Hubbs et al. 1953; Kuehne 1955; Tilton 1961; Wayne 1979).

Biology: Vegetation (e.g., green filamentous algae) main component of diet (Wayne 1979). Spawns from January – August with peaks occurring April - May and July - August (Wayne 1979; Wayne and Whiteside 1985).

Dionda sp 3

(Colorado) Roundnose Minnow

Status: SGCN

Threats in Colorado NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Likely similar to *D. flavipinnis*: Dorsal region dusky, black band through eye to snout; black, rounded caudal spot. (Cope 1880; Hubbs et al. 2008).

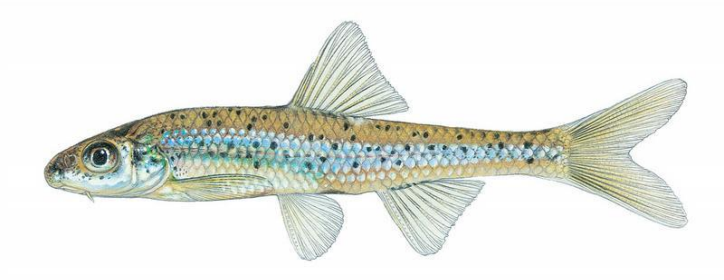
Range: Endemic to San Saba and Concho rivers, northern Colorado drainage (Schönhuth et al. 2012).

Habitat: Likely similar to *D. flavipinnis*: Primarily restricted to clear spring-fed waters that have slight temperature variations (Brown 1953; Hubbs et al. 1953; Jurgens 1951; Kuehne 1955; Tilton 1961; Wayne 1979).

Biology: Likely similar to *D. flavipinnis*: Vegetation (e.g., green filamentous algae) is the main component of diet (Wayne 1979). Spawns from January – August with peaks occurring April - May and July - August (Wayne 1979; Wayne and Whiteside 1985).

Macrhybopsis hyostoma

Shoal Chub



Status: SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Relatively large, oval eyes set high on head, cross-eyed appearance when viewed from above; one or two pairs of maxillary barbels; translucent pale green or gray dorsally, silvery white ventrally, with broad silver lateral stripe; small to large pigmentations on dorsal and lateral regions; pigmentation on fins variable, usually along rays of pectoral, pelvic, dorsal, anal and caudal fins (Eisenhour 2004).

Range in Texas: Sabine, Brazos and Colorado rivers (Underwood et al. 2003).

Habitat: Prefers streams with well-defined pools and riffles/runs, braided channels, and shifting sand/gravel bars. Considered a habitat specialist in habitats with clean sand or pea-size gravel substrates and moderate current velocities (Luttrell et al. 2002).

Biology: Feeds on aquatic insects, small crustaceans, and plant material (Starrett 1950). Likely similar to Peppered Chub (*Macrhybopsis tetranema*), which is a flood-pulse spawner (Bottrell et al. 1964; Miller and Robison 2004).

Macrhybopsis marconis

Burrhead Chub

Status: SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Lateral stripe distinct along side of body; one pair of maxillary barbels; pale olive dorsally and silvery-white ventrally with broad silver lateral stripe; small melanophores on posterior dorsolateral scales concentrated to form submarginal band on scales appearing as vague diamond pattern (Eisenhour 2004; Hubbs et al. 2008).

Range: Endemic to San Antonio and Guadalupe rivers; remnant populations may exist in the Edwards Plateau portion of the Colorado River (Eisenhour 2004; Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in medium to large streams; found to be most abundant in riffles over large gravel and cobble (Eisenhour 2004).

Biology: Likely similar to *M. aestivalis* with a diet consisting of small insects, crustaceans and plant material, sedentary when not seeking food (Miller et al. 2005).

Notropis buccula

Smalleye Shiner

Status: federally endangered; state endangered; SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Black pigments outlining dorsal scales, especially posterior to dorsal fin; dorsal stripe conspicuously interrupted in base of dorsal fin, producing a dark dash at base of dorsal fin (Hubbs et al. 2008).

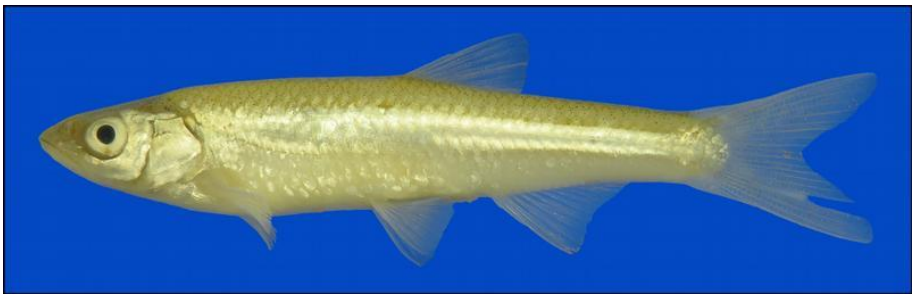
Range: Endemic to the Brazos River watershed; presumed to have been introduced into the Colorado River (Hubbs et al. 2008).

Habitat: Common in river channels or periphery of channels in water with moderate depth and current velocities; substrate usually sand or silt (Moss and Mayes 1993).

Biology: Opportunistic invertivore consuming aquatic insects, primarily dipterans, terrestrial insects, detritus, and plant material (Moss and Mayes 1993; Marks et al. 2001). Pelagic, broadcast spawner, producing multiple cohorts of semi-buoyant eggs within a spawning season; may spawn synchronously during pulse flows (Durham 2007, Wilde and Urbanczyk 2013).

Notropis oxyrhynchus

Sharpnose Shiner



Status: federally endangered; state endangered; SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Slightly falcate anal fin, dorsal fin begins well behind insertion of the pelvic fin (Hubbs et al. 2008).

Range: Endemic to Brazos River drainage. Thought to be introduced in the Colorado River drainage (Conner and Suttkus 1986).

Habitat: Usually found over sand substrate in moderate current velocities and depths (Ostrand and Wilde 2002; Durham 2007).

Biology: Generalist drift invertivore, consuming aquatic and terrestrial invertebrates, detritus, plant material and sand (Moss and Mayes 1993; Marks 1999, Marks et al. 2001). Pelagic, broadcast spawner during mid-May through September with multiple peaks (Durham 2007, Wilde and Urbanczyk 2013).

Phenacobius mirabilis

Suckermouth Minnow

Status: SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Dark lateral stripe ending in a spot at base of caudal fin (Sublette et al. 1990). Lower lip thick with fleshy lobe on each side that is partially separated from mandible by a groove (Hubbs et al. 2008).

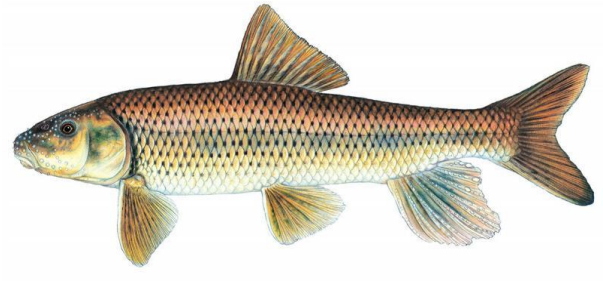
Range in Texas: Occurs in limited numbers in Canadian, Red, Sabine, Trinity and Colorado drainages (Wilde and Bonner 2000; Hubbs et al. 2008).

Habitat: Predominates in riffles and shallow race ways (Burr and Warren1986) and may move into shallow gravel riffles at night (Starrett 1950a; Deacon 1961).

Biology: Benthic grazing invertivore; feeds by probing the substrate with its sensitive snout and lips (Starrett 1950b). Spawns in late spring or early summer (Hubbs and Ortenburger 1929; Starrett 1951; Pflieger 1997) in gravelly riffles (Becker 1983).

Minytrema melanops

Spotted Sucker



Status: disjunct population in the Llano River

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; siltation

Description: Slim-bodied (Miller and Robison 2004) with rows of black spots along sides (Hubbs et al. 2008). Lips fairly thin and plicate (Miller and Robison 2004).

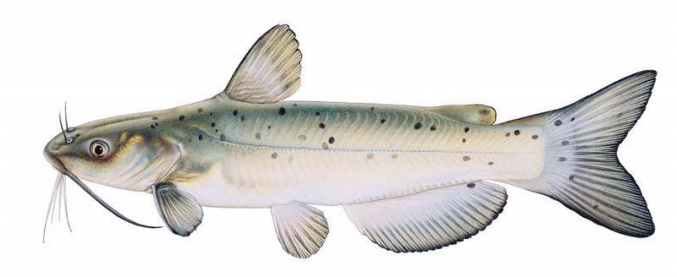
Range: Ranges widely throughout U.S. and in Texas is found primarily in east Texas streams from the Red to the Brazos basins. An isolated, disjunct population occurs in the Llano River near Junction downstream to about Mason (Hubbs et al. 2008). This may be an introduced population (Lowman 1957).

Habitat: Typically in clear creeks with firm substrates (Gilbert and Burgess 1980).

Biology: Invertivore/herbivore (Becker 1983). Spawns March – June (Edwards 1999) over rock and gravel with pelagic free embryos (Simon 1999).

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in Colorado NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

Range: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990) Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al., 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. It is likely similar to Channel Catfish in most respects.

Gambusia heterochir

Clear Creek Gambusia


Status: federally endangered; state endangered; SGCN

Threats in Colorado NFCA: diminished spring flows; hybridization with Western Mosquitofish

Description: Relatively stocky gambusia with a metallic sheen; scattered terminal dark marks on many lateral or dorsal scales form distinctive crescentric marks; females have a more pronounced anal spot than that found in *G. affinis*; males are distinct in having a unique notch in their pectoral fins (Hubbs et al. 2002).

Range: Endemic to headwaters of Clear Creek, Menard County (Hubbs et al. 2002).

Habitat: Impounded headwater spring pool of Clear Creek formed by a small earthen 2-m wide dam built in 1880 (Hubbs et al. 2002).

Biology: Females have an interbrood interval of 48-60 days (Yan 1986). Males place their gonopodia on their unique pectoral fins during copulation (Peden 1970).

Cyprinodon rubrofluviatilis

Red River Pupfish

Status: SGCN

Threats in Colorado NFCA: habitat loss; hybridization with Sheepshead Minnow

Description: Juveniles, females, non-breeding males with a lateral and dorso-lateral series of brownish irregularly shaped blotches; females with spot at base of dorsal fin that is lacking in mature males; breeding males have bright blue iridescence in upper body, most intense in nape region; caudal fin bordered posteriorly with an intense black band; abdomen naked anterior to pelvic fins (Echelle 1973; Hubbs et al. 2008).

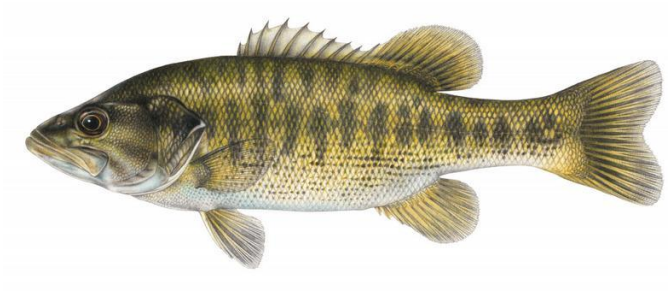
Range: Endemic to upper Red and Brazos basins, introduced in the Canadian and Colorado basins (Echelle et al. 1977; Page and Burr 1997; Hubbs et al. 2008).

Habitat: River edges, channels, backwaters, over sand bottoms; euryhaline and eurythermal (Minckley et al. 1991).

Biology: High salinity tolerance, up to 150‰ (Hill and Holland 1971; Echelle et al. 1972; Higgins and Wilde 2005). Primarily a bottom-feeding omnivore (Echelle 1973) feeding on midge and other insect larvae (Miller and Robison 2004). Spawns February through November in territories maintained by individual males (Echelle 1973).

Micropterus treculii

Guadalupe Bass



Status: SGCN; State Fish of Texas

Threats in Colorado NFCA: reductions in stream flow; habitat loss; fragmentation; hybridization with Smallmouth Bass

Description: Distinctive black, diamond-shaped pattern along sides and rows of spots that form stripes on its belly; jaw does not extend beyond eye; glossohyal teeth present on tongue (Hubbs and Bailey 1942; Garrett 1991).

Range: Endemic to the streams of the northern and eastern Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio basins; species also found outside of the Edwards Plateau streams in decreased abundance, primarily in the lower Colorado River; two introduced populations have been established in the Nueces River system (Garrett 1991; Hubbs et al. 2008).

Habitat: Prefers small lentic environments in flowing water; absent from extreme headwaters; smaller fish occur in rapids, often near eddies; large individuals found mainly in riffle tail races; uses large rocks, cypress knees, stumps and similar types of cover for refuge (Hubbs et al. 1953; Edwards 1980; Garrett 1991; Edwards 1999).

Biology: Food preferences include larval ephemeropterans, fishes, aquatic dipteran larvae and terrestrial hymenopterans (Hurst et al. 1975; Edwards 1980). Males tend to build nests near a source of slow to moderately moving water from early March through May or June (Hurst et al 1975; Edwards 1980; Garrett 1991; Edwards 1999), with an apparent secondary spawning period in the late summer and fall (Edwards 1980; Edwards 1999).

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Appendix 4 - Conservation Plans for Chihuahuan Desert NFCAs

Conservation Activities and Monitoring Guidelines for the Chihuahuan Desert Native Fish Conservation Areas

The NFCAs of the Chihuahuan Desert region are comprised of the most remote watersheds in the state. The Rio Grande NFCA is functionally composed of two very diverse segments (above and below Mariscal Canyon) with distinct differences in base flow, sediment movement and water quality. These differences are primarily due to reduced base flow and water quality in the upper segment and considerable spring flow inputs and improved water quality in the lower segment.

