RAPID QUANTITATIVE ASSESSMENT TO ASSIST IN IDENTIFICATION OF IMPERILED FISHES

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

ABSTRACT

Methodologies for ranking conservation status of fishes range from a rapid qualitative method (e.g., expert opinion) commonly used by state agencies to time-consuming quantitative method (i.e., Species Status Assessment; SSA) currently used by US Fish and Wildlife Service. Purpose of this study was to develop a rapid but quantitative methodology for ranking conservation status of freshwater fishes. Using parameters of SSA, redundancy (i.e., occurrence in numbers of independent drainages and semi-independent reaches, occurrences outside of the study area), representation (i.e., commonality within reaches), and resiliency (i.e., number of reaches with recently reported absences) were compiled for 50 species of fishes within the Edwards Plateau, Chihuahuan Desert, and South Texas Plains ecoregions of Texas. The 50 species represented 12 families of fishes and consisted of narrowly distributed fishes (i.e., occurring in one drainage) and widely-distributed fishes (i.e., occurring in up to six drainages) and among 1 to 50 reaches. Twenty-six percent (N = 13) of the fishes occur only within the study area. Parameters were analyzed with multivariate analysis. Principal component axis I described a redundancy gradient, contrasting narrowly distributed fishes from widely distributed fishes, and principal component axis II described resiliency and representation gradient, contrasting fishes with greater percent absence or percent rare from those with fewer percent absences and occasional to

abundant in relative abundances. Weighted summation of species scores for axes I and II were sorted from least (i.e., towards low redundancy, representation, and resiliency) to greatest (i.e., towards high redundancy, representation, and resiliency), and species were ranked. Species ranks were similar to the list of Texas Species of Greatest Conservation (SGCN), which were developed from rapid qualitative method, but discrepancies highlighted limitations of qualitative methods and expert opinion. Most notably, charismatic and well-studied fishes with moderate redundancy, representation, and resiliency were listed as SGCN, whereas less-studied fishes with lower redundancy, representation, and resiliency were not listed as SGCN. Among life history traits, majority of the top 50% ranked fishes were small-bodied fishes associated with aquifer dependent surface waters. Reproductive and trophic guilds were similar between the top and bottom 50% ranked fishes.

1. INTRODUCTION

The United States Fish and Wildlife Service (USFWS) currently uses an analytical approach, called Species Status Assessments, to guide decisions on listing species as threatened or endangered under the Endangered Species Act (1973) (USFWS 2016). Species Status Assessments (SSA) include a comprehensive review of historical and current distributional, ecological, and biological information for candidate species, a summary of documented and potential threats to species long term viability, a forecast of a species future with known and potential threats, and peer and public review of the assessment. Species Status Assessments incorporate the concepts of resiliency (i.e., tolerating stochastic disturbances), redundancy (i.e., surviving catastrophic events), and representation (i.e., enduring environmental conditions) (3Rs; Shaffer and Stein 2000) as a framework to identify level of species imperilment and risk of a species extinction currently and into the future. Time frame to complete a SSA is lengthy and completion of a recent SSA report took multiple years for the Sharpnose Shiner *Notropis oxyrhynchus* and Smalleye Shiner *N. buccula* (USFWS 2014).

In Texas, Texas Parks and Wildlife Department (TPWD) maintains a list of Species of Greatest Conservation Need (SGCN; TPWD 2005, 2012, In press). Species of Greatest Conservation Need include those that are considered rare, declining, or vulnerable for the purpose of identifying likely imperiled species and managing the species to prevent listing under Endangered Species Act (TPWD 2012). Species are periodically added to or deleted from SGCN list via stakeholder meetings with natural resource experts (e.g., agency biologists, academia) and with the use of NatureServe. Expert opinion is a common methodology used to assess conservation status of species

(Clark et al. 2006) but susceptible to subjectivity, experience, and knowledge breadth of an organism or the expert (Clark et al. 2006, Halpren et al. 2007, Donlan et al. 2010). NatureServe is a ranking system that considers three facets of imperilment: rarity, threats, and trends (Master et al. 2012). Determination of these facets is at the national level and, for some taxonomic groups, aspects of rarity, threats, and trends are determined at the family level (e.g., cyprinids) (NatureServe 2017), which collectively might be suitable or not when assessing rarity, threats, and trends at the state or region scale.

Purposes and processes differ between the USFWS and SGCN listings, and, therefore represent endpoints along a gradient of methodologies to support assessment of freshwater fish imperilment. On one end, the USFWS process is time consuming, comprehensive, and used for one or a few species at a time, whereas on the other end, SGCN process is less time consuming, less comprehensive, and used for all freshwater fishes in Texas. Several additional methodologies exist that are intermediate in time, comprehensiveness, and extent to support assessment of fish imperilment. Hudy et al. (2008) developed an assessment approach using historical records and current status to assess self-sustaining populations and extirpated populations of Brook Trout *Salvelinus fontinalis* by subwatershed. Given and Norton (1993) used a multi-metric approach to develop rankings and priorities for 47 perceived threatened plant species based on multivariate analysis, rather than linear ranking schemes, to lessen collinearity among metrics. Moyle et al. (2011) assessed conservation status of 129 fishes in California using a multi-metric approach with metrics estimating current abundance, area occupied, and certainty of the provided information.

The purpose of this study was to develop a quantitative methodology for the assessment of freshwater fish imperilment that uses components and approaches of existing methodologies for a rapid assessment of SCGN, while avoiding limitations of assessing species status based on expert opinion and NatureServe alone. The methodology was intended to be an intermediate between current SGCN and SSA in length of time to assess, especially since SGCN reviews occur about every five years. Similar to SSA, metrics linked to the 3 R concept were used with the added benefit of assembling data conducive for use by USFWS if eventually needed. The methodology should aid in the process of identifying SCGN but does not directly designate species as SCGN. In part, hazards and threats to species, which are additional components in listing imperiled fishes (Moyle et al. 2011), were not assessed because of the lack in quantitative information for many species and uncertainty associated with hazards and threats.

The methodology was developed using freshwater fish communities within three ecoregions of Texas (i.e., Chihuahuan Desert, Edwards Plateau, and South Texas Plains; Griffith et al. 2007). The three ecoregions were selected to develop and assess the feasibility of the methodology, because these regions are established as hotspots of fish endemism and contain a mix of narrowly distributed and widely distributed fishes (Conner and Suttkus 1987, Maxwell 2013). The methodology is a compilation of publicly available data, which facilitates application and repeatability of the model elsewhere and facilitates transparency in the methodological process. Components of the methodology correlate with the 3Rs concepts. Redundancy is represented by determination of inland fish occurrences reported within the regions by the delineation of independent drainages and semi-independent reaches within each drainage similar to

Hudy et al. (2008) and by verification of occurrence within drainage and reach using museum vouchers. Estimations of relative abundances were used from recent fish community surveys from published and unpublished data within a reach to assess commonality of a species (i.e., representation) or potential of extirpation (i.e., resiliency). Components were arranged in a data matrix and analyzed with a multivariate model generating species scores and a rank similar to Given and Norton (1993) and Moyle et al. (2011). Ranking of species was compared and contrasted to current federal and state lists in order to assess model methodology viability. Life history characteristics, such as body size, water source, and reproduction and trophic guilds, were used to examine ranked fishes for biological patterns associated with low redundancy, resiliency and representation.