Agricultural and municipal water diversions have greatly diminished water quantity in the upper part of the Pecos River NFCA and increased salinity to near that of seawater. Inputs from Independence Creek and other springs greatly improve water quality and quantity in the lower segment. Other threats include groundwater extraction, oil and gas development and invasive species. Included in the Pecos NFCA are the Balmorhea Springs Complex and streams in the Guadalupe Mountains and Davis Mountains. The Balmorhea Springs Complex was once a massive ciénega system fed by spring flows of more than 20 million gallons per day. Because of groundwater pumping and draining ciénegas for agriculture, today there are only refuge ciénegas and canals for habitat. McKittrick Creek (Guadalupe Mountains) and Little Aguja Creek (Davis Mountains) are very small systems with very unique attributes. The Balmorhea Springs Complex, McKittrick Creek and Little Aguja Creek connect to the Pecos River only during extremely high water events.

A significant threat that is (so far) unique to the Rio Grande and Pecos NFCAs is the establishment of the invasive giant reed (*Arundo donax*) and saltcedar (*Tamarix* spp.) These non-native plants have effectively channelized stream segments and the resulting constricted flow has reduced shallow, backwater habitat and changed bottom sediments from a mixture of sand and gravels to one of primarily larger gravels and cobble. The effect of the dense stands has also armored and stabilized the riverbanks, thus preventing natural sediments and sand to be available for habitat within the river itself (Garrett and Edwards 2014).

The Devils River NFCA is situated in an ecological transition zone at the confluence of three ecoregions (Edwards Plateau, Tamaulipan Thornscrub and Chihuahuan Desert) and as a result supports a high level of aquatic biodiversity and several endemic species. The primary threat is groundwater extraction and the resultant reduction or loss of spring flows.

Areas being actively managed for conservation include Big Bend National Park, Big Bend Ranch State Park, Alamito Creek watershed, Independence Creek and Devils River (Texas Parks and Wildlife Department and Nature Conservancy).

A multi-species, ecosystem approach to species conservation provides an improved method for addressing the common nature and magnitude of threats facing ecosystems and their component species. It is also improves efficiency, cost effectiveness and is more likely to succeed. This plan is designed to coordinate projects to improve water quality, increase water quantity, restore natural habitats, reduce impacts of non-native species, diminish stream system fragmentation, and restore proper function of springs, creeks, rivers, and riparian areas. It will only be effective if it is able to inform and influence water

management, land-use planning and zoning, and land-management decisions that will determine current and future conditions of rivers and streams and the associated habitat quality for native fishes. Additionally, to provide long-term benefits to focal species populations, conservation actions must be coordinated at sufficient scales to meet all life history stages of these species and must adopt conservation approaches that are cost-effective and sustainable over time.

To accomplish this goal, it is necessary to develop a holistic, habitat-oriented approach to conservation of focal species, restore and protect habitat, restore habitat connectivity and reduce deleterious effects of non-native species. Threat factors need to be delineated and prioritized based on threat level and what can be managed. Currently known threats in the Chihuahuan Desert NFCAs are identified in the species accounts at the end of this document and include:

a. habitat fragmentation
b. barriers to migration
c. loss of natural flow regime
d. reduced stream flow
e. spring flow declines
f. channel narrowing and sediment accumulation
g. habitat loss
h. non-native species – habitat modification, hybridization, competition and predation

Objective 1: Protect and maintain intact, healthy habitats

- Determine locations and extent of healthy habitats.
- Assess degree of threats and limiting factors present in healthy habitats.
- Develop a priority list of stream segments for protection actions.
- Organize Technical Advisory Teams for individual stream segments to analyze current data, define challenges, determine conservation methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
    - Maintain floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
    - Maintain appropriate sediment transport and avoid channel narrowing.
    - Maintain native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.
    - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.

  - Seek appropriate easements, water rights acquisitions and flow agreements to maintain appropriate hydrologic conditions.
  - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor conservation efforts and assess benefits to focal species populations

Objective 2: Restore impacted habitats

- Determine locations, extent and type of impacted habitats.
- Assess degree of threats and limiting factors present in impacted habitats.
- Develop a priority list of stream segments for restoration actions.
- Organize Technical Advisory Teams for individual stream segments to analyze data, define challenges, determine restoration methods and engage public support.
- Develop action plans for addressing the objectives, select the best watershed management alternatives, list strategies for implementing alternatives and determine appropriate milestones for measuring progress.
  - Where feasible, restore floodplain functions such as aquifer recharge, natural flow regime, base flows, spring flows, water quality, soil moistening, habitat diversity and sediment transport.
  - Restore appropriate sediment transport and reduce channel narrowing.
  - Restore native vegetation throughout stream segments, including riparian corridors, floodplains and upland areas.
  - Develop voluntary, non-regulatory tools such as financial incentives, conservation easements, landowner agreements and targeted acquisition.
  - Seek appropriate easements, water rights acquisitions and flow agreements to improve appropriate hydrologic conditions.
  - Adopt conservation approaches that are cost-effective and sustainable over time.
- Convene stakeholder groups to foster support of action plans.
- Monitor restoration efforts and assess benefits to focal species populations.

Objective 3: Restore stream and habitat connectivity

- Inventory fish passage barriers and delineate impacts on ecology of focal species.
- Where feasible, diminish or remove fish passage barriers and restore aquatic connectivity.

Objective 4: Mitigate effects of invasive species

- Assess current status of focal species affected by invasive species.
- Develop methods for reducing non-native species in targeted areas.

- Develop methods to prevent introductions of invasive species and minimize impacts of existing invasive species.
- Restore or improve the ecological balance in habitats negatively affected by non-native, invasive or problem species.
- Reestablish genetic integrity of hybridized populations in targeted areas.

Objective 5: Organize networks of public and private landowners

- Provide technical guidance workshops, newsletters, social media, etc. to facilitate development and expansion of local citizen-based partnerships.
- Landowner networks should be committed to the cooperative conservation of land and water resources within the watershed.
- Landowner networks should promote values of functional upland, riparian, and stream systems and emphasize the conservation of native fish communities and supporting habitats.
- Landowner networks should work to reduce or eliminate activities on the landscape that degrade water quality, reduce water quantity, degrade riparian systems, favor non-native species, or fragment stream systems.
- Landowner networks should encourage an array of sustainable land-use activities that are compatible with aquatic resource conservation.
- Landowner networks promote collaboration across jurisdictional and land ownership boundaries.

Objective 6: Develop conservation demonstration areas

- Provide fishing, paddling, and hiking opportunities.
- Promote sustainable public use of rivers.
- Describe benefits to other native species.
- Demonstrate best management practices.
- Highlight restoration actions through educational kiosks.

Objective 7: Conduct research to fill critical information gaps

- Identify knowledge gaps critical to restoration and conservation of the focal species.
- Design and conduct research as needed to enhance conservation efforts outlined in Objectives 1-4.
- Initial sampling at representative locations within each NFCA should be quarterly and include:
    - Biological characteristics of focal species: population size, population structure (genetics & demographics), fecundity, food habits, habitat selectivity, flow-ecology relationships, associated species
    - Habitat structure: flow and discharge rates, channel width, channel morphology, substrate types, depth, cover, trends in surrounding land use

  - Water quality: temperature, pH, dissolved oxygen, conductivity, total dissolved solids, alkalinity, hardness, chemical and biological oxygen demand

- Threats and limiting factors for the focal species will determine the scale at which the monitoring is designed. As baseline data are developed, monitoring parameters can be modified and streamlined to address critical issues and needs for the focal species.

Objective 8: Adaptive management and reporting

- Develop annual and long-term reporting requirements to document acquired data, departures from plan and evaluations necessary for adaptive management.
- Determine research needs for refining restoration and management actions.
- Periodically modify strategies based on monitoring, evaluation and research results.
- Share information with the public in an easy to use and understandable format.

Fishes of the Rio Grande NFCA

Focal species are highlighted in blue and non-native species are in red.

Scaphirhynchus platorynchus (Shovelnose Sturgeon)	*Moxostoma austrinum* (Mexican Redhorse)
Lepisosteus oculatus (Spotted Gar)	*Moxostoma congestum* (Gray Redhorse)
Lepisosteus osseus (Longnose Gar)	*Astyanax mexicanus* (Mexican Tetra)
Anguilla rostrata (American Eel)	Ameiurus *natalis* (Yellow Bullhead)
Dorosoma cepedianum (Gizzard Shad)	*Ictalurus furcatus* (Blue Catfish)
Dorosoma petenense (Threadfin Shad)	*Ictalurus* sp (Rio Grande Blue Catfish)
Campostoma ornatum (Mexican Stoneroller)	*Ictalurus* sp (Chihuahua Catfish)
Carassius auratus (Goldfish)	*Ictalurus lupus* (Headwater Catfish)
Cyprinella lutrensis (Red Shiner)	*Ictalurus punctatus* (Channel Catfish)
Cyprinella venusta (Blacktail Shiner)	*Pylodictis olivaris* (Flathead Catfish)
Cyprinus carpio (Common Carp)	*Menidia beryllina* (Inland Silverside)
Dionda sp 1 (Conchos Roundnose Minnow)	*Fundulus grandis* (Gulf Killifish)
Hybognathus amarus (Rio Grande Silvery Minnow)	*Fundulus zebrinus* (Plains Killifish)
Macrhybopsis aestivalis (Speckled Chub)	*Gambusia affinis* (Western Mosquitofish)
Notemigonus crysoleucas (Golden Shiner)	*Gambusia gaigei* (Big Bend Gambusia)
Notropis amabilis (Texas Shiner)	*Cyprinodon eximius* (Conchos Pupfish)
Notropis braytoni (Tamaulipas Shiner)	*Morone chrysops* (White Bass)
Notropis chihuahua (Chihuahua Shiner)	*Lepomis auritus* (Redbreast Sunfish)
Notropis jemezanus (Rio Grande Shiner)	*Lepomis cyanellus* (Green Sunfish)
Notropis orca (Phantom Shiner)	*Lepomis gulosus* (Warmouth)
Notropis stramineus (Sand Shiner)	*Lepomis macrochirus* (Bluegill)
Pimephales promelas (Fathead Minnow)	*Lepomis megalotis* (Longear Sunfish)
Pimephales vigilax (Bullhead Minnow)	*Lepomis microlophus* (Redear Sunfish)
Rhinichthys cataractae (Longnose Dace)	*Micropterus salmoides* (Largemouth Bass)
Carpiodes carpio (River Carpsucker)	*Pomoxis annularis* (White Crappie)
Cycleptus sp (Rio Grande Blue Sucker)	*Aplodinotus grunniens* (Freshwater Drum)

Ictiobus bubalus (Smallmouth Buffalo) *Ictiobus niger* (Black Buffalo)	*Herichthys cyanoguttatus* (Rio Grande Cichlid) *Oreochromis aureus* (Blue Tilapia)

Scaphirhynchus platorynchus

Shovelnose Sturgeon

Status: state threatened; SGCN; rare or extirpated in Rio Grande NFCA

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; sedimentation; loss of spawning habitat

Description: Flat, shovel-shaped snout surrounded by barbels; long, slender caudal peduncle flat in cross section and covered with bony scutes; upper lobe of caudal fin is greatly elongated (Hubbs 1958; Pflieger 1975; Page and Burr 1997).

Range in Texas: Currently found in the Red River below Lake Texoma Reservoir (Hubbs et al. 2008). Evidence of the presence of this species in the lower Pecos River during prehistoric times, strongly suggests that it likely occurred in many Texas rivers (Jurgens 2005; Hubbs et al. 2008). Cope and Yarrow (1875) reported Shovelnose Sturgeon in the Rio Grande near Albuquerque. Hubbs et al. (1977) obtained hearsay reports of sturgeon from near Dryden Crossing and from Mexican tributaries in Coahuila.

Habitat: Frequently inhabits flowing water over sandy bottoms or near rocky points or bars (Bailey and Cross 1954; Pflieger 1975; Page and Burr 1997; Keenlyne 1997).

Biology: Shovelnose Sturgeon feed by raking the bottom with sensitive barbels. Bulk of the diet made up of aquatic insect larvae (Lee 1980). Spawning normally occurs from April through early July with mature shovelnose migrating upriver to spawn over rocky substrates in flowing water. Larval fish drift in the water column for up to 12 days after hatching before settling out of the water column to begin the benthic phase of life (Kynard et al. 2002; Braaten et al. 2007). Adults do not spawn every year; frequency of spawning is influenced by food supply and ability to store adequate fat to produce gametes (Keenlyne 1997).

Anguilla rostrata

American Eel

Status: SGCN

Threats in Rio Grande NFCA: barriers to migration; habitat loss

Description: Body snakelike, lacking pelvic fins and dorsal fin is continuous with caudal and anal (Page and Burr 1997). Mouth large, slightly oblique; gape extended to posterior margin of eye; teeth in bands on jaws and vomer; Scales small, cycloid and embedded (Hardy 1978).

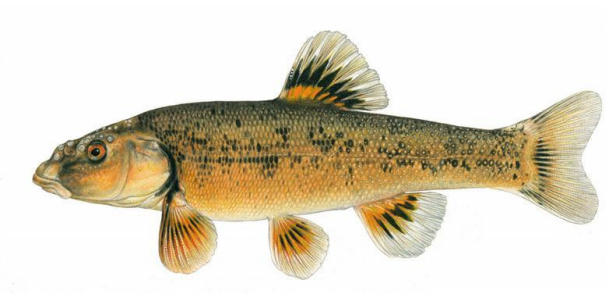
Range: This species is known from most of the Atlantic and Gulf coasts of North America, including the Caribbean coasts of Central and South America to Brazil. Texas records include specimens from the Red River to the Rio Grande in most of the large river systems of the state. Dams impede the upstream migrations of the species and have effectively eradicated the species in the western part of the state (Koster 1957; Hubbs and Echelle 1973; Hubbs et al. 2008).

Habitat: The species is found in a wide range of habitats (Helfman et al. 1987, Warren et al. 2000). Postlarval eels tend to be bottom-dwellers, hiding in burrows, tubes, snags, plant masses, other types of shelter, or the substrate itself (Fahay 1978; Van Den Avyle 1984).

Biology: American Eel is carnivorous, the main food items are fishes and invertebrates (Goldstein and Simon 1999). American Eel exhibits facultative catadromy, has multiple life stages, is semelparous and panmictic. Sexual maturity is not reached until at least 5 years, and often 20+ years for females (Hardy 1978; Haro et al. 2000); Males reported to mature at about 280 mm, and females at about 460 mm; however females may mature at lesser sizes (Hardy 1978).

Campostoma ornatum

Mexican Stoneroller



Status: state threatened; SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; reduced stream flow; competition with introduced Plains Killifish

Description: Most adults have mottled coloration typical of the genus; juveniles generally lack mottling but frequently have a dark mid-lateral stripe extending from snout to caudal peduncle and terminating in a small basicaudal spot; fins are typically transparent in both sexes, but the dorsal fin may have a black band prior to and during breeding season (Burr 1976).

Range: Occurs primarily in Mexico and ranges into Texas in Rio Grande tributaries in Brewster and Presidio counties (Hubbs 1940; Hubbs 1954; Hubbs et al. 2008).

Habitat: Favors gravel runs or gravel-bottom pools in shallow headwaters of tributaries; vegetation may or may not be present (Burr 1976).

Biology: Herbivorous, bottom feeder (Contreras-Balderas 1974) with a diet consisting mainly of diatoms, bacteria and algae (Burr 1976). Spawns in winter and spring (Hubbs and Wauer 1973). In Cienega Creek (tributary of Alamito Creek) on Big Bend Ranch State Park, there are only two fish species (*C. ornatum* and *Lepomis cyanellus*) and in an unpublished study (Garrett 1989) Mexican Stoneroller was found to have 75% relative abundance. In collections from Tornillo Creek, prior to the introduction of *F. zebrinus* (around 1954), *C. ornatum* was the most abundant fish (Hubbs and Wauer, 1973). In the period from 1967 to 1970, Hubbs and Wauer (1973) found that the relative abundance of this species in Tornillo Creek ranged from 0 to 17% and occurred in only 5 of 11 samples. Apparently, the introduced *Fundulus zebrinus* caused displacement of *C. ornatum*.

Dionda sp 1

Conchos Roundnose Minnow

Status: SGCN

Threats in Rio Grande NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Dark lateral stripe extends from snout to base of caudal and ends in a round spot (Hubbs and Brown 1956; Hubbs 1958).

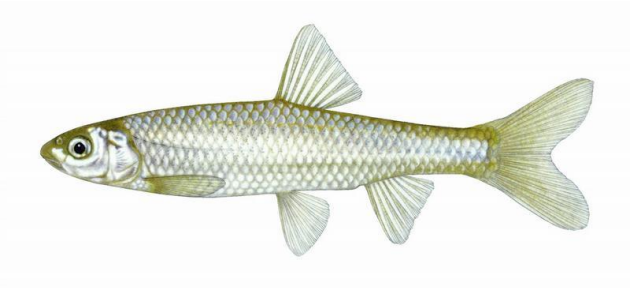
Range: Rìo Conchos and tributaries (e.g., Cibolo, Alamito, Terlingua and Tornillo creeks) in the Big Bend region of the Rio Grande (Schonhuth et al. 2012).

Habitat: Prefers clear, spring-fed waters of tributaries (Hubbs 1958).

Biology: Unknown, but likely similar to *Dionda argentosa* with a peak in reproduction during the fall (Cantu and Winemiller 1997).

Hybognathus amarus

Rio Grande Silvery Minnow



Status: federally endangered; state endangered; SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; reduced stream flow; habitat fragmentation; habitat loss; interactions with non-native species

Description: Back and upper sides silvery to olive with broad, greenish mid-dorsal stripe on lower sides and abdomen (Sublette et al. 1990). Subterminal mouth extends horizontally to almost the anterior margin of the orbit; snout is rounded and overhangs the upper lip when viewed ventrally; eye is small and orbit diameter is much less than gape width or snout length (Bestgen and Propst 1996).

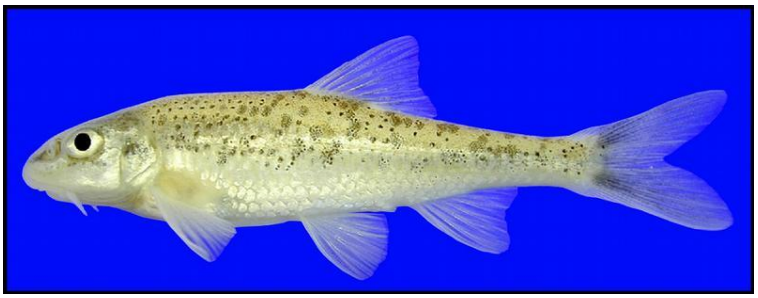
Range: Historically was one of the most abundant and widespread of the native fishes in the Rio Grande/Río Bravo and Pecos River, from northern New Mexico to the Gulf of Mexico. More recently, until reintroductions began in the Big Bend region, the fish had been confined to about seven percent of its historical range (US Fish and Wildlife Service 2010).

Habitat: During its various life stages, the Rio Grande silvery minnow uses relatively shallow, low velocity habitats with sandy and silty substrates, historically inhabiting a meandering river that included a diversity of aquatic habitats including side channels, oxbows, and backwaters (US Fish and Wildlife Service 2010). Most often found in areas of low or moderate water velocity (e.g., eddies formed by debris piles, pools, backwaters and embayments) and is rarely found in habitats with high water velocities, such as main channel runs (Dudley and Platania 1997, Watts et al. 2002, US Fish and Wildlife Service 2010).

Biology: Important food components include macroinvertebrates, aufwuch and epipsammic algae on benthic substrates (Cowley et al. 2006; USFWS 2010). The Rio Grande silvery minnow is a pelagic spawner (Platania 1995) that produces thousands of semibuoyant, non-adhesive eggs that passively drift while developing (Platania and Altenbach 1998). Spawning is associated with high and/or increased flow events such as spring runoff or summer rainstorms, and typically occurs over a relatively brief period in May or June (Platania and Dudley 2006).

Macrhybopsis aestivalis

Speckled Chub



Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Upper sides covered in fine speckles; the mouth is ventral with a pair of barbels on the upper jaw (Eisenhour 2004; Hubbs et al. 2008).

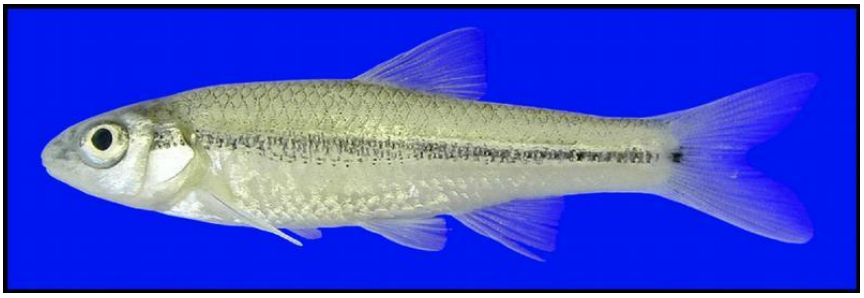
Range in Texas: Found primarily in the Rio Grande between the Río Conchos confluence and the Pecos River (Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in streams; typically found in raceways and runs (Eisenhour 2004). Bedrock, coarse gravel, or sand bottom under a strong to rapid current (Treviño 1955). Typically over small-gravel riffles or shifting sands (Miller et al. 2005; Garrett and Edwards 2014).

Biology: Diet consists of small insects, crustaceans and plant material; sedentary when not seeking food (Miller et al. 2005). Pelagic, broadcast spawner producing semibuoyant eggs that drift considerable distances downstream (Platania and Altenbach 1998).

Notropis braytoni

Tamaulipas Shiner



Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Distinct lateral stripe terminates in a basicaudal spot (Miller et al. 2005).

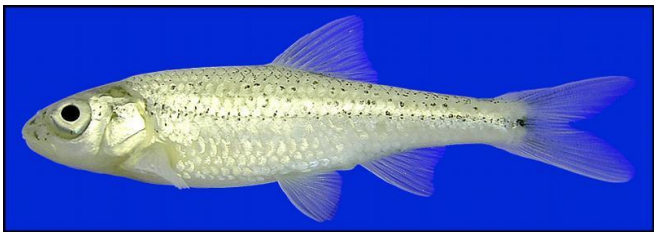
Range: Endemic to the Rio Grande (including the Devils River and lower Pecos River) in Texas and Río Conchos in Mexico (Edwards et al. 2004).

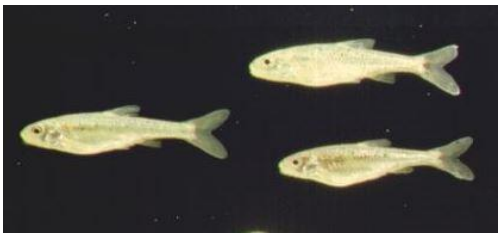
Habitat: Rocky and sandy channels of large creeks and small to medium rivers over substrates of rock and gravel to silt and mud (Page and Burr 1997; Miller et al. 2005). Typically does not exhibit narrow ecological limitations (Treviño 1955).

Biology: Diet consists primarily of aquatic insects (Contreras-Balderas 1974). Population abundance in Texas has declined in recent decades (Hubbs et al. 2008), with collections during the 1990s yielding no Tamaulipas Shiners below Amistad Reservoir to the mouth of the river. The decline in abundance is likely due to reservoir construction, dewatering of stream courses, and decreases in water quantity and quality (Edwards et al. 2004). Conversely, collections in the Big Bend region of the Rio Grande from 1977–2006 indicated that relative abundance has increased (Hubbs et al. 1977; Garrett and Edwards 2014).

Notropis chihuahua

Chihuahua Shiner





Status: state threatened; SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Upper sides of body with scattered, large melanophores (Hubbs et al. 2008).

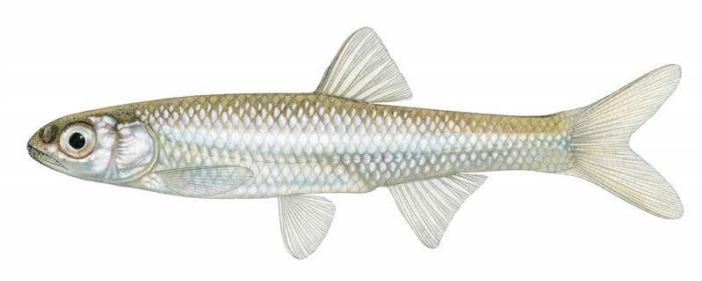
Range: Occurs only sporadically in tributaries in the Big Bend region of the Rio Grande, but is currently abundant in tributaries of the Río Conchos (Edwards et al. 2002).

Habitat: Typically in clear water with nearby springs, over gravel or sandy bottoms (Burr 1980; Burr and Mayden 1981) without dense vegetation (Hubbs 1958).

Biology: Feeds on small, aquatic insects; spawns from March through August (Miller et al. 2005).

Notropis jemezanus

Rio Grande Shiner



Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Mostly plain silvery, except for a faint dusky band; eye diameter equal to length of snout (Koster 1957)

Range: Endemic to the Rio Grande basin, including the Rio Grande, Pecos River (New Mexico and Texas), and the Río Conchos, San Juan and Salado drainages of Mexico, and was once abundant throughout the basin (Treviño 1955; Treviño-Robinson 1959). Now sparsely distributed in Texas in the Rio Grande downstream from the Río Conchos confluence to Amistad Reservoir and in Independence Creek in the lower Pecos River (Edwards et al. 2002). None have been taken below Amistad Reservoir since the mid-1990s (Edwards et al. 2004) or in New Mexico since 1949 (Platania 1991). This species has not been collected in Independence Creek since 1991 or in the lower Pecos River since 1987 (Hoagstrom 2003; Bonner et al. 2005).

Habitat: Main channel of rivers and streams over sand and small-gravel riffles with sparse vegetation (Miller et al. 2005; Garrett and Edwards 2014).

Biology: Primarily carnivorous-omnivorous (Sublette et al. 1990). Pelagic spawners with eggs and larvae that drift considerable distances downstream (Platania and Altenbach 1998).

Rhinichthys cataractae

Longnose Dace

Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Upper sides are dark or coarsely mottled; the mouth is ventral with a small barbel on the upper jaw (Hubbs 1958).

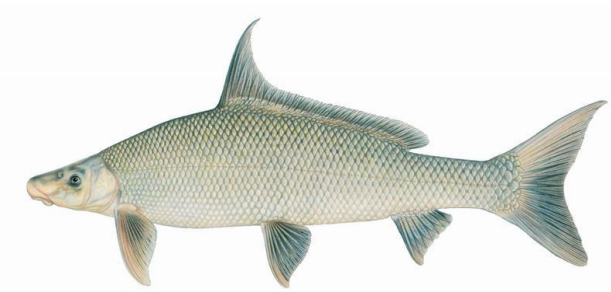
Range: Inhabits a widespread area of north-central North America south to throughout the Rio Grande in Texas downstream to about Laredo (Hubbs et al. 2008) and the Río Conchos basin in Mexico (Miller et al. 2005).

Habitat: Prefers clear, flowing water in gravelly riffles (Miller et al. 2005).

Biology: Adults feed on a variety of aquatic invertebrates, especially ephemeropterans and dipterans, as well as plant material (Gerald 1966). Spawns in riffles over gravelly bottoms; larvae are benthic (Balon 1990) and fry are pelagic, inhabiting quiet waters inshore (Scott and Crossman 1973).

Cycleptus sp.

Rio Grande Blue Sucker



Status: state threatened; SGCN

Threats in Rio Grande NFCA: habitat loss; fragmentation; loss of natural flow regime; reduced water quality

Description: Morphologically similar to *C. elongatus*, but lip papillae are longer, extending forward onto end of snout (Hubbs et al. 2008). Body color of *Cycleptus* sp. tends to be more golden or brassy than *C. elongatus* (Burr and Mayden 1999).