2. METHODS

Study Area— Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions compose 32% of the surface area in Texas (Griffith et al. 2007) and provide aquatic habitats for 70% (N = 7) of the federally-listed Texas fishes and 57% (N = 32) of the Texas-SGCN fishes (Figure 1). Chihuahuan Desert ecoregion is about 13% of the surface area in Texas and is bounded by the state boundary with New Mexico and the USA international boundary with Mexico in the west to the Pecos River in the east. Surface and ground water flow are within the Rio Grande basin with some endorheic watersheds. Edwards Plateau ecoregion is about 11% of the surface area in Texas and is bounded by the Pecos River in the west and the Balcones Escarpment in the east. Surface and ground water flow are within the Rio Grande, Nueces River, Guadalupe River, San Antonio River, Colorado River, and Brazos River basins. South Texas Plains ecoregion is about 8% of the surface area in Texas and is bounded by the Edwards Plateau ecoregion in the north, the Rio Grande in the south, and the lower Rio Grande (i.e., Falcon Reservoir on the Rio Grande) in the east. Surface and ground water flow are within the Rio Grande and Nueces River basins.

Designation of independent drainages and semi-independent reaches and compilation of species occurrences, museum records, and relative abundances were similar to the methodologies described by Craig et al. (2017). An independent drainage was defined as a drainage without contemporary connection with another drainage and with a coastal or near coastal terminus (i.e., Gulf of Mexico). Rio Grande, Nueces, Colorado, and Brazos rivers have separate coastal termini with the Gulf of Mexico.

Guadalupe River and San Antonio River share a near coastal terminus, connecting about 15 km upstream from San Antonio Bay. A semi-independent reach was a named stream (e.g., San Marcos River, Guadalupe River drainage), a named tributary of stream (e.g., Blanco River, tributary of the San Marcos River), or a reach of a named stream (e.g., upper San Marcos River, upstream from confluence with Blanco River) within an independent drainage. Reaches of a named stream were separated by a major confluence or by a dam. Museum records (Fishes of Texas Project Database, Version 2; Hendrickson and Cohen 2015) and published literature (Hubbs et al. 2008, Thomas et al. 2008) were used to document and verify fish occurrences within drainage and reach. Species considered extinct or extirpated from the study area or with peripheral occurrences within the study area (Conner and Suttkus 1987, Maxwell 2013) were removed from further analyses in order to only quantify fishes with primary occurrences within the study area. Relative abundances of fishes were obtained from the most recently available published literature and unpublished data within drainage and reach. Species identified among published and unpublished literature were accepted as reported, although some populations (e.g., Guadalupe Bass *Micropterus treculii*, Bean et al. 2013; and Headwater Catfish *Ictalurus lupus*, McClure-Baker et al. 2010, Bean et al. 2011) are known to hybridize with non-native congenera. Relative abundances were sorted into categories: Abundant (>75% in relative abundance), Common (50 to 74%), Frequent (25 to 49%), Occasional (5 to 24%), and Rare (> 0 to 4%) (ACFOR) scale (Stiers et al. 2011). Zero relative abundance was categorized as absent, which might or might not indicate extirpation. Fishes in independent drainages and semi-independent reaches were excluded if museum vouchers and recent relative abundances were not available. These two

criteria ensured that a species occurrence and relative abundance are verifiable. Consequently, not all reaches and water bodies with a known occurrence of a species were included in the analyses.

Species data tables were constructed and consisted of columns that identified occurrences in independent drainage, occurrences in semi-independent drainage, earliest date of first collection as a museum voucher, relative abundance, date of relative abundance estimate, ACFOR category, absence, and citation for most recent relative abundance. Species data tables were used to develop a species matrix with each row representing a species of fish and columns consisting of the number of independent drainages of occurrence, number of semi-independent reaches of occurrence, percent of semi-independent reaches categorized as rare, percent of semi-independent reaches categorized as absent, the number of independent drainages where a fish occurs in other ecoregions of Texas, and if the fish occurs outside of Texas or not. Species matrix was assessed with Principal Components Analysis (PCA). Species scores from PC I and PC II axes, which describe the greatest percent of variation explained, were weighted by each axis percent variation explained, and then summed together. Product of PCA axis II score multiplied by proportion of variation explained was multiplied by -1. Multiplication by -1 was necessary to convert PC axes 1 & 2 gradients into compatible linear contrasts to distinguish species with low redundancy, representation, and resiliency from those with high redundancy, representation, and resiliency. A single number was associated with each species of fish. Species numbers were sorted in ascending order with the lowest number representing the fish with collectively the estimated lowest

redundancy, representation, and resiliency and the highest number representing the fish with collectively the estimated highest redundancy, representation, and resiliency.

Species by rank were compared to current species listed by USFWS and Texas-SGCN and assessed among life history characteristics. Fishes listed by USFWS were added between 1970 and 1998 and previous to the SSA process. Texas SGCN (2012) list was used although a revised listing is forthcoming. Associated water source (groundwater via aquifer or surface flow via river), body size, reproductive guild, and trophic guild were obtained from multiple sources (Goldstein and Simon 1999, Thomas et al. 2007, Hubbs et al. 2008, Craig et al. 2016). When information was lacking, life history information was taken from closely-related species. Body sizes relative to species examined herein were determined using reported maximum total length for each species (small: ≤70 mm, medium: 71 – 115 mm, large: >150 mm).

3. RESULTS

A total of 88 native freshwater fishes was reported within the study area. Twelve species with peripheral occurrences were excluded (Appendix 1, listed in phylogenetic order). Among the remaining 74 species, 11 species (15%) were excluded because of lack of relative abundance data (e.g., Pecos Pupfish *C. pecosensis*) or lack of museum and historical records (e.g., Alligator Gar, *A. spatula*) (Appendix 1). Among the remaining 63 species, species data tables were constructed for 50 species (79%) of the available fishes (Appendix 2). The 50 species data tables represented 12 families of fishes and consisted of narrowly distributed fishes (i.e., occurring in one drainage) and widely-distributed fishes (i.e., occurring in up to six drainages) and among 1 to 50 reaches (species matrix; Table 1). Twenty-six percent (N = 13) of the fishes occur only within the study area. Among the 74% (N = 37) of fishes with occurrences outside of the study area, 21 fishes (e.g., Channel Catfish *Ictalurus punctatus*) occur in independent Texas drainages outside the study area and in drainages outside of Texas, one fish (i.e., Texas Logperch *Percina carbonaria*) occurs in independent Texas drainages outside the study area only, and 15 fishes (e.g., Chihuahua Shiner *Notropis chihuahua*) occur in drainages outside of Texas (e.g., primarily Mexico or New Mexico) but not in independent Texas drainages outside of the study area. Species data tables were not constructed for 13 fishes (21%) (Appendix 1). The 13 fishes represented widely-

distributed species in independent drainages outside of the study area in Texas and outside of Texas.