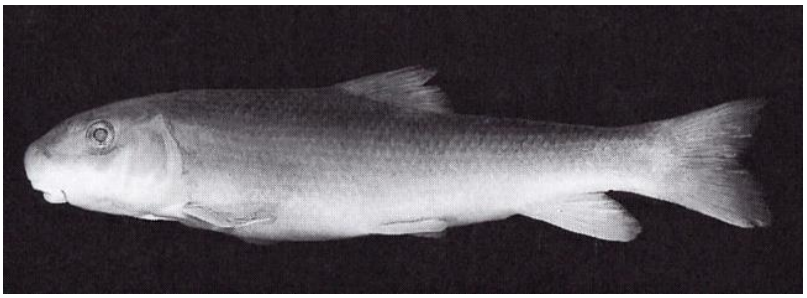
Range: Endemic to the Rio Grande basin (Bessert 2006).

Habitat: Requirements are likely very similar to *C. elongatus*. Typically found over cobble and bedrock substrates; adults occupy deep riffles in areas of very swift flow; juveniles occupy shallower, less swift water (Moss et al. 1983).

Biology: Rio Grande Blue Sucker probably spawns in March and April (Miller et al. 2005). Likely similar to *C. elongatus* by spawning in deep riffles with cobble and bedrock substrates (Moss et al. 1983). As with *C. elongatus*, adults probably winter in deep pools and move upstream in spring to spawn in riffles (Cross 1967). Males likely migrate into spawning area before females (Moss et al. 1983).

Moxostoma austrinum

Mexican Redhorse



Status: SGCN; rare in U.S., uncommon in Mexico

Threats in Big Bend NFCA: habitat loss; fragmentation; loss of natural flow regime; reduced water quality

Description: Pectoral fin length less than head length; width of eye goes nearly 5.5 times into head length; 47 - 50 scales along the lateral line. Closely related, and similar, to the Gray Redhorse.

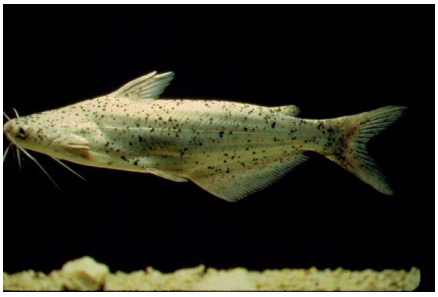
Range: Pacific coast drainages and Río Conchos system in Mexico to the mid-Rio Grande in Texas (Garrett and Edwards 2001; Hubbs et al. 2008). FoTX data shows distribution extends downstream through Maverick County.

Habitat: Rocky runs and riffles of creeks and small to medium rivers; often near boulders in swift water (Page and Burr 1997; Miller et al. 2005).

Biology: Nuptial tuberculation suggests spring spawning period (Jenkins 1980).

Ictalurus sp.

Rio Grande Blue Catfish



Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Differs in appearance from Blue Catfish in having small spots (1-2 mm) uniformly distributed over back and sides (Wilcox 1960; Graham 1999), 54 vertebrae (Rodiles-Hernandez et al. 2010) and 35-36 anal rays (Knapp 1953). Baird and Girard (1854) originally described it as a unique species, *Pimelodus affinis*, based in part on the unique coloration pattern. Knapp (1953) considered it a subspecies of Blue Catfish (*I. furcatus affinis*).

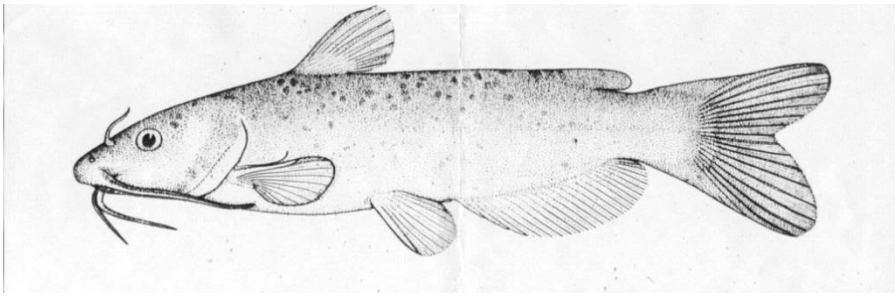
Range: Big Bend region of the Rio Grande to the vicinity of Laredo (Garrett and Edwards 2001).

Habitat: There are no studies on habitat requirements

Biology: There are no studies on biological aspects.

Ictalurus sp

Chihuahua Catfish



Status: SGCN

Threats in Rio Grande NFCA: habitat loss; hybridization with Channel Catfish

Description: 22 to 26 (usually 23-24) anal rays; 38 to 42 (usually 39-41) vertebrae; shallowly forked caudal fin; short pectoral and dorsal spines; robust, heavy-set body, cylindrical in cross section, with a deep caudal peduncle and broad head; pectoral spine with smooth anterior surface and weak posterior serration (Humphries and Miller, unpubl).

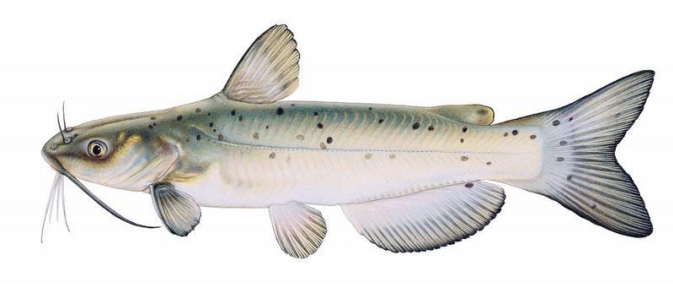
Range: Historically occurred in the Rio Grande basin of New Mexico and Texas (including the Pecos River), the Río Conchos basin in Chihuahua and the Río San Fernando in Tamaulipas. Occurrences in the Davis Mountains include a 1929 sample from Limpia Creek and specimens from Big Aguja Canyon in 1980 (Hubbs et al. 2008; Humphries and Miller, unpubl; FoTX database). It has also been introduced into the Gila River, western New Mexico.

Habitat: Similar to Headwater Catfish, with which it is commonly sympatric except in the Río Conchos basin. It inhabits the middle to upper parts of moderate to large rivers and occurs also in small, headwater creeks and springs over gravel, rubble, rocks, boulders and mud substrates (Humphries and Miller, unpubl).

Biology: Very little is known about this rare species.

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in Rio Grande NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

Range in Texas: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990) Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al., 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. They are likely similar to Channel Catfish in most respects.

Gambusia gaigei

Big Bend Gambusia

Status: federally endangered; state endangered; SGCN

Threats in Rio Grande NFCA: habitat loss; spring flow reductions; exotic species

Description: Plain, yellowish in color with a faint lateral stripe; suborbital bar and a faint, dark chin bar; the gonopodium has a pronounced elbow, with only one or two segments (Hubbs et al. 2002).

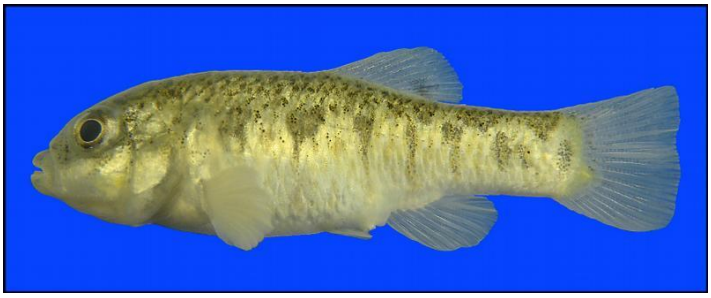
Range: Originally occurred in Boquillas Spring and Graham Ranch Warm Springs in present day Big Bend National Park. Currently, several thousand Big Bend Gambusia inhabit two spring pool refuges in the park (Hubbs et al. 2002).

Habitat: The species is often found in dense stands of *Chara* in the refuge ponds (Hubbs et al. 2002).

Biology: Little is known about most aspects of the life history of this species in its natural environments. It can compete with *G. affinis* only in stenothermal warm spring environments and is unsuccessful in habitats with more eurythermal conditions (U.S. Fish and Wildlife Service 1984). All *G. gaigei* are descendants of the three individuals taken in 1956 (Hubbs and Broderick 1963). Big Bend Gambusia presumably reproduces year-round (Hubbs and Mosier 1985).

Cyprinodon eximius

Conchos Pupfish



Status: state threatened; SGCN

Threats in Rio Grande NFCA: reductions in stream flow; habitat loss; hybridization with Sheepshead Minnow

Description: Caudal fin on mature males has black spots on the interradial membranes and the caudal fin bar is relatively wide preceded by a clear band (Miller 1976).

Range: Widely distributed in the upper Río Conchos and Río Sauz in Chihuahua, Mexico and Alamito, Terlingua and Tornillo creeks in the Big Bend region of Texas (Miller 1981). Except for the Devils River population, the other Rio Grande tributary populations are sparse (Garrett et al. 2005). The Devils River population is a disjunct and morphologically distinct at the subspecific level (Hubbs and Echelle 1972; Miller 1976; Minckley 1980; Hubbs et al. 2008).

Habitat: Typically in backwaters, stream margins and creek mouths: rarely in headsprings (Minckley 1980; Minckley et al. 1991).

Biology: Herbivorous, bottom feeder (Contreras-Balderas 1974). Reproductive characteristics for this species have not been documented (Garrett et al. 2005).

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Fishes of the Pecos River NFCA

Focal species are highlighted in blue and non-native species are in red.

Lepisosteus oculatus (Spotted Gar)	*Ictalurus lupus* (Headwater Catfish)
Lepisosteus osseus (Longnose Gar)	*Ictalurus punctatus* (Channel Catfish)
Anguilla rostrata (American Eel)	*Ictalurus* sp (Chihuahua Catfish)
*Dorosoma cepe*dianum (Gizzard Shad)	*Pylodictis olivaris* (Flathead Catfish)
Campostoma anomalum (Central Stoneroller)	*Oncorhynchus clarki virginalis* (Rio Grande Cutthroat Trout)
Carassius auratus (Goldfish)	*Menidia beryllina* (Inland Silverside)
Cyprinella lutrensis (Red Shiner)	*Fundulus gra*ndis (Gulf Killifish)
Cyprinella proserpina (Proserpine Shiner)	*Fundulus zebrinus* (Plains Killifish)
Cyprinella venusta (Blacktail Shiner)	*Lucania par*va (Rainwater Killifish)
Cyprinus carpio (Common Carp)	*Gambusia aff*inis (Western Mosquitofish)
Dionda argentosa (Manantial Roundnose Minnow)	*Gambusia ge*iseri (Largespring Gambusia)
Dionda episcopa (Roundnose Minnow)	*Gambusia nobilis* (Pecos Gambusia)
Gila pandora (Rio Grande Chub)	*Gambusia speciosa* (Tex-Mex Gambusia)
Hybognathus amarus (Rio Grande Silvery Minnow)	*Cyprinodon bovinus* (Leon Springs Pupfish)
Macrhybopsis aestivalis (Speckled Chub)	*Cyprinodon elegans* (Comanche Springs Pupfish)
Notemigonus crysoleucas (Golden Shiner)	
Notropis amabilis (Texas Shiner)	

Notropis braytoni (Tamaulipas Shiner)	*Cyprinodon pecosensis* (Pecos Pupfish)
Notropis buchanani (Ghost Shiner)	*Cyprinodon variegatus* (Sheepshead Minnow)
Notropis jemezanus (Rio Grande Shiner)	*Morone chrysops* (White Bass)
Notropis orca (Phantom Shiner)	*Lepomis auritus* (Redbreast Sunfish)
Notropis stramineus (Sand Shiner)	*Lepomis cyanellus* (Green Sunfish)
Pimephales promelas (Fathead Minnow)	*Lepomis gu*losus (Warmouth)
Pimephales vigilax (Bullhead Minnow)	*Lepomis macr*ochirus (Bluegill)
Carpiodes carpio (River Carpsucker)	*Lepomis meg*alotis (Longear Sunfish)
Moxostoma congestum (Gray Redhorse)	*Lepomis micr*olophus (Redear Sunfish)
Cycleptus sp (Rio Grande Blue Sucker)	*Micropterus salmoides* (Largemouth Bass)
Ictiobus bubalus (Smallmouth Buffalo)	*Etheostoma grahami* (Rio Grande Darter)
Astyanax mexicanus (Mexican Tetra)	*Herichthys cyano*guttatus (Rio Grande Cichlid)
Ameiurus melas (Black Bullhead)	*Oreochromis mossambicus* (Mozambique Tilapia)
Ictalurus furcatus (Blue Catfish)	

Anguilla rostrata

American Eel

Status: SGCN

Threats in Pecos NFCA: barriers to migration; habitat loss

Description: Body snakelike, lacking pelvic fins and dorsal fin is continuous with caudal and anal (Page and Burr 1997). Mouth large, slightly oblique; gape extended to posterior margin of eye; teeth in bands on jaws and vomer; scales small, cycloid and embedded (Hardy 1978).

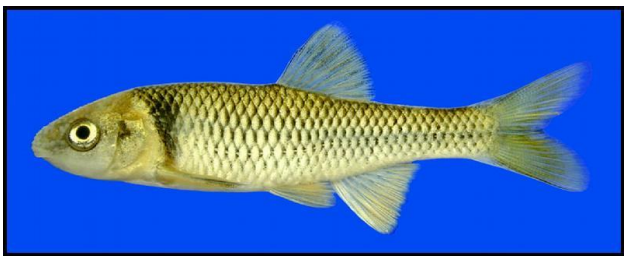
Range: This species is known from most of the Atlantic and Gulf coasts of North America, including the Caribbean coasts of Central and South America to Brazil. Texas records include specimens from the Red River to the Rio Grande in most of the large river systems of the state. Dams impede the upstream migrations of the species and have effectively eradicated the species in the western part of the state (Koster 1957; Hubbs and Echelle 1973; Hubbs et al. 2008).

Habitat: The species is found in a wide range of habitats (Helfman et al. 1987, Warren et al. 2000). Postlarval eels tend to be bottom-dwellers, hiding in burrows, tubes, snags, plant masses, other types of shelter, or the substrate itself (Fahay 1978; Van Den Avyle 1984).

Biology: American Eel is carnivorous, the main food items are fishes and invertebrates (Goldstein and Simon 1999). American Eel exhibits facultative catadromy, has multiple life stages, is semelparous and panmictic. Sexual maturity is not reached until at least 5 years, and often 20+ years for females (Hardy 1978; Haro et al. 2000); Males reported to mature at about 280 mm, and females at about 460 mm; however females may mature at lesser sizes (Hardy 1978).

Cyprinella proserpina

Proserpine Shiner




Status: state threatened; SGCN

Threats in Pecos NFCA: loss of natural flow regime

Description: Dark stripe between jaws extends to below eye (Hubbs 1954). Dark bar on side behind head (Page and Burr 1997).

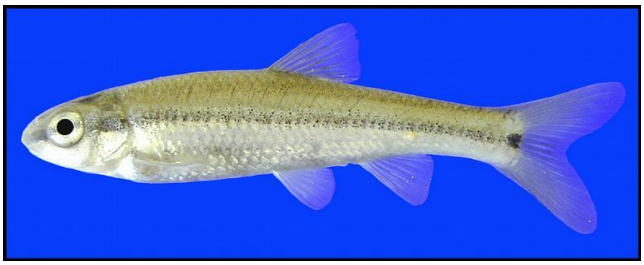
Range: Extremely limited range includes the Devils and lower Pecos rivers, Las Moras, Pinto, and San Felipe creeks in west Texas, and the Río San Carlos in Mexico (Hubbs et al. 2008).

Habitat: Prefers with spring-fed tributaries (Harrell 1978; Bonner et al. 2005) in pools to swift channels and riffles (Matthews 1980).

Biology: Benthic invertivore feeding on dipterans, lepidopterans, trichopterans, ephemeropterans and coleopterans (Harrell 1978; Watson 2006). Spawns late spring to early fall (Valdes and Winemiller 1997; Bonner et al. 2005).

Dionda argentosa

Manantial Roundnose Minnow




Status: SGCN

Threats in Pecos NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: A black band through eye to snout; small black caudal spot (Hubbs and Brown 1956; Hubbs et al. 2008).

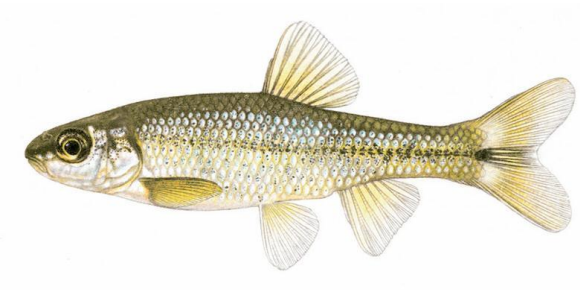
Range in Texas: Lower Pecos drainage below the spring-fed tributaries of Live Oak Creek and Independence Creek, Devils River, San Felipe and Sycamore creeks in Val Verde County (Garrett et al. 1992; Hubbs et al. 2008; Schonhuth et al. 2012).

Habitat: Occurs in most mesohabitats in headwaters and runs of spring-influenced waters (Hubbs and Brown 1956; Hubbs and Garrett 1990; Hubbs et al. 2008).

Biology: Reproduction peaks during the fall in the Devils River, Texas (Cantu and Winemiller 1997). Sympatric with Devils River minnow (*D. diaboli*) in the Devils River, Sycamore Creek and San Felipe Creek (Schonhuth et al. 2012).

Dionda episcopa

Roundnose Minnow



Status: SGCN

Threats in Pecos NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Dark lateral stripe extends from snout to base of caudal and ends in a round spot (Cope 1880; Hubbs et al. 2008).

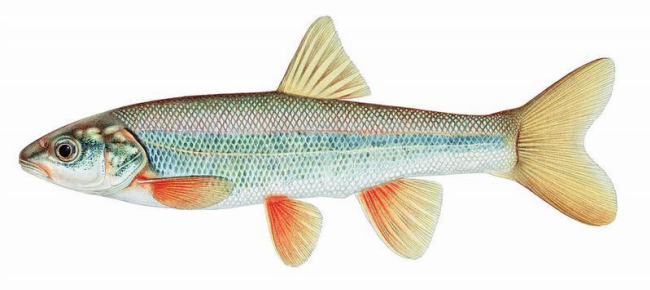
Range: Isolated desert springs and spring-fed creeks of the middle Pecos River drainage in southern New Mexico and Texas (Schonhuth et al. 2012).

Habitat: Prefers clear, spring-fed waters of tributaries (Hubbs et al. 2008).

Biology: Herbivorous (Hlohowskyj et al. 1989; Sublette et al. 1990). Vegetation comprises the bulk of diet (Koster 1957). Spawns over gravel in spring-fed streams (Koster 1957).

Gila pandora

Rio Grande Chub



Status: state threatened; SGCN

Threats in Pecos NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Back and sides dusky; sides with two darker stripes (Sublette et al. 1990). Breeding individuals with red-orange anal, dorsal, and paired fin bases and side of head; orange lower side (Page and Burr 1997). Males commonly have brighter and more intense breeding coloration than females (Rinne 1995).

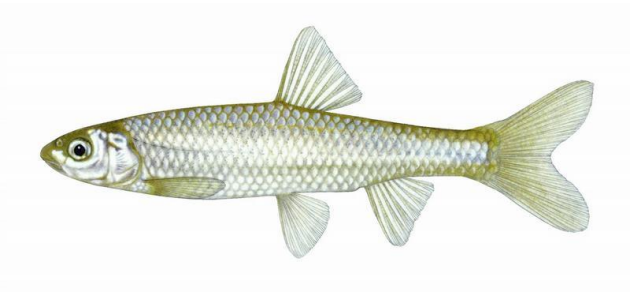
Range: Inhabits limited areas of the Rio Grande and Pecos basins in New Mexico and southern Colorado and in the Canadian River in New Mexico (Probst et al. 1987; Probst 1999; Hubbs et al. 2008). Isolated, disjunct population found in Little Aguja Creek, Davis Mountains (Hubbs et al. 2008).

Habitat: Prefers clear, cool, fast-flowing water over rubble or gravel substrates (Platania 1991; Rinne 1995).

Biology: In spring and early summer, *G. pandora* apparently moves from pools into riffles to spawn (Koster 1957; Rees et al. 2005). Spawns in mid-June to mid-August, in the Rio Bonito, New Mexico (Caldwell et al. 2004). Mid-water carnivore with a diet of zooplankton, aquatic and terrestrial insects, crustaceans and juvenile fish (Sublette et al. 1990; Zuckerman and Langlois 1990; Bestgen et al. 2003).

Hybognathus amarus

Rio Grande Silvery Minnow



Status: federally endangered; state endangered; SGCN

Threats in Pecos NFCA: loss of natural flow regime; reduced stream flow; habitat fragmentation; habitat loss; interactions with non-native species

Description: Back and upper sides silvery to olive with broad, greenish middorsal strip lower sides and abdomen silver (Sublette et al. 1990). Subterminal mouth extends horizontally to almost the anterior margin of the orbit; snout is rounded and overhangs the upper lip when viewed ventrally; eye is small and orbit diameter is much less than gape width or snout length (Bestgen and Propst 1996).

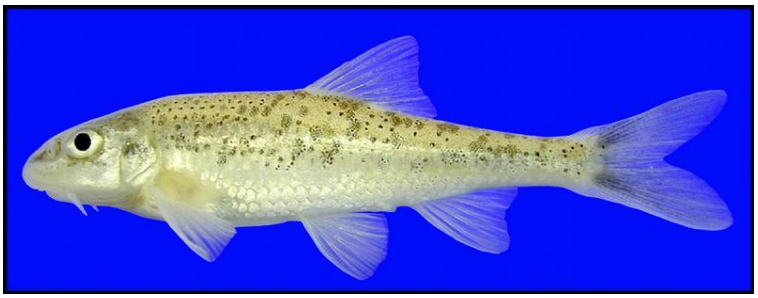
Range: Historically was one of the most abundant and widespread of the native fishes in the Rio Grande/Río Bravo and Pecos River, from northern New Mexico to the Gulf of Mexico. More recently, until reintroductions began in the Big Bend region, the fish had been confined to about seven percent of its historical range (US Fish and Wildlife Service 2010).

Habitat: During its various life stages, the Rio Grande silvery minnow uses relatively shallow, low velocity habitats with sandy and silty substrates, historically inhabiting a meandering river that included a diversity of aquatic habitats including side channels, oxbows, and backwaters (US Fish and Wildlife Service 2010). Most often found in areas of low or moderate water velocity (e.g., eddies formed by debris piles, pools, backwaters and embayments) and is rarely found in habitats with high water velocities, such as main channel runs (Dudley and Platania 1997, Watts et al. 2002, Remshardt 2007).

Biology: Important food components include macroinvertebrates, aufwuch and epipsammic algae on benthic substrates (Cowley et al. 2006; US Fish and Wildlife Service 2010). The Rio Grande silvery minnow is a pelagic spawner (Platania 1995) that produces thousands of semibuoyant, non-adhesive eggs that passively drift while developing (Platania and Altenbach 1998). Spawning is associated with high and/or increased flow events such as spring runoff or summer rainstorms, and typically occurs over a relatively brief period in May or June (Platania and Dudley 2006).

Macrhybopsis aestivalis

Speckled Chub



Status: SGCN

Threats in Pecos NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Upper sides covered in fine speckles; the mouth is ventral with a pair of barbels on the upper jaw (Eisenhour 2004; Hubbs et al. 2008).

Range: Found primarily in the Rio Grande between the confluence with the Río Conchos and the Pecos River (Hubbs et al. 2008).

Habitat: Flowing water over coarse sand and fine gravel substrates in streams; typically found in raceways and runs (Eisenhour 2004). Bedrock, coarse gravel, or sand bottom under a strong to rapid current

(Treviño 1955). Typically over small-gravel riffles or shifting sands (Miller et al. 2005; Garrett and Edwards 2014).

Biology: Diet consists of small insects, crustaceans and plant material, sedentary when not seeking food (Miller et al. 2005). Pelagic, broadcast spawner producing semibuoyant eggs that drift considerable distances downstream (Platania and Altenbach 1998).

Notropis braytoni

Tamaulipas Shiner

Status: SGCN

Threats in Pecos NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Distinct lateral stripe terminates in a basicaudal spot (Miller et al. 2005).

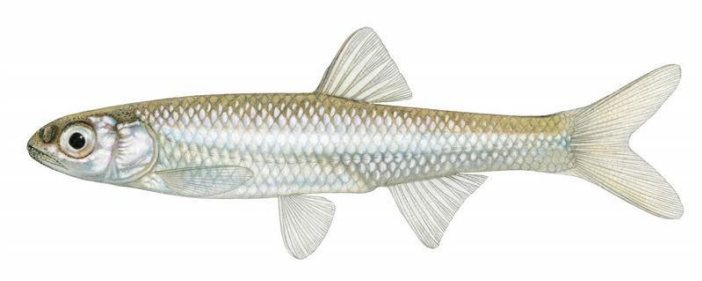
Range: Endemic to the Rio Grande (including the Devils River and lower Pecos River) in Texas and Río Conchos in Mexico (Edwards et al. 2004).

Habitat: Rocky and sandy channels of large creeks and small to medium rivers over substrates of rock and gravel to silt and mud (Page and Burr 1997; Miller et al. 2005). Typically does not exhibit narrow ecological limitations (Treviño 1955).

Biology: Diet consists primarily of aquatic insects (Contreras-Balderas 1974). Population abundance in Texas has declined in recent decades (Hubbs et al. 2008), with collections during the 1990s yielding no Tamaulipas Shiners below Amistad Reservoir to the mouth of the river. The decline in abundance is likely due to reservoir construction, dewatering of stream courses, and decreases in water quantity and quality (Edwards et al. 2004). Conversely, collections in the Big Bend region of the Rio Grande from 1977–2006 indicated that relative abundance has increased (Hubbs et al. 1977; Garrett and Edwards 2014).

Notropis jemezanus

Rio Grande Shiner



Status: SGCN

Threats in Pecos NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Mostly plain silvery, except for a faint dusky band; eye diameter equal to length of snout (Koster 1957)

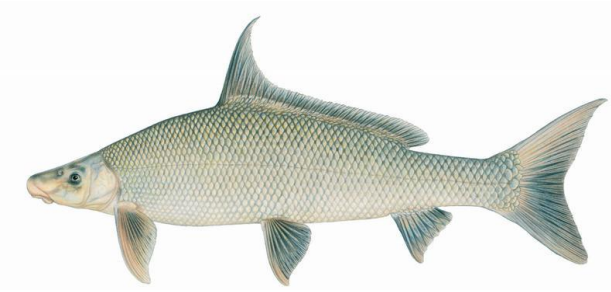
Range: Endemic to the Rio Grande basin, including the Rio Grande, Pecos River (New Mexico and Texas), and the Río Conchos, San Juan and Salado drainages of Mexico, and was once abundant throughout the basin (Treviño 1955; Treviño-Robinson 1959). Now sparsely distributed in Texas in the Rio Grande downstream from the Río Conchos confluence to Amistad Reservoir and in Independence Creek in the lower Pecos River (Edwards et al. 2002). None have been taken below Amistad Reservoir since the mid-1990s (Edwards et al. 2004) or in New Mexico since 1949 (Platania 1991). This species has not been collected in Independence Creek since 1991 or in the lower Pecos River since 1987 (Hoagstrom 2003; Bonner et al. 2005).

Habitat: Main channel of rivers and streams over sand and small-gravel riffles with sparse vegetation (Miller et al. 2005; Garrett and Edwards 2014).