Principal component axes I and II explained 71% of the total variation in the species data matrix (Figure 2). PC axis I explained 49% of the total variation and described a redundancy gradient, contrasting narrowly distributed fishes (i.e., negative scores) from widely distributed fishes (i.e., positive scores; Table 2). Species with strong positive scores along PC axis I included Western Mosquitofish *Gambusia affinis*, Longear Sunfish *Lepomis megalotis*, Bluegill *L. macrochirus*, and Channel Catfish *Ictalurus punctatus*. Species with strong negative scores included Comanche Springs Pupfish *Cyprinodon elegans*, Clear Creek Gambusia *Gambusia heterochir*, and Fountain Darter *Etheostoma fonticola*. PC axis II explained 22% of the total variation and described a resiliency and representation gradient, contrasting fishes with greater percent absence or percent rare (i.e., positive scores) from those with fewer percent absences and occasional to abundant in relative abundances (i.e., negative scores). Species with strong positive scores along PC axis II included Rio Grande Shiner *Notropis jemezanus*, Longnose Dace *Rhinichthys cataractae*, and Speckled Chub *Macrhybopsis aestivalis*. Species with strong negative scores included Fountain Darter *Etheostoma fonticola*, Rio Grande Cichlid *Herichthys cyanoguttatus*, and Largespring Gambusia *Gambusia geiseri*.

Weighted summation of species scores for axes I and II were sorted from least (i.e., towards low redundancy, representation, and resiliency) to greatest (i.e., towards high redundancy, representation, and resiliency) and ranked (Table 3). Final scores ranged from -1.195 for Comanche Springs Pupfish to 1.735 for Western Mosquitofish. Comparing to USFWS listed species and current Texas SGCN list, ranks assigned by this

study were more similar to the Texas SGCN list than the USFWS list. Among the 24 fishes listed as Texas SGCN within the study area, 18 Texas SGCN were ranked 1 – 20, and all 24 Texas SGCN were ranked 1 – 38 by this methodology. Among the 6 fishes listed by USFWS within the study area, all were ranked in the top 20 with this methodology. Top 50% ranked fishes were associated more with aquifer (64%; N = 16) than river (36%; N = 9) water sources, whereas bottom 50% ranked fishes were associated with river (64%) than aquifer (36%) (Figure 3). Top 50% ranked fishes consisted primarily of small body size (52%; N = 13), whereas bottom 50% ranked fishes consisted primarily of large body size (56%; N = 12). Most frequently occurring reproductive guild was nonguarder, and most frequently occurring trophic guild was invertivore for top and bottom 50% ranked fishes.

4. DISCUSSION

The methodology met the intended purpose of providing a rapid quantitative assessment and ranking for potentially 85% of the fishes found within the study area based on their distribution, commonality, and potential for extirpation. The ranked list of fishes is not a ranking of imperiled fishes like that of Moyle et al. (2011), because threats were not included in the final ranking. Instead, the ranked list provides quantitative distributional information to assist in imperiled fish identification along with often qualitative evaluations of threats and economics (Given and Norton 1993).

Ranking of fishes was similar to the current SGCN listings but with some notable differences. The top 20 ranked fishes are listed as SGCN except for two species: Tex-Mex Gambusia *Gambusia speciosa* and Spotfin Gambusia *Gambusia krumholzi*. Tex-Mex Gambusia occurs within the Rio Grande drainage of USA and Mexico and was split from Western Mosquitofish *Gambusia affinis* (Rauchenburger 1989). Uncertainty exists about its natural range (see Miller 2005), and the species account is listed as data deficient by IUCN (NatureServe 2017). However, this methodology ranked Tex-Mex Gambusia as 9th, indicating a need for more information. Spotfin Gambusia occurrence in Texas was first reported in 1997 but reported as a new species, San Felipe Gambusia *Gambusia clarkhubbsi* (Garrett and Edwards 2003). Later, San Felipe Gambusia was determined to be a junior synonym of Spotfin Gambusia *Gambusia krumholzi* (Echelle et al. 2013). San Felipe Gambusia is listed on the current SGCN list (2012) and will be replaced with Spotfin *Gambusia krumholzi* on the revised SGCN list(in press).

Four of the fishes ranked 21 to 30 are listed as SGCN. The remaining six species are highlighted and available for additional discussion by a stakeholder group. Among the six species, four species (i.e., Spotted Gar *Lepisosteus oculatus*, Orangespotted Sunfish *Lepomis humilis*, Rainwater Killifish *Lucania parva*, and Plains Killifish *Fundulus zebrinus*) have ubiquitous distributions outside of the study area (Hendrickson and Cohen 2015) and likely not considered for listing as SGCN. However, two other species (Largespring Gambusia *Gambusia geiseri* and Texas Logperch *Percina carbonaria*) could be assessed for listing as SGCN since both are endemic to drainages within Texas. Largespring Gambusia is thought to be introduced into the Rio Grande drainage during malaria control efforts in the 1930s (Rauchenberger 1989; Hubbs et al. 2008) and competing with endemic congenera (Sanchez et al. 2013), which possibly prevented its inclusion on previous SCGN lists. However, Largespring Gambusia has relatively lower redundancy (i.e., 3 drainages and 10 reaches) when counting native and non-native populations and therefore ranked 23rd. Texas Logperch, another endemic fish to Texas and ranked 29, has greater than average redundancy (i.e., 5 drainages and 21 reaches) but is absent in 42% of the reaches and rare in 92% of the extant reaches.

Fishes ranked 32 and 38 are listed as SGCN. Guadalupe Bass, ranked 32, is listed by SGCN and ranked lower than eight other non-SGCN fishes. Guadalupe Bass listing as SGCN includes the quantified threats of introgression with the introduced Smallmouth Bass *Micropterus dolomieu* (Bean et al. 2013). Adding known and potential threats to species ranking can justify listing of species as SGCN with lower ranks than others. Texas Shiner *Notropis amabilis* has greater than average redundancy and representation. Its Texas endemic status was a primary factor in listing as a SGCN species. However,

recent work by Craig et al. (2017) indicated higher redundancy and representation, and therefore suggested for deletion on the forthcoming SGCN list, especially now that the measures of redundancy, representation, and resiliency for Texas Shiner have context given that measures of the 3 Rs are provided for other fishes within the region.

The methodology was not applicable to 15% of the fishes (i.e., 11 species) within the study area because of the lack of verifiable museum records or lack of relative abundance data. Lack of information is common in assessment and ranking efforts (O'Grady et al. 2004, McGeoch et al. 2012) with Hudy et al. (2008) reporting incomplete data in 33% of their study area when assessing Brook Trout populations by watersheds. As such, the inability to assess 15% of the species within the study area is likely acceptable for a methodology to assess imperiled status of species. Regardless, the methodology identified gaps in knowledge for 15% of the fishes within the study area, which can be used to prioritize species for further research. In particular, six of the 11 fishes are listed on federal or SGCN lists and likely would be ranked high by this methodology.