Biology: Primarily carnivorous-omnivorous (Sublette et al. 1990). Pelagic spawners with eggs and larvae that drift considerable distances downstream (Platania and Altenbach 1998).

Cycleptus sp.

Rio Grande Blue Sucker



Status: state threatened; SGCN

Threats in Pecos NFCA: habitat loss; fragmentation; loss of natural flow regime; reduced water quality

Description: Morphologically similar to *C. elongatus*, but lip papillae are longer, extending forwards onto end of snout (Hubbs et al. 2008). Body color of *Cycleptus* sp. tends to be more golden or brassy than *C. elongatus* (Burr and Mayden 1999).

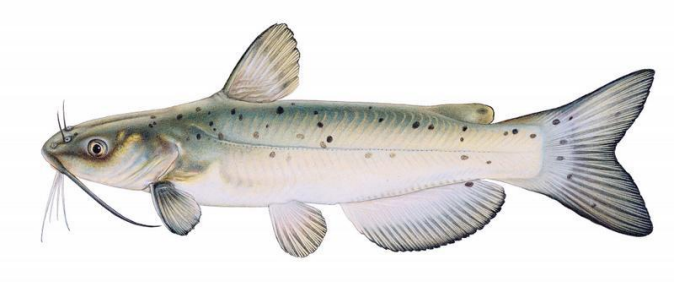
Range: Endemic to the Rio Grande basin (Bessert 2006).

Habitat: Requirements are likely very similar to *C. elongatus*. Typically found over cobble and bedrock substrates; adults occupy deep riffles in areas of very swift flow; juveniles occupy shallower, less swift water (Moss et al. 1983).

Biology: Rio Grande Blue Sucker probably spawns in March and April (Miller et al. 2005). Likely similar to *C. elongatus* by spawning in deep riffles with cobble and bedrock substrates (Moss et al. 1983). As with *C. elongatus*, adults probably winter in deep pools and move upstream in spring to spawn in riffles (Cross 1967). Males likely migrate into spawning area before females (Moss et al. 1983).

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in Pecos NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

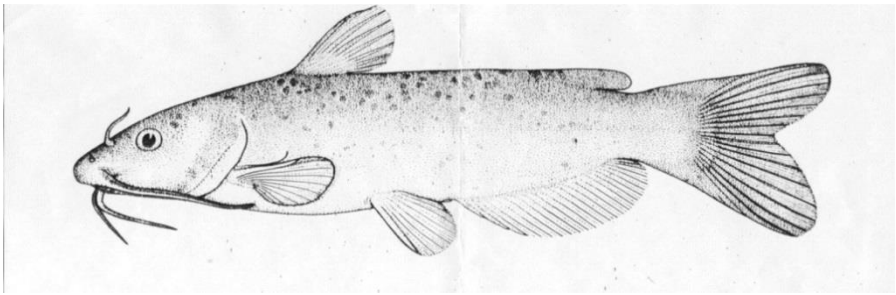
Range in Texas: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990) Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al., 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. They are likely similar to Channel Catfish in most respects.

Ictalurus sp.

Chihuahua Catfish



Status: SGCN

Threats in Pecos NFCA: habitat loss; hybridization with Channel Catfish

Description: 22 to 26 (usually 23-24) anal rays; 38 to 42 (usually 39-41) vertebrae; shallowly forked caudal fin; short pectoral and dorsal spines; robust, heavy-set body, cylindrical in cross section, with a deep caudal peduncle and broad head; pectoral spine with smooth anterior surface and weak posterior serration (Humphries and Miller, unpubl).

Range: Historically occurred in the Rio Grande basin of New Mexico and Texas (including the Pecos River), the Río Conchos basin in Chihuahua and the Río San Fernando in Tamaulipas. Occurrences in the Davis Mountains include a 1929 sample from Limpia Creek and specimens from Big Aguja Canyon in 1980 (Hubbs et al. 2008; Humphries and Miller, unpubl; FoTX database). It has also been introduced into the Gila River, western New Mexico.

Habitat: Similar to Headwater Catfish, with which it is commonly sympatric except in the Rio Conchos basin. It inhabits the middle to upper parts of moderate to large rivers and occurs also in small, headwater creeks and springs over gravel, rubble, rocks, boulders and mud substrates (Humphries and Miller, unpubl).

Biology: Very little is known about this rare species.

Oncorhynchus clarkii virginalis

Rio Grande Cutthroat Trout

Status: SGCN; extirpated

Threats in Pecos NFCA: habitat loss; hybridization with Rainbow Trout

Description: Paired fins uniformly brown or reddish but without a white border; deep red to orangish slash on each side of throat along inner side of dentary bone; large spots concentrated on caudal peduncle in adults (Hubbs et al. 2008).

Range: The current distribution is one of highly fragmented populations within the Canadian, Pecos and Rio Grande systems (Behnke 1979). It is thought to have been originally present in at least Limpia and McKittrick creeks in Texas and possibly elsewhere in the Davis mountains (Garrett and Matlock 1991).

Habitat: Originally occupied a variety of fluvial habitats, ranging from first-order streams to the Rio Grande mainstem, now restricted to small headwater streams with gravelly substrates (Behnke 1979, 1980; Pritchard and Cowley 2006)

Biology: Opportunistic foragers, feeding mainly on insects and small fishes (Goldstein and Simon 1999; Pritchard and Cowley 2006). Sexual maturity reached at two (males) to three (females) years (Pritchard and Cowley 2006).

Gambusia nobilis

Pecos Gambusia

Status: federally endangered; state endangered; SGCN

Threats in Pecos NFCA: groundwater pumping; habitat loss; pollution; hybridization with introduced Largespring Gambusia

Description: Relatively robust *Gambusia*, with a caudal peduncle depth approximately two-thirds of the head length; margins of the scale pockets are outlined in black and dorsal fin has a subbasal row of spots; females have a prominent black area on the abdomen that surrounds the anus and anal fin (Hubbs and Springer 1957).

Range: Endemic to the Pecos River basin in southeastern New Mexico and western Texas. Restricted to two locations in New Mexico and two in Texas (Balmorhea springs complex and Diamond Y Draw; Hubbs et al. 2002).

Habitat - Stenothermal springs, runs, ciénegas and irrigation canals carrying spring waters (Echelle and Echelle 1980). One or two other *Gambusia* may also be found in association with *G. nobilis* but these segregate by habitat (Hubbs et al. 1995).

Biology: Pecos Gambusia feed relatively non-selectively, consuming a diversity of food types with an inclination towards amphipods (Hubbs et al. 1978).

Cyprinodon bovinus

Leon Springs Pupfish

Status: federally endangered; state endangered; SGCN

Threats in Pecos NFCA: groundwater pumping; habitat loss; pollution; hybridization with Sheepshead Minnow

Description: Rectangular lateral blotches of female longer than deep; dark terminal caudal bar of adult males; abdomen fully scaled (Baird and Girard 1853; Echelle and Miller 1974; Hubbs et al. 2008).

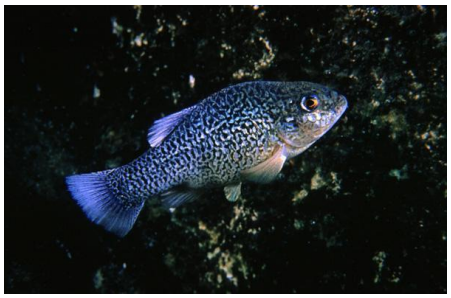
Range: The type locality, Leon Springs, no longer exists due to impounding and groundwater pumping (Hubbs 1980). Now only found in a small segment (8–10 km) of Diamond Y Draw, a flood tributary of the Pecos River owned by The Nature Conservancy (Hubbs et al. 2008).

Habitat: Quiet water near edges of shallow pools, especially in areas with minimal vegetation (Echelle and Miller 1974).

Biology: Individuals live about 20–23 months and have a generalized diet of algae and invertebrates; spawning occurs almost year around, but peaks in July (Kennedy 1977).

Cyprinodon elegans

Comanche Springs Pupfish




Status: federally endangered; state endangered; SGCN

Threats in Pecos NFCA: groundwater pumping; habitat loss; hybridization with Sheepshead Minnow

Description: Males possess a unique, speckled color pattern and all individuals have a relatively streamlined body shape (Garrett et al. 2002).

Range: Originally inhabited two isolated spring systems approximately 90 km apart in the Pecos River drainage of west Texas. Groundwater pumping caused the type locality, Comanche Springs, Pecos County, to go dry in 1954 and that population is extinct. The other population is restricted to the Balmorhea springs complex (Phantom, San Solomon, Giffin and East Sandia springs) and three artificial refugia, all near Balmorhea (Reeves County), Texas (Garrett et al. 2002).

Habitat: Modified springs, various irrigation canals and refugia designed to resemble the original natural habitat (Garrett et al. 2002).

Biology: Food is mostly filamentous algae and some snails (Winemiller and Anderson 1997). Breeding occurs over territories maintained by males. Eggs are guarded by the males who aggressively defend their territories against all intruders until the young fish hatch (Itzkowitz 1969).

Cyprinodon pecosensis

Pecos Pupfish

Status: state threatened; SGCN

Threats in Pecos NFCA: hybridization with Sheepshead Minnow; groundwater pumping

Description: The only scales on the abdomen are in a patch anterior to the pelvic fins and one posterior to the gill membrane isthmus; males have larger dorsal and anal fins, a dark bar on the distal portion of the caudal fin and an iridescent blue nape (Echelle and Echelle 1978). Females are cryptically colored olive-brown and the dorsal fin is marked by a dark ocellus; young adult males may retain the female color pattern (Garrett 1981a).

Range: Originally occurring in the Pecos River system from Roswell, New Mexico to Independence Creek, Terrell County, Texas, its range is now restricted to Salt Creek in Texas and a few locations in New Mexico (Propst 1999).

Habitat: Can occur in a wide variety of habitats and water quality conditions, ranging from highly saline sinkholes to typical desert streams (Garrett et al. 2002).

Biology: Opportunistic omnivores, feeding mainly on algae and detritus (Davis 1981). Few adults survive more than one year; winter populations consist primarily of fish born the previous summer (Kodric-Brown 1977, Garrett 1981b). Age at reproductive maturity, ovary size, egg size and egg number varies among populations, and are apparently associated with population density. With the exception of egg size, these reproductive traits can be altered in response to changing environments (Garrett 1982).

Etheostoma grahami

Rio Grande Darter

Status: state threatened; SGCN

Threats in Pecos NFCA: loss of natural flow regime; habitat loss

Description: Throat red in males; 10-12 body bars (Hubbs et al. 2008). Many small red (on male) or black (on female) spots on side; red 1st dorsal fin (faint on female); male has red 2nd dorsal, anal, and pelvic fins, also yellow caudal and pectoral fins; olive above (Page and Burr 1997).

Range: Endemic to the lower Pecos River and the mainstem and spring-fed tributaries of the Rio Grande from the Pecos River confluence downstream to the Devils River and Dolan, San Felipe and Sycamore creeks (Hubbs et al. 2008).

Habitat: Runs, riffles, and shorelines with clean cobble substrate having a small amount of attached macrophytes (Platania 1990).

Biology: Invertivore. Spawns late March to early June; eggs laid on vegetation and on the tops or undersides of rocks (Strawn 1956; Harrell 1980; Page 1983).

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Fishes of the Devils River NFCA

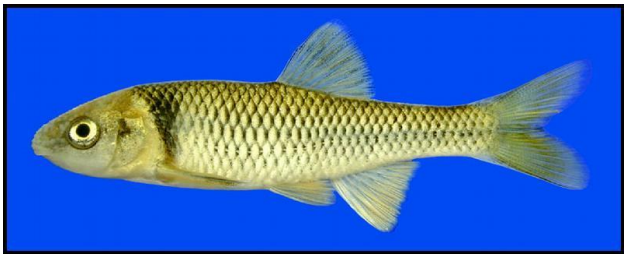
Focal species are highlighted in blue and non-native species are in red.

Dorosoma petenense (Threadfin Shad)	*Fundulus zebrinus* (Plains Killifish)
Campostoma anomalum (Central Stoneroller)	*Gambusia affinis* (Western Mosquitofish)
Cyprinella lutrensis (Red Shiner)	*Gambusia krumholzi* (Spotfin Gambusia)
Cyprinella proserpina (Proserpine Shiner)	*Gambusia geiseri* (Largespring Gambusia)
Cyprinella venusta (Blacktail Shiner)	*Gambusia senilis* (Blotched Gambusia)
Cyprinus carpio (Common Carp)	*Gambusia speciosa* (Tex-Mex Gambusia)
Dionda argentosa (Manantial Roundnose Minnow)	*Poecilia latipinna* (Sailfin Molly)
Dionda diaboli (Devils River Minnow)	*Cyprinodon eximius* ssp (Devils River Pupfish)
Hybognathus placitus (Plains Minnow)	*Cyprinodon variegatus* (Sheepshead Minnow)
Notropis amabilis (Texas Shiner)	*Morone chrysops* (White Bass)
Notropis braytoni (Tamaulipas Shiner)	*Lepomis auritus* (Redbreast Sunfish)
Notropis buchanani (Ghost Shiner)	*Lepomis cyanellus* (Green Sunfish)
Notropis jemezanus (Rio Grande Shiner)	*Lepomis gulosus* (Warmouth)
Notropis stramineus (Sand Shiner)	*Lepomis macrochirus* (Bluegill)
Pimephales vigilax (Bullhead Minnow)	*Lepomis megalotis* (Longear Sunfish)
Carpiodes carpio (River Carpsucker)	*Lepomis microlophus* (Redear Sunfish)
Ictiobus niger (Black Buffalo)	*Lepomis miniatus* (Redspotted Sunfish)
Moxostoma albidum (Longlip Jumprock)	*Micropterus dolomieu* (Smallmouth Bass)
Moxostoma congestum (Gray Redhorse)	*Micropterus salmoides* (Largemouth Bass)
Astyanax mexicanus (Mexican Tetra)	

Ictalurus furcatus (Blue Catfish)	*Micropterus salmoides nuecensis* (Rio Grande largemouth bass)
Ictalurus lupus (Headwater Catfish)	*Etheostoma grahami* (Rio Grande Darter)
Ictalurus punctatus (Channel Catfish)	*Percina macrolepida* (Bigscale Logperch)
Pylodictis olivaris (Flathead Catfish)	*Herichthys cyanoguttatus* (Rio Grande Cichlid)
Hypostomus sp (Armadillo Del Rio)	*Oreochromis aureus* (Blue Tilapia)
Menidia beryllina (Inland Silverside)	

Cyprinella proserpina

Proserpine Shiner




Status: state threatened; SGCN

Threats in Devils NFCA: loss of natural flow regime

Description: Dark stripe between jaws extends to below eye (Hubbs 1954). Dark bar on side behind head (Page and Burr 1997).