Quantification of species distributions and life history traits provide insight into similarities among the top ranked fishes with the top 50% ranked fishes being primarily endemic fishes of the arid and semi-arid regions of southwestern USA and northern Mexico and small to medium in body size. High rates of endemism among fishes within the study area are related to zoogeographical processes, such as immigration with wet environments during maximum glacial extent in North America and isolation with arid environments during interglacial periods (Conner and Suttkus 1986, Maxwell 2013, others). During the current Holocene interglacial period, climate in central and west

Texas is trending towards greater aridity (Wong et al. 2015) causing reductions in surface water availability (Sylvia and Galloway 2006). In theory, the contemporary fish community within the study area is a subset of a more diverse fish community at the start of the Holocene (Conner and Suttkus 1986). As such, top ranked fishes with small body size and broadcast or livebearing reproductive strategies can either represent fishes more prone to increasing aridity gradients, or fishes less susceptible to increases in aridity given that they have persisted under increasing aridity during the last 12,000 years. Regardless, anthropogenic uses of ground and surface water resources in arid and semi-arid regions will soon be, if not already, unsustainable without proper management (Gleick 2010) and therefore a continued threat to fishes endemic to the area.

The methodology developed herein provided several advantages to the process of imperiled species consideration. The rapid quantification of fish distribution, commonality, and potential for extirpation identified three species not previously listed as SGCN. In addition, species accounts provided a summary of available information, which can be edited in the future with new information based on new species occurrences and with changes in relative abundances. Also, updated species matrix can be reanalyzed to provide an update on species rankings. The species matrix can be expanded to other regions. In doing so, fishes across regions (e.g., arid to humid regions of Texas and outside of the state) can be assessed using the same criteria and providing a relative ranking of distribution, commonality, and extirpation potential. Currently, all federally-listed fishes and 88% of the SGCN fishes are found in arid regions (i.e., study region herein and prairie streams of northwest Texas), which might or might not indicate oversight of species in more humid areas of Texas. Ultimately, this methodology could

be expanded to other aquatic organisms (e.g., macroinvertebrates, mussels, aquatic salamanders) to provide common and consistent criteria in imperiled species quantification across taxa.

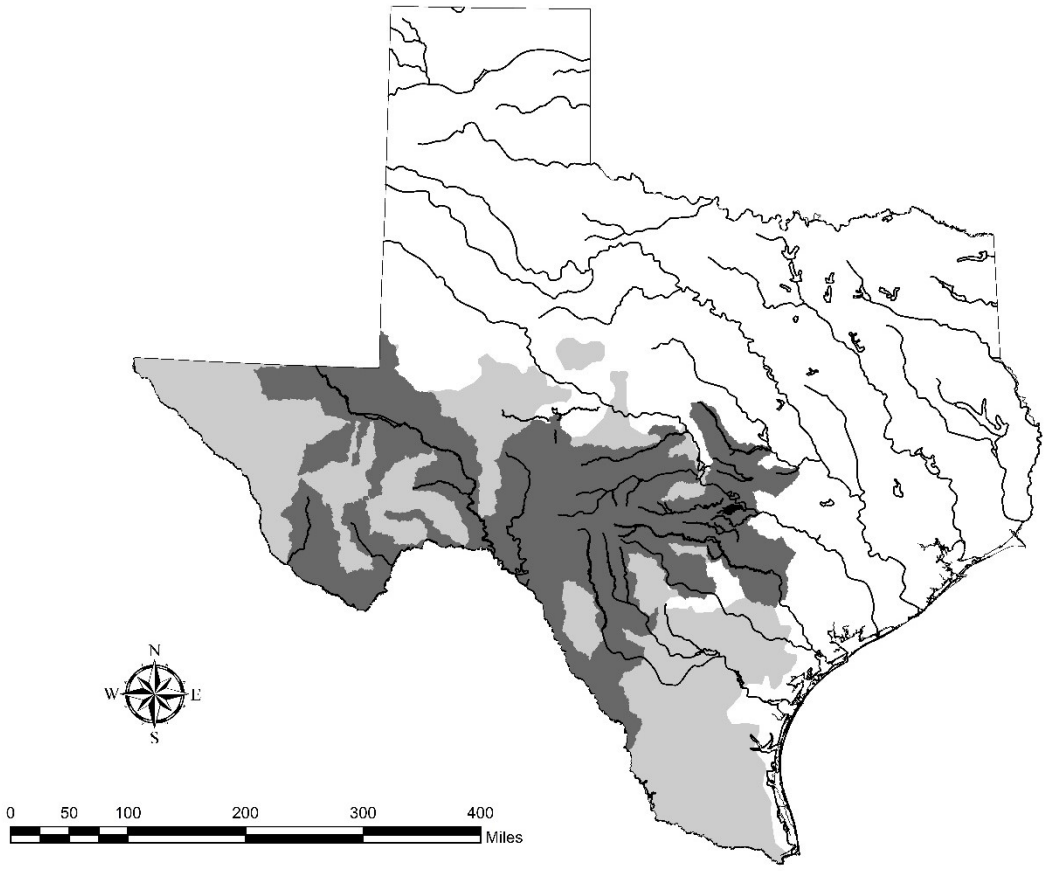

Figure 1. Map of the study area in Texas. Light shaded areas represent the Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions. Dark shaded areas represent the hydrologic units of the semi-independent reaches within the study area.

Table 1. Number of drainages and reaches inhabited by each species of fish within the study area, percent (%) of reaches where species is categorized as rare, percent (%) of reaches where species were absent from most recent collections, number of independent drainages inhabited by each species of Texas but outside of study area, and if occurring or not outside of Texas.

Species	Drainages	Reaches	% Rare of Extant Reaches	% Absent of Total Reaches	Independent Drainages in Texas	Found Outside of Texas
Lepisosteus oculatus	4	13	100	54	3	1
Dorosoma cepedianum	6	24	100	54	4	1
Campostoma anomalum	6	38	72	16	3	1
Campostoma ornatum	1	4	0	50	0	1
Cyprinella lepida	2	5	100	20	0	0
Cyprinella lutrensis	6	40	38	40	4	1
Cyprinella proserpina	1	10	20	50	0	0
Cyprinella venusta	6	41	25	12	3	1
Dionda argentosa	1	9	0	33	0	0
Dionda diaboli	1	4	67	25	0	1
Dionda episcopa	1	7	100	71	0	1
Dionda nigrotaeniata	3	19	86	26	0	0
Dionda serena	1	5	25	20	0	0
Macrhybopsis aestivalis	1	8	100	75	0	1
Notropis amabilis	6	34	34	15	0	1
Notropis braytoni	1	10	60	50	0	1
Notropis chalybaeus	1	1	100	0	2	1
Notropis chihuahua	1	3	100	33	0	1
Notropis jemezanus	1	7	100	86	0	1
Notropis stramineus	5	25	82	56	2	1
Pimephales vigilax	6	35	76	51	4	1
Rhinichthys cataractae	1	5	100	80	0	1
Carpiodes carpio	5	25	100	48	4	1
Moxostoma congestum	6	35	100	46	0	1
Astyanax mexicanus	6	36	73	28	2	1
Ameiurus natalis	6	22	100	55	3	1
Ictalurus lupus	3	16	100	56	0	1
Ictalurus punctatus	6	41	100	27	4	1
Fundulus zebrinus	2	12	67	50	2	1
Lucania parva	3	7	80	29	0	1
Gambusia affinis	6	50	49	14	4	1

Table 1. continued

Species	Drainages	Reaches	% Rare of Extant Reaches	% Absent of Total Reaches	Independent Drainages in Texas	Found Outside of Texas
Gambusia geiseri	3	10	25	20	0	0
Gambusia heterochir	1	2	0	50	0	0
Gambusia krumholzi	1	1	100	0	0	0
Gambusia nobilis	1	4	0	25	0	1
Gambusia speciosa	1	4	0	50	0	1
Cyprinodon bovinus	1	1	100	0	0	0
Cyprinodon elegans	1	3	0	67	0	0
Lepomis humilis	3	12	100	75	3	1
Lepomis macrochirus	6	40	86	8	4	1
Lepomis megalotis	6	45	84	4	4	1
Lepomis miniatus	5	18	100	56	3	1
Micropterus treculii	5	21	100	19	0	0
Etheostoma fonticola	1	2	0	0	0	0
Etheostoma grahami	1	7	83	14	0	1
Etheostoma lepidum	4	26	85	23	2	1
Etheostoma spectabile	4	18	80	44	2	1
Percina apristis	1	4	100	50	0	0
Percina carbonaria	5	21	92	43	1	0
Herichthys cyanoguttatus	6	30	96	10	1	1

Table 2. Results for the PCA used to create the rankings from the data matrix. Values represent loadings along PCI and PC II for variables used in the PCA.

Variable	PC I	PC II
Drainages	0.54	-0.17
Reaches	0.53	-0.21
Drainages outside Study Area	0.52	0.02
Found Outside Texas	0.33	0.49
Percent Rare	0.22	0.38
Percent Absent	-0.06	0.73

Table 3. Names, code for genus and specific epithet abbreviations, final score, and ranking of fishes. See Methods for designation and definitions of water source, body size, reproductive guilds, and trophic guilds. Abbreviations for trophic guilds: planktivore (plank), herbivore (herb), detritivore (detrit), omnivore (omni), invertivore (invert), and carnivore (carn).

Species	Code	Final Score	Rank	Water source	Body size	Reproduction guild	Trophic guild
Cyprinodon elegans[1,2]	Cyp ele	-1.195	1	aquifer	small	nonguarder	invert-herb
Notropis jemezanus[2]	Not jem	-1.100	2	river	medium	nonguarder	carn-invert
Rhinichthys cataractae[2]	Rhi cat	-1.092	3	river	large	nonguarder	invert
Gambusia heterochir[1,2]	Gam het	-1.071	4	aquifer	small	live bearer	invert
Macrhybopsis aestivalis[2]	Mac aes	-0.984	5	river	small	nonguarder	invert
Dionda episcopa[2]	Dio epi	-0.972	6	aquifer	medium	nonguarder	herb
Percina apristis[2]	Per apr	-0.967	7	aquifer	medium	nonguarder	invert
Campostoma ornatum[2]	Cam orn	-0.919	8	river	medium	nonguarder	herb
Gambusia speciosa	Gam spe	-0.919	9	aquifer	small	live bearer	invert
Cyprinella proserpina[2]	Cyp pro	-0.885	10	river	medium	nonguarder	invert
Dionda argentosa[2]	Dio arg	-0.774	11	river	medium	nonguarder	herb
Notropis braytoni[2]	Not bra	-0.752	12	aquifer	medium	nonguarder	invert
Dionda serena[2]	Dio ser	-0.734	13	aquifer	medium	nonguarder	herb
Notropis chihuahua[2]	Not chi	-0.734	14	river	small	nonguarder	invert
Gambusia nobilis[1,2]	Gam nob	-0.704	15	aquifer	small	live bearer	invert
Dionda diaboli[1,2]	Dio dia	-0.663	16	aquifer	small	nonguarder	herb
Etheostoma fonticola[1,2]	Eth fon	-0.643	17	aquifer	small	nonguarder	invert

Table 3. continued

Species	Code	Final Score	Rank	Water source	Body size	Reproduction guild	Trophic guild
Gambusia krumholzi	Gam kru	-0.603	18	aquifer	small	live bearer	invert
Cyprinodon bovinus[1,2]	Cyp bov	-0.603	19	aquifer	small	nonguarder	detrit-invert
Cyprinella lepida[2]	Cyp lep	-0.549	20	aquifer	medium	nonguarder	invert
Etheostoma grahami[2]	Eth gra	-0.494	21	aquifer	small	nonguarder	invert
Ictalurus lupus[2]	Ict lup	-0.371	22	aquifer	large	guarder	omni
Gambusia geiseri	Gam gei	-0.348	23	aquifer	small	live bearer	invert
Lucania parva	Luc par	-0.347	24	river	small	nonguarder	invert
Fundulus zebrinus	Fun zeb	-0.254	25	river	medium	nonguarder	herb
Notropis chalybaeus[2]	Not cha	-0.183	26	aquifer	small	nonguarder	invert
Dionda nigrotaeniata[2]	Dio nig	-0.166	27	aquifer	medium	nonguarder	herb
Lepomis humilis	Lep hum	-0.154	28	river	large	guarder	invert
Percina carbonaria	Per car	0.168	29	aquifer	medium	nonguarder	invert
Lepisosteus oculatus	Lep ocu	0.186	30	river	large	nonguarder	carn
Etheostoma spectabile	Eth spe	0.213	31	river	small	nonguarder	invert
Micropterus treculii[2]	Mic tre	0.223	32	aquifer	large	guarder	carn-invert
Notropis stramineus	Not str	0.402	33	river	medium	nonguarder	detrit-invert
Lepomis miniatus	Lep min	0.416	34	aquifer	large	guarder	invert
Moxostoma congestum	Mox con	0.544	35	aquifer	large	nonguarder	invert
Etheostoma lepidum	Eth lep	0.570	36	aquifer	small	nonguarder	invert
Ameiurus natalis	Ame nat	0.650	37	river	large	guarder	carn-invert
Notropis amabilis[2]	Not ama	0.747	38	aquifer	small	nonguarder	invert-herb
Herichthys cyanoguttatus	Her cya	0.787	39	river	large	guarder	omni

Table 3. continued

Species	Code	Final Score	Rank	Water source	Body size	Reproduction guild	Trophic guild
Carpiodes carpio	Car car	0.792	40	river	large	nonguarder	detrit-plank
Dorosoma cepedianum	Dor cep	0.858	41	river	large	nonguarder	herb
Astyanax mexicanus	Ast mex	1.014	42	aquifer	medium	nonguarder	omni
Pimephales vigilax	Pim vig	1.108	43	river	medium	guarder	invert-herb
Cyprinella lutrensis	Cyp lut	1.288	44	river	medium	nonguarder	invert-herb
Campostoma anomalum	Cam ano	1.315	45	river	large	nonguarder	herb
Cyprinella venusta	Cyp ven	1.386	46	river	large	nonguarder	invert
Ictalurus punctatus	Ict pun	1.459	47	river	large	guarder	carn-invert
Lepomis macrochirus	Lep mac	1.591	48	river	large	guarder	invert
Lepomis megalotis	Lep meg	1.733	49	river	large	guarder	invert
Gambusia affinis	Gam aff	1.735	50	river	small	live bearer	invert