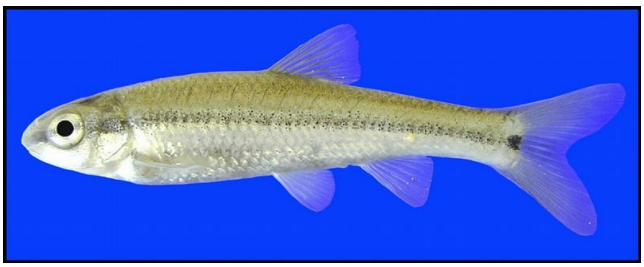
Range: Extremely limited range includes the Devils and lower Pecos rivers, Las Moras, Pinto, and San Felipe creeks in west Texas, and the Río San Carlos in Mexico (Hubbs et al. 2008).

Habitat: Prefers with spring-fed tributaries (Harrell 1978; Bonner et al. 2005) in pools to swift channels and riffles (Matthews 1980).

Biology: Benthic invertivore feeding on dipterans, lepidopterans, trichopterans, ephemeropterans and coleopterans (Harrell 1978; Watson 2006). Spawns late spring to early fall (Cantu and Winemiller 1997; Bonner et al. 2005).

Dionda argentosa

Manantial Roundnose Minnow




Status: SGCN

Threats in Devils NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: A black band through eye to snout; small black caudal spot (Hubbs and Brown 1956; Hubbs et al. 2008).

Range: Endemic to the Lower Pecos drainage below the spring-fed tributaries of Live Oak Creek and Independence Creek, Devils River, San Felipe and Sycamore creeks in Val Verde County (Garrett et al. 1992; Hubbs et al. 2008; Schonhuth et al. 2012).

Habitat: Occurs in most mesohabitats in headwaters and runs of spring-influenced waters (Hubbs and Brown 1956; Hubbs and Garrett 1990; Hubbs et al. 2008).

Biology: Reproduction peaks during the fall in the Devils River, Texas (Cantu and Winemiller 1997). Sympatric with Devils River minnow (*D. diaboli*) in the Devils River, Sycamore Creek and San Felipe Creek (Schonhuth et al. 2012).

Dionda diaboli

Devils River Minnow


Status: federally threatened; state threatened; SGCN

Threats in Devils NFCA: reduced spring flows; habitat fragmentation; habitat loss

Description: Darkly outlined scales above the lateral stripe give a cross-hatched appearance; black lateral stripe through the eye and onto the snout; double dashes along the lateral line; black spot on the caudal fin base that is often wedge shaped (Hubbs and Brown 1956; Garrett et al. 2002).

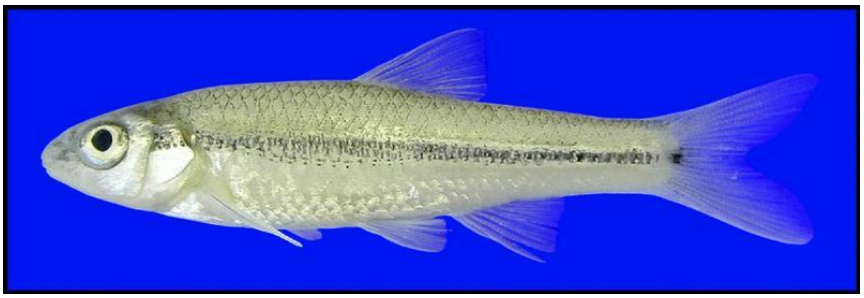
Range: Devils River, San Felipe Creek and Sycamore Creek, Val Verde County, Las Moras (extirpated) and Pinto creeks, Kinney County (Garrett et al. 2004). Río San Carlos and upper Río Salado basin in Mexico (Scharpf 2005).

Habitat: Often found in association with spring outflows over gravel-cobble substrate and adjacent to aquatic macrophytes; may inhabit a microhabitat associated with the interface between spring runs and the river (Hubbs and Garrett 1990).

Biology: Likely to spawn in the spring with non-adhesive and demersal eggs, similar to traits reported for *D. serena* (Hubbs 1951).

Notropis braytoni

Tamaulipas Shiner



Status: SGCN

Threats in Devils NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Distinct lateral stripe terminates in a basicaudal spot (Miller et al. 2005).

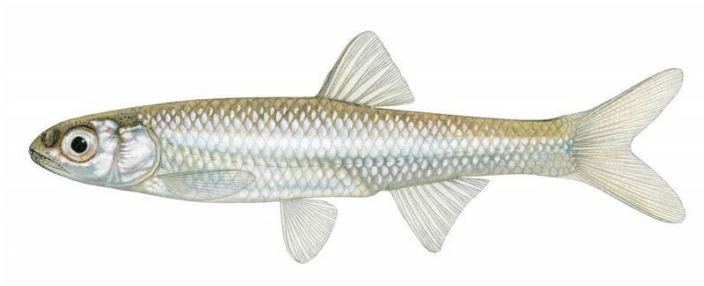
Range: Endemic to the Rio Grande (including the Devils River and lower Pecos River) in Texas and Río Conchos in Mexico (Edwards et al. 2004).

Habitat: Rocky and sandy channels of large creeks and small to medium rivers over substrates of rock and gravel to silt and mud (Page and Burr 1997; Miller et al. 2005). Typically does not exhibit narrow ecological limitations (Treviño 1955).

Biology: Diet consists primarily of aquatic insects (Contreras-Balderas 1974). Population abundance in Texas has declined in recent decades (Hubbs et al. 2008), with collections during the 1990s yielding no Tamaulipas Shiners below Amistad Reservoir to the mouth of the river. The decline in abundance is likely due to reservoir construction, dewatering of stream courses, and decreases in water quantity and quality (Edwards et al. 2004). Conversely, collections in the Big Bend region of the Rio Grande from 1977–2006 indicated that relative abundance has increased (Hubbs et al. 1977; Garrett and Edwards 2014).

Notropis jemezanus

Rio Grande Shiner



Status: SGCN

Threats in Devils NFCA: loss of natural flow regime; habitat fragmentation; habitat loss

Description: Mostly plain silvery, except for a faint dusky band; eye diameter equal to length of snout (Koster 1957)

Range: Endemic to the Rio Grande basin, including the Rio Grande, Pecos River (New Mexico and Texas), and the Río Conchos, San Juan and Salado drainages of Mexico, and was once abundant throughout the basin (Treviño 1955; Treviño-Robinson 1959). Now sparsely distributed in Texas in the Rio Grande downstream from the Río Conchos confluence to Amistad Reservoir and in Independence Creek in the lower Pecos River (Edwards et al. 2002). None have been taken below Amistad Reservoir since the mid-1990s (Edwards et al. 2004) or in New Mexico since 1949 (Platania 1991). This species has not been collected in Independence Creek since 1991 or in the lower Pecos River since 1987 (Hoagstrom 2003; Bonner et al. 2005).

Habitat: Main channel of rivers and streams over sand and small-gravel riffles with sparse vegetation (Miller et al. 2005; Garrett and Edwards 2014).

Biology: Primarily carnivorous-omnivorous (Sublette et al. 1990). Pelagic spawners with eggs and larvae that drift considerable distances downstream (Platania and Altenbach 1998).

Moxostoma albidum

Longlip Jumprock

Status: SGCN

Threats in Devils NFCA: habitat loss; fragmentation; loss of natural flow regime; reduced water quality

Description: Typically with 20 or more lip plicae; 46 to 47 scales along the lateral line. Closely related, and similar, to the Gray Redhorse.

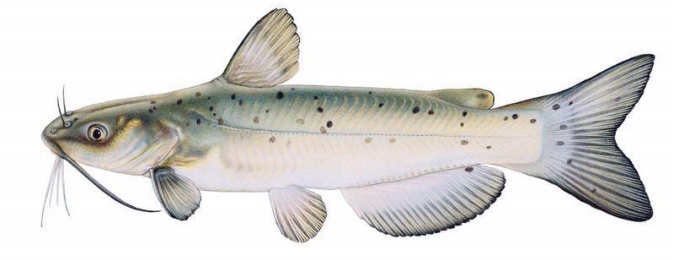
Range: Restricted to the lower Rio Grande and tributaries (e.g., Devils River) and to the upper Rio San Fernando system (Clements et al. 2012)

Habitat: Likely similar to Gray Redhorse: Rocky runs and riffles of creeks and small to medium rivers; often near boulders in swift water (Page and Burr 1997; Miller et al. 2005).

Biology: Likely similar to West Mexican Redhorse and Gray Redhorse: Nuptial tuberculation suggests spring spawning period (Jenkins 1980).

Ictalurus lupus

Headwater Catfish



Status: SGCN

Threats in Devils NFCA: loss of natural flow regime; habitat fragmentation; habitat loss; competition and hybridization with Channel Catfish

Description: Yellowish-green back and sides with a few scattered, diffuse black spots on the sides; silvery abdomen (Sublette et al. 1990).

Range: Originally found in Rio Grande as well as the headwaters of the Nueces, San Antonio, Guadalupe, and Colorado basins, but appears to be extirpated from most of this range (Kelsch and Hendricks 1990) Currently found in the Rio Grande below the Río Conchos confluence downstream through the lower canyons of the Big Bend region, but in low abundance (Edwards et al. 2002). It also occurs in Sycamore, Pinto and Las Moras creeks (Garrett et al., 1992) as well as Independence Creek in the Pecos River, Devils River and upper Frio River (Bean et al. 2011).

Habitat: Spring-fed headwaters in swift-flowing riffles and chutes (Miller et al. 2005) and is most abundant in deep, run habitats (Bonner et al. 2005).

Biology: There are no definitive studies of spawning behavior and ecological requirements for Headwater Catfish. It is likely similar to Channel Catfish in most respects.

Gambusia krumholzi

Spotfin Gambusia

Status: state threatened; SGCN

Threats in Devils NFCA: habitat modification; water quality from urban pollution

Description: Dark scale margins (3–5 melanophores in width) give a strong cross-hatched appearance throughout the body; both the middorsal stripe and lateral band are broad, however the lateral band is somewhat obscured by the cross-hatched pattern on the scales; there is no subocular bar and no spotting pattern on the caudal fin (Minckley 1963; Garrett and Edwards 2003).

Range: Endemic to San Felipe and Sycamore creeks in Texas, ríos San Diego and la Compuerta in Mexico (Echelle et al. 2013).

Habitat: Prefers densely vegetated, edge or quiet water habitats in close association to areas with swift flows (Edwards and Garrett 2006).

Biology: Stomach content analysis revealed large quantities of filamentous green algae; however, this ay be a result of incidental ingestion with other prey (Garrett and Edwards 2003).

Gambusia senilis

Blotched Gambusia

Status: state threatened; SGCN; likely extirpated

Threats in Devils NFCA: habitat loss

Description: Dusky stripe (about 1 scale deep) along side; dark scale outlines (often appearing as black crescents) and black spots (often poorly developed on male) on lower side; usually a large black teardrop (Page and Burr 1997).

Range: Primarily within the Río Conchos drainage of Chihuahua, Mexico; known from the Devils River in Texas (Hubbs and Springer 1957; Hubbs 1958; Edwards et al. 2002), but likely extirpated (Edwards et al. 2004; Hubbs et al. 2008)

Habitat: Springs, marshes, channels, vegetated quiet pools and backwaters (Minckley et al. 1991, Page and Burr 1997).

Biology: Feeds on invertebrates, fish and sometimes algae. Ovoviparous, reproducing year around (Lozano-Vilano et al. 2009).

Cyprinodon eximius ssp.

Devils River Pupfish

Status: state threatened; SGCN

Threats in Devils NFCA: reductions in stream flow; habitat loss; hybridization with Sheepshead Minnow

Description: Caudal fin on mature males has black spots on the interradial membranes and the caudal fin bar is relatively wide preceded by a clear band (Miller 1976).

Range: Widely distributed in the upper Río Conchos and Río Sauz in Chihuahua, Mexico and Alamito, Terlingua and Tornillo creeks in the Big Bend region of Texas (Miller 1981). Except for the Devils River population, the other Rio Grande tributary populations are sparse (Garrett et al. 2005). The Devils River population is a disjunct and morphologically distinct at the subspecific level (Hubbs and Echelle 1972; Miller 1976; Minckley 1980; Hubbs et al. 2008). The population in the Devils River at one time extended from Dolan Creek to the confluence with the Rio Grande (Hubbs and Echelle 1972). Cyprinodon eximius ssp. was first taken in the Devils River during surveys by the Texas Game and Fish Commission in 1953 (Hubbs and Garrett 1990). Subsequent activities (e.g., reservoir filling and stream rotenoning) reduced the range to a small portion of the Devils River. In 1979, approximately 200 individuals from the remaining population were transported upstream, above Dolan Falls, to reestablish them in one of their previous locations, Dolan Creek (Garrett 1980; Hubbs and Garrett 1990). The Texas Parks and Wildlife Department and The Nature Conservancy now own most of Dolan Creek and adjacent habitats in the Devils River.

Habitat: Typically in backwaters, stream margins and creek mouths: rarely in headsprings (Minckley 1980; Minckley et al. 1991).