[1] Listed by US Fish and Wildlife Service as threatened or endangered

[2] Listed as Texas Species of Greatest Conservation Need

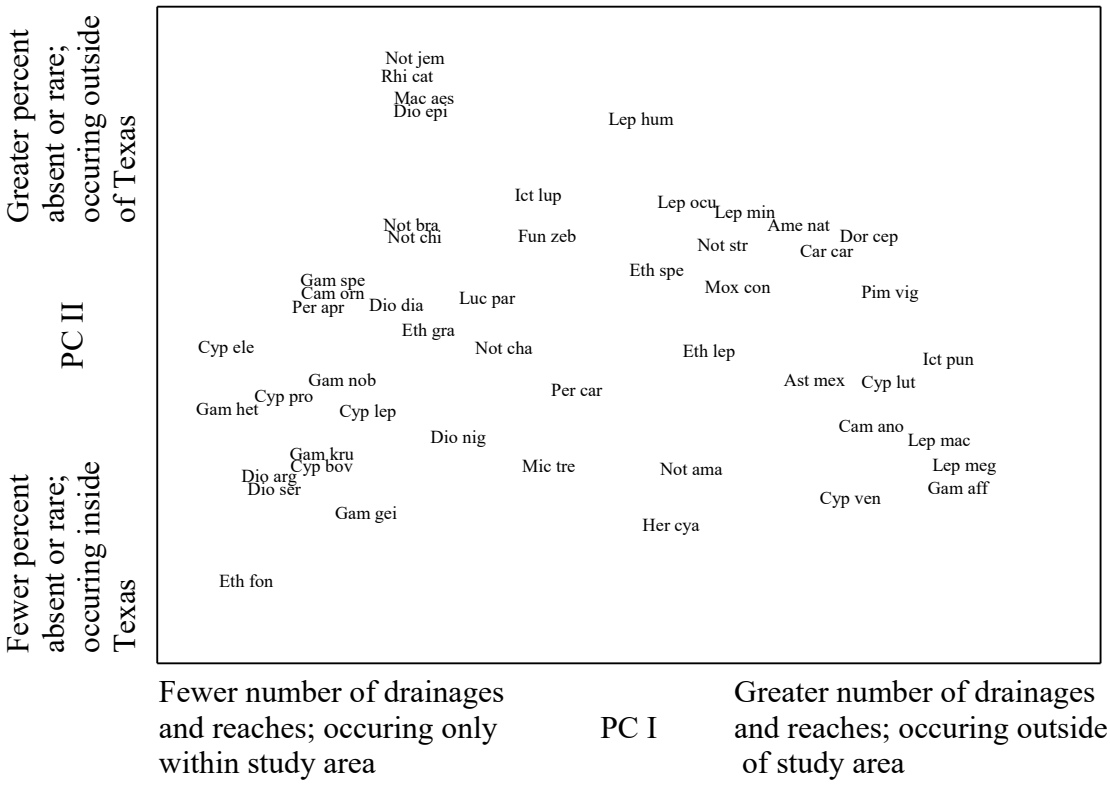

Figure 2. Fishes (first three letters of genus and specific epithets provided; see Table 3) distributed along PC axes I and II, representing fishes with wide distributions (i.e., positive along PC I) and narrow distributions (negative on PC I) and species with numerous reach extirpations (positive on PC II) and few reach extirpations (negative on PC II). Some fish names were jittered to allow readability.

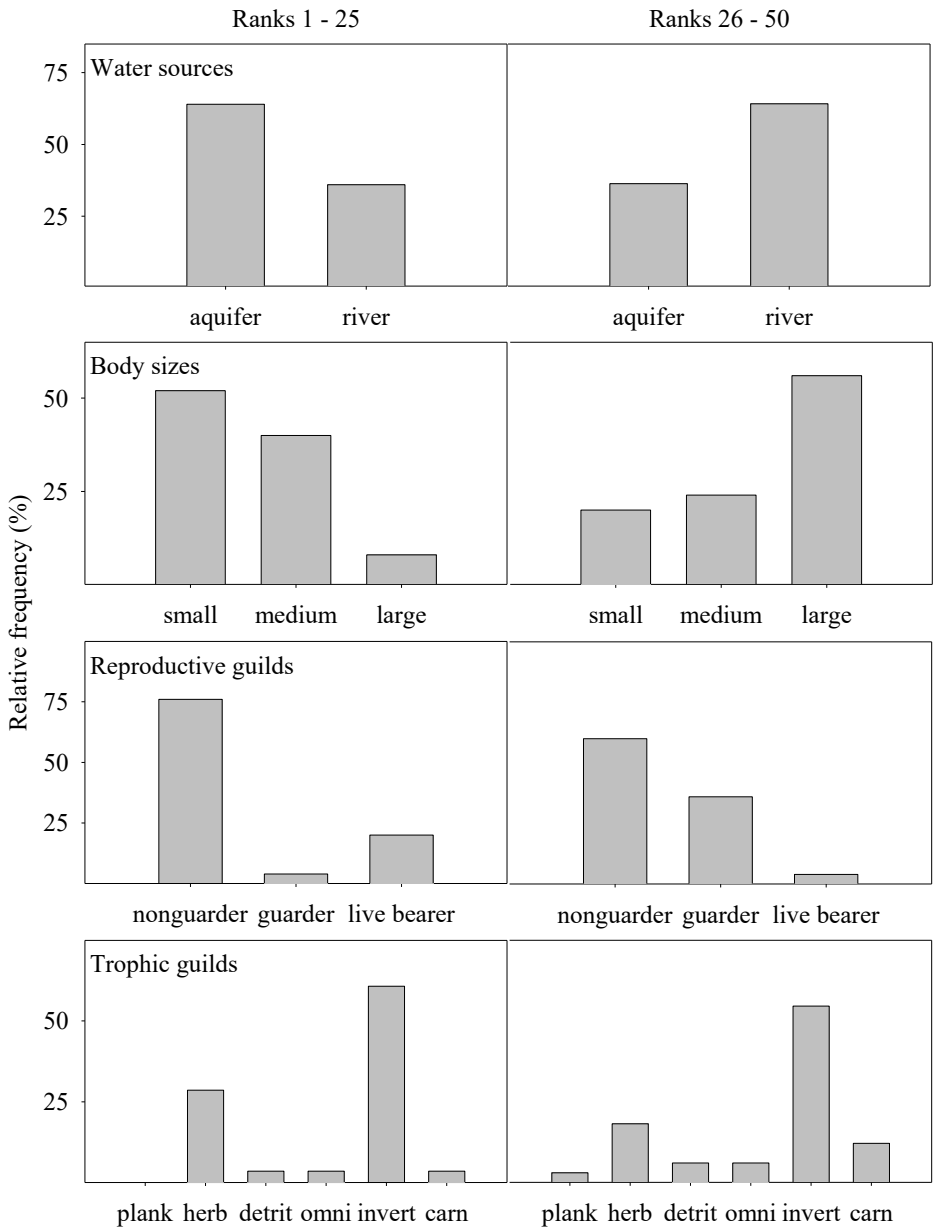

Figure 3. Summary statistics of life history characteristics of ranked fishes. Comparison between top and bottom ranked fishes associated with water sources body sizes, reproductive guilds, and trophic guilds (plank = planktivore, herb = herbivore, detrit = detritivore, omni = omnivore, invert = invertivore, carn = carnivore).