Biology: Herbivorous, bottom feeder (Contreras-Balderas 1974). Reproductive characteristics for this species have not been documented (Garrett et al. 2005).

Micropterus salmoides nuecensis

Rio Grande Largemouth Bass

Status: SGCN

Threats in Devils NFCA: habitat loss; hybridization with Florida Largemouth Bass; competition with Smallmouth Bass

Description: Glossohyal tooth patch (Bailey and Hubbs 1949, Edwards 1980). Genetically distinct based on nuclear microsatellite markers (Lutz-Carrillo et al. 2006).

Range: Original distribution thought to be from the Nueces River in Texas to the Río Soto La Marina, Mexico (Bailey and Hubbs 1949, Edwards 1980), currently in the upper Devils River.

Habitat: unknown, but likely similar to *M. salmoides.*

Biology: unknown, but likely similar to *M. salmoides.*

Etheostoma grahami

Rio Grande Darter

Status: state threatened; SGCN

Threats in Devils NFCA: loss of natural flow regime; habitat loss

Description: Throat red in males; 10-12 body bars (Hubbs et al. 2008). Many small red (on male) or black (on female) spots on side; red 1st dorsal fin (faint on female); male has red 2nd dorsal, anal, and pelvic fins, also yellow caudal and pectoral fins; olive above (Page and Burr 1997).

Range: Endemic to the lower Pecos River and the mainstem and spring-fed tributaries of the Rio Grande from the Pecos River confluence downstream to the Devils River and Dolan, San Felipe and Sycamore creeks (Hubbs et al. 2008).).

Habitat: Runs, riffles, and shorelines with clean cobble substrate having a small amount of attached macrophytes (Platania 1990).

Biology: Invertivore. Spawns late March to early June; eggs laid on vegetation and on the tops or undersides of rocks (Strawn 1956; Harrell 1980; Page 1983).

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Appendix 5 – Supplemental Modeling Data

Appendix 5, Table 1 - Proposed SGCN species (see Appendix 1) considered for analysis with summary statistics of data input to the SDM and model quality (Test AUC) with reason for any model not produced (with model statistics indicated with a dash).

Family	Genus Species	Common Name	Test AUC	No. Records	Reason for exclusion
Acipenseridae	Scaphirhynchus platorynchus	Shovelnose Sturgeon	-	-	too few records
Anguillidae	Anguilla rostrata	American Eel	0.9507	24	
Catostomidae	Carpiodes sp. 1	Llano River River Carp Sucker	-	-	too few records
Catostomidae	Cycleptus elongatus	Blue Sucker	0.972	64	
Catostomidae	Cycleptus sp Rio Grande blue sucker	Rio Grande blue sucker	0.9945	90	
Catostomidae	Erimyzon claviformis	Western Creek Chubsucker	0.9772	39	
Catostomidae	Moxostoma albidum	Longlip Jumprock	-	-	too few records
Catostomidae	Moxostoma austrinum	Mexican Redhorse	0.9981	12	
Centrarchidae	Micropterus salmoides nuecensis	Rio Grande Largemouth Bass	-	-	too few records
Centrarchidae	Micropterus treculii	Guadalupe Bass	0.9839	181	
Cyprinidae	Campostoma ornatum	Mexican Stoneroller	0.9973	35	
Cyprinidae	Cyprinella lepida	Plateau Shiner	0.9975	30	
Cyprinidae	Cyprinella proserpina	Proserpine Shiner	0.9954	66	
Cyprinidae	Cyprinella sp Nueces River shiner	Nueces River shiner	0.9983	16	
Cyprinidae	Dionda argentosa	Manantial Roundnose Minnow	0.9954	78	
Cyprinidae	Dionda diaboli	Devils River Minnow	0.9956	22	
Cyprinidae	Dionda episcopa	Roundnose Minnow	0.9968	34	

Family	Genus Species	Common Name	Test AUC	No. Records	Reason for exclusion
Cyprinidae	Dionda flavipinnis	n/a	0.9926	61	
Cyprinidae	Dionda nigrotaeniata	Guadalupe Roundnose Minnow	0.9996	5	
Cyprinidae	Dionda serena	Nueces Roundnose Minnow	0.9983	32	
Cyprinidae	Dionda sp 1 Conchos roundnose minnow	Conchos roundnose minnow	0.9979	5	
Cyprinidae	Dionda sp 3 Colorado roundnose minnow	Colorado roundnose minnow	0.9975	13	
Cyprinidae	Dionda texensis	n/a	0.9981	26	
Cyprinidae	Gila pandora	Rio Grande Chub	-	-	too few records
Cyprinidae	Hybognathus amarus	Rio Grande Silvery Minnow	0.985	18	
Cyprinidae	Hybognathus hayi	Cypress Minnow	0.9485	5	
Cyprinidae	Hybognathus nuchalis	Mississippi Silvery Minnow	0.9868	110	
Cyprinidae	Hybognathus placitus	Plains Minnow	0.9641	90	
Cyprinidae	Hybopsis amnis	Pallid Shiner	0.9816	150	
Cyprinidae	Macrhybopsis aestivalis	Speckled Chub	0.9885	113	
Cyprinidae	Macrhybopsis australis	Prairie Chub	0.9951	25	
Cyprinidae	Macrhybopsis hyostoma	Shoal Chub	0.9654	234	
Cyprinidae	Macrhybopsis marconis	Burrhead Chub	0.9934	79	
Cyprinidae	Macrhybopsis storeriana	Silver Chub	0.9841	33	
Cyprinidae	Macrhybopsis tetranema	Peppered Chub	0.9905	69	
Cyprinidae	Notropis amabilis	Texas Shiner	0.9783	310	
Cyprinidae	Notropis atherinoides	Emerald Shiner	0.9752	104	

Family	Genus Species	Common Name	Test AUC	No. Records	Reason for exclusion
Cyprinidae	Notropis atrocaudalis	Blackspot Shiner	0.9768	163	
Cyprinidae	Notropis bairdi	Red River Shiner	0.9648	46	
Cyprinidae	Notropis blennius	River Shiner	-	-	too few records
Cyprinidae	Notropis braytoni	Tamaulipas Shiner	0.9902	127	
Cyprinidae	Notropis buccula	Smalleye Shiner	0.9831	49	
Cyprinidae	Notropis chalybaeus	Ironcolor Shiner	0.9894	38	
Cyprinidae	Notropis chihuahua	Chihuahua Shiner	0.9969	36	
Cyprinidae	Notropis girardi	Arkansas River Shiner	0.9701	303	
Cyprinidae	Notropis jemezanus	Rio Grande Shiner	0.9923	79	
Cyprinidae	Notropis maculatus	Taillight Shiner	0.9991	8	
Cyprinidae	Notropis oxyrhynchus	Sharpnose Shiner	0.9854	77	
Cyprinidae	Notropis potteri	Chub Shiner	0.9777	57	
Cyprinidae	Notropis sabinae	Sabine Shiner	0.9901	157	
Cyprinidae	Notropis shumardi	Silverband Shiner	0.9763	68	
Cyprinidae	Notropis simus pecosensis	Pecos Bluntnose Shiner	-	-	too few records
Cyprinidae	Phenacobius mirabilis	Suckermouth Minnow	0.925	1036	
Cyprinidae	Platygobio gracilis	Flathead Chub	0.9793	204	
Cyprinidae	Pteronotropis hubbsi	Bluehead Shiner	0.999	16	
Cyprinidae	Rhinichthys cataractae	Longnose Dace	0.9945	84	
Cyprinodontidae	Cyprinodon bovinus	Leon Springs Pupfish	0.9996	8	

Family	Genus Species	Common Name	Test AUC	No. Records	Reason for exclusion
Cyprinodontidae	Cyprinodon elegans	Comanche Springs Pupfish	0.9981	22	
Cyprinodontidae	Cyprinodon sp.	Devils River Pupfish	-	-	too few records
Cyprinodontidae	Cyprinodon pecosensis	Pecos Pupfish	0.9935	35	
Cyprinodontidae	Cyprinodon rubrofluviatilis	Red River Pupfish	0.977	110	
Hiodontidae	Hiodon alosoides	Goldeye	-	-	too few records
Ictaluridae	Ictalurus furcatus	Blue Catfish	0.9762	49	
Ictaluridae	Ictalurus lupus	Headwater Catfish	0.9764	56	
Ictaluridae	Ictalurus sp Chihuahua catfish	Chihuahua Catfish	-	-	too few records
Ictaluridae	Ictalurus sp Rio Grande blue catfish	Rio Grande blue catfish	0.9915	56	
Ictaluridae	Satan eurystomus	Widemouth Blindcat	-	-	too few records
Ictaluridae	Trogloglanis pattersoni	Toothless Blindcat	-	-	too few records
Lepisosteidae	Atractosteus spatula	Alligator Gar	0.9725	18	
Mugilidae	Agonostomus monticola	Mountain Mullet	0.9528	12	
Percidae	Ammocrypta clara	Western Sand Darter	0.9946	29	
Percidae	Etheostoma asprigene	Mud Darter	0.9833	26	
Percidae	Etheostoma fonticola	Fountain Darter	0.9981	10	
Percidae	Etheostoma fusiforme	Swamp Darter	0.9882	9	
Percidae	Etheostoma grahami	Rio Grande Darter	0.9957	56	
Percidae	Etheostoma radiosum	Orangebelly Darter	-	-	too few records
Percidae	Etheostoma thompsoni	Gumbo Darter	0.9952	31	

Family	Genus Species	Common Name	Test AUC	No. Records	Reason for exclusion
Percidae	Percina apristis	Guadalupe Darter	0.9957	37	
Percidae	Percina maculata	Blackside Darter	0.9916	21	
Percidae	Percina shumardi	River Darter	0.9752	36	
Poeciliidae	Gambusia gaigei	Big Bend Gambusia	-	-	too few records
Poeciliidae	Gambusia heterochir	Clear Creek Gambusia	-	-	too few records
Poeciliidae	Gambusia krumholzi	Spotfin Gambusia	-	-	too few records
Poeciliidae	Gambusia nobilis	Pecos Gambusia	0.997	25	
Poeciliidae	Gambusia senilis	Blotched Gambusia	-	-	too few records
Polyodontidae	Polyodon spathula	Paddlefish	-	-	too few records
Salmonidae	Oncorhynchus clarkii virginalis	Rio Grande Cutthroat Trout	-	-	too few records

Appendix 5, Table 2 - Environmental variables used in species distribution models.

Layer category	Description	Variable code	Source
Topological	Slope	slope	National Hydrology Dataset V2[1]
Topological	compound topological index (ln(acc.flow/tan[slope]))	cti	30-arc second DEM
Climate	annual mean temperature	bio_1	Wordclim variable 1
Climate	mean diurnal range (mean of monthly (max temp - min temp))	bio_2	Wordclim variable 2
Climate	isothermality (P2/P7)(*100)	bio_3	Wordclim variable 3
Climate	(temperature seasonality (sd *100)	bio_4	Wordclim variable 4
Climate	max temperature of warmest month	bio_5	Wordclim variable 5
Climate	min temperature of coldest month	bio_6	Wordclim variable 6
Climate	temperature annual range (P5-P6)	bio_7	Wordclim variable 7
Climate	Mean Temperature of Wettest Quarter	bio_8	Wordclim variable 8
Climate	Mean Temperature of Driest Quarter	bio_9	Wordclim variable 9
Climate	Mean Temperature of Warmest Quarter	bio_10	Wordclim variable 10

Climate	Mean Temperature of Coldest Quarter	bio_11	Wordclim variable 11
Climate	annual precipitation	bio_12	Wordclim variable 12
Climate	precipitation of wettest month	bio_13	Wordclim variable 13
Climate	precipitation of driest month	bio_14	Wordclim variable 14
Climate	precipitation seasonality (coefficient of variation)	bio_15	Wordclim variable 15
Climate	precipitation of wettest quarter	bio_16	Wordclim variable 16
Climate	precipitation of driest quarter	bio_17	Wordclim variable 17
Climate	precipitation of warmest quarter	bio_18	Wordclim variable 18
Climate	precipitation of coldest quarter	bio_19	Wordclim variable 19
Geographic	fresh water ecoregion	feow	The Nature Conservancy
Hydrologic	upstream distance (arbolate sum)	arbolatesu	National Hydrology Dataset V2[1]
Hydrologic	maximum elevation	maxelevsmo	National Hydrology Dataset V2[1]
Hydrologic	distance to Gulf of Mexico	pathlength	National Hydrology Dataset V2[1]
Hydrologic	potential evapotranspiration	pet0001	National Hydrology Dataset V2[1]
Hydrologic	annual precipitation of catchment	ppt0001	National Hydrology Dataset V2[1]
Hydrologic	annual flow with reference gage regression applied	q0001c	National Hydrology Dataset V2[1]

Hydrologic	mean runoff in area upstream	runoffvc	National Hydrology Dataset V2[1]
Hydrologic	modified Strahler Stream Order	Streamorde	National Hydrology Dataset V2[1]
Hydrologic	annual temperature at catchment	temp0001	National Hydrology Dataset V2[1]
Hydrologic	total upstream cumulative drainage area	totdasqkm	National Hydrology Dataset V2[1]
Hydrologic	velocity for q0001c	v0001c	National Hydrology Dataset V2[1]

[1]variables sourced from the National Hydrology Dataset V2 were converted to 30 arc-second grids using the NHDplus catchment unit

Appendix 6 – Field Based Survey Data and Specimens Cataloged into the Ichthyology Collection

The data in attached spreadsheet (Appendix6.xlsx) document details of specimens collected during 3 special field sampling events as part of this project, and all other specimens from other sources cataloged into the TNHC Fish Collection database during this project year.

Survey Code	Survey description	N specimen lots
1	Species list from 3 supplemental sites of the upper Frio River Basin	46
2	Species list from 13 supplemental sites and 2 bioblitz sites of the Big Cypress Basin	235
3	Species list from May, 2015 trip to Village Creek Basin	77
4	Miscellaneous other specimen lots catalogued into TNHC database during this report year	1485