APPENDIX SECTION

Appendix 1. List of all the species recorded in Chihuahuan Desert, Edwards Plateau, and South Texas Plains Ecoregions and their current conservation statuses. USFWS denote species listed as threatened or endangered by United States Fish and Wildlife Service; SGCN denotes species listed as Texas Species of Greatest Conservation Need; IUCN denotes species ranked by the International Union for the Conservation of Nature. Abbreviations for IUCN: extinct (EX), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), not evaluated (NE). See methods for definitions of species considered or excluded from methodology.

	Current Listed Status			Considered for Method			Excluded from Method	
Species	**USFWS**	**SGCN**	**IUCN**	**Study Subset**	**Applicable Species**	**Information Deficit**	**Peripheral Occurrence**	**Extinct/ Extirpated**
Atractosteus spatula		X	NE			X		
Lepisosteus oculatus			NE	X				
Lepisosteus osseus			LC		X			
Anguilla rostrata		X	EN				X	
Dorosoma cepedianum			LC	X				
Dorosoma petenense			LC				X	
Campostoma anomalum			LC	X				
Campostoma ornatum		X	LC	X				
Cyprinella lepida		X	EN	X				
Cyprinella lutrensis			LC	X				
Cyprinella proserpina		X	VU	X				
Cyprinella venusta			LC	X				
Dionda argentosa		X	NT	X				

Appendix 1. continued

	Current Listed Status			Considered for Method			Excluded from Method	
Species	**USFWS**	**SGCN**	**IUCN**	**Study Subset**	**Applicable Species**	**Information Deficit**	**Peripheral Occurrence**	**Extinct/ Extirpated**
Dionda diaboli	X	X	EN	X				
Dionda episcopa		X	LC	X				
Dionda nigrotaeniata		X	LC	X				
Dionda serena		X	LC	X				
Gila pandora		X	LC			X		
Hybognathus amarus	X	X	EN			X		
Hybopsis amnis			LC				X	
Macrhybopsis aestivalis		X	LC	X				
Macrhybopsis hyostoma			LC				X	
Macrhybopsis marconis			LC				X	
Notemigonus crysoleucas			LC		X			
Notropis amabilis		X	LC	X				
Notropis braytoni		X	NE	X				
Notropis buchanani			LC				X	
Notropis chalybaeus		X	LC	X				
Notropis chihuahua		X	NE	X				
Notropis jemezanus		X	LC	X				
Notropis orca			EX					X
Notropis simus	X	X	EN					X
Notropis stramineus			LC	X				
Notropis texanus			LC				X	
Notropis volucellus			LC		X			

Appendix 1. continued

	Current Listed Status			Considered for Method			Excluded from Method	
Species	**USFWS**	**SGCN**	**IUCN**	**Study Subset**	**Applicable Species**	**Information Deficit**	**Peripheral Occurrence**	**Extinct/ Extirpated**
Opsopoeodus emiliae			LC				X	
Pimephales promelas			LC				X	
Pimephales vigilax			LC	X				
Rhinichthys cataractae		X	LC	X				
Carpiodes carpio			LC	X				
Cycleptus elongatus		X	LC			X		
Erimyzon sucetta			LC			X		
Ictiobus bubalus			LC		X			
Minytrema melanops			LC		X			
Moxostoma austrinum		X	NE			X		
Moxostoma congestum			LC	X				
Astyanax mexicanus			LC	X				
Ameiurus melas			LC		X			
Ameiurus natalis			LC	X				
Ictalurus furcatus			LC		X			
Ictalurus lupus		X	DD	X				
Ictalurus punctatus			LC	X				
Noturus gyrinus			LC				X	
Noturus nocturnus			LC				X	
Pylodictis olivaris			LC		X			
Oncorhynchus clarkii		X	NE					X
Agonostomus monticola			LC			X		

Appendix 1. continued

	Current Listed Status			Considered for Method			Excluded from Method	
Species	**USFWS**	**SGCN**	**IUCN**	**Study Subset**	**Applicable Species**	**Information Deficit**	**Peripheral Occurrence**	**Extinct/ Extirpated**
Menidia beryllina			LC		X			
Fundulus notatus			LC			X		
Fundulus zebrinus			LC	X				
Lucania parva			LC	X				
Gambusia affinis			LC	X				
Gambusia amistadensis			EX					X
Gambusia gaigei	X	X	VU			X		
Gambusia geiseri			LC	X				
Gambusia georgei	X		EX					X
Gambusia heterochir	X	X	VU	X				
Gambusia krumholzi			VU	X				
Gambusia nobilis		X	EN	X				
Gambusia senilis	X	X	NT					X
Gambusia speciosa			DD	X				
Cyprinodon bovinus	X	X	VU	X				
Cyprinodon elegans	X	X	EN	X				
Cyprinodon eximius		X	NT			X		
Cyprinodon pecosensis		X	VU			X		
Lepomis cyanellus			LC		X			
Lepomis humilis			LC	X				
Lepomis macrochirus			LC	X				

Appendix 1. continued

	Current Listed Status			Considered for Method			Excluded from Method	
Species	**USFWS**	**SGCN**	**IUCN**	**Study Subset**	**Applicable Species**	**Information Deficit**	**Peripheral Occurrence**	**Extinct/ Extirpated**
Lepomis megalotis			LC	X				
Lepomis microlophus			LC		X			
Lepomis miniatus			LC	X				
Micropterus salmoides			LC		X			
Micropterus treculii		X	NT	X				
Etheostoma fonticola	X	X	EN	X				
Etheostoma gracile			LC				X	
Etheostoma grahami		X	VU	X				
Etheostoma lepidum			NT	X				
Etheostoma spectabile			LC	X				
Percina apristis		X	LC	X				
Percina carbonaria			LC	X				
Percina macrolepida			LC				X	
Percina sciera			LC				X	
Aplodinotus grunniens			LC		X			
Herichthys cyanoguttatus			LC	X				

Appendix 2.1 First records and recent abundances of Spotted Gar *Lepisosteus oculatus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1952	5.4	2010	Occasional	Labay 2010
	San Gabriel	1951	<0.1	2010	Rare	Labay 2010
	Rocky Creek	1938	43	2010	Frequent	Labay 2010
Colorado	South Concho	1954	<0.1	1999	Rare	Hubbs 2004
	Spring Creek	1984	0.6	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1955	0.7	2012	Rare	Curtis 2012
	Llano Middle Reach	1972	1.5	2012	Rare	Curtis 2012
	Llano Lower Reach	1970	0.5	2012	Rare	Curtis 2012
	North Llano	1931	0.6	2012	Rare	Curtis 2012
	James River	2009	10	2012	Occasional	Curtis 2012
	Johnson Fork	1939	0.9	2012	Rare	Curtis 2012
	Barton Creek	1884	7.8	2008	Occasional	Labay et al. 2011
	Little Barton Creek	1988	15	1988	Occasional	Linam et al. 2002
	Onion Creek	1930	28	1988	Frequent	Linam et al. 2002
	San Saba	1948	2.7	2009	Rare	Higgins 2009
	Pedernales	1939	0.4	2010	Rare	Shattuck 2010
	Live Oak Creek	1998	17	2010	Occasional	Shattuck 2010
	Barons Creek	1998	3.3	2010	Rare	Shattuck 2010
	North Grape Creek	1970	4.7	2010	Rare	Shattuck 2010
	Cypress Creek	1976	42	2010	Frequent	Shattuck 2010

Appendix 2.1 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1938	2.5	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1897	0	2015	Absent	Behen 2013
	Blanco	1949	3.5	2007	Rare	Bean et al. 2007
	Little Blanco	1974	4.9	2007	Rare	Bean et al. 2007
	Cypress Creek	1955	12	2007	Occasional	Bean et al. 2007
San Antonio	Medina	1892	3.7	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1999	0.4	2015	Rare	Craig et al. 2016
Nueces	Nueces	1938	5.1	2015	Rare	Craig, unpublished data
	Pulliam Creek	1952	1.1	2015	Rare	Craig, unpublished data
	Frio	1951	1	2015	Rare	Craig, unpublished data
	Mill Creek	1953	0.6	2015	Rare	Craig, unpublished data
	Sabinal	1854	0.3	2015	Rare	Craig, unpublished data
Rio Grande	Spring Reach of Pecos	2006	0	2011	Absent	Bonner, unpublished data
	Independence Creek	1967	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1993	0	2011	Absent	Bonner, unpublished data
	Rio Grande Downstream	1993	0	2011	Absent	Bonner, unpublished data
	Devils River	1948	0	2011	Absent	Kollaus and Bonner 2011
	Sycamore Creek	1990	0.2	1989	Rare	Garrett et al. 1992.

Appendix 2.2 First records and recent abundances of Gizzard Shad *Dorosoma cepedianum* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	San Gabriel	1999	<0.1	2010	Rare	Labay 2010
Colorado	South Concho	1987	0	1999	Absent	Hubbs 2004
	Llano Upper Reach	1971	0	2012	Absent	Curtis 2012
	Llano Middle Reach	1963	0	2012	Absent	Curtis 2012
	Llano Lower Reach	1963	0.7	2012	Rare	Curtis 2012
	North Llano	1963	0.2	2012	Rare	Curtis 2012
	Onion Creek	1947	0	1988	Absent	Linam et al. 2002
	San Saba	1956	0	2009	Absent	Higgins 2009
	Pedernales	1952	0.2	2010	Rare	Shattuck 2010
	Cypress Creek	1955	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1939	1.9	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1961	0	2015	Absent	Scanes 2016
	Blanco	1965	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1953	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1978	0.7	2015	Rare	Craig et al. 2016
Nueces	Nueces	1938	0	2015	Absent	Craig, unpublished data
	Frio	1938	0	2015	Absent	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1963	0.2	2011	Rare	Bonner, unpublished data
	Independence Creek	1967	<0.1	2002	Rare	Bonner et al. 2002

Appendix 2.2 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Rio Grande Big Bend	1954	2	2011	Rare	Bonner, unpublished data
	Rio Grande Downstream	1953	0.6	2011	Rare	Bonner, unpublished data
	Devils River	1948	0	2011	Absent	Kollaus and Bonner 2011
	Las Moras	1970	0.8	1989	Rare	Garrett et al 1992

Appendix 2.3 First records and recent abundances of Central Stoneroller *Campostoma anomalum* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1952	5.4	2010	Occasional	Labay 2010
	San Gabriel	1951	<0.1	2010	Rare	Labay 2010
	Rocky Creek	1938	43	2010	Frequent	Labay 2010
Colorado	South Concho	1954	<0.1	1999	Rare	Hubbs 2004
	Spring Creek	1984	0.6	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1955	0.7	2012	Rare	Curtis 2012
	Llano Middle Reach	1972	1.5	2012	Rare	Curtis 2012
	Llano Lower Reach	1970	0.5	2012	Rare	Curtis 2012
	North Llano	1931	0.6	2012	Rare	Curtis 2012
	James River	2009	10	2012	Occasional	Curtis 2012
	Johnson Fork	1939	0.9	2012	Rare	Curtis 2012
	Barton Creek	1884	7.8	2008	Occasional	Labay et al. 2011
	Little Barton Creek	1988	15	1988	Occasional	Linam et al. 2002
	Onion Creek	1930	28	1988	Frequent	Linam et al. 2002
	San Saba	1948	2.7	2009	Rare	Higgins 2009
	Pedernales	1939	0.4	2010	Rare	Shattuck 2010
	Live Oak Creek	1998	17	2010	Occasional	Shattuck 2010
	Barons Creek	1998	3.3	2010	Rare	Shattuck 2010
	North Grape Creek	1970	4.7	2010	Rare	Shattuck 2010
	Cypress Creek	1976	42	2010	Frequent	Shattuck 2010

Appendix 2.3 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1938	2.5	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1897	0	2015	Absent	Behen 2013
	Blanco	1949	3.5	2007	Rare	Bean et al. 2007
	Little Blanco	1974	4.9	2007	Rare	Bean et al. 2007
	Cypress Creek	1955	12	2007	Occasional	Bean et al. 2007
San Antonio	Medina	1892	3.7	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1999	0.4	2015	Rare	Craig et al. 2016
Nueces	Nueces	1938	5.1	2015	Rare	Craig, unpublished data
	Pulliam Creek	1952	1.1	2015	Rare	Craig, unpublished data
	Frio	1951	1	2015	Rare	Craig, unpublished data
	Mill Creek	1953	0.6	2015	Rare	Craig, unpublished data
	Sabinal	1854	0.3	2015	Rare	Craig, unpublished data
Rio Grande	Spring Reach of Pecos	2006	0	2011	Absent	Bonner, unpublished data
	Independence Creek	1967	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1993	0	2011	Absent	Bonner, unpublished data
	Rio Grande Downstream	1993	0	2011	Absent	Bonner, unpublished data
	Devils River	1948	0	2011	Absent	Kollaus and Bonner 2011
	Sycamore Creek	1990	0.2	1989	Rare	Garrett et al. 1992.

Appendix 2.4 First records and recent abundances of Mexican Stoneroller *Campostoma ornatum* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Rio Grande Big Bend	1956	0	2011	Absent	Bonner, unpublished data
	Terlingua Creek	1938	6.7	2011	Occasional	Miyazono and Taylor 2016
	Alamito Creek	1964	97	2011	Abundant	Miyazono and Taylor 2016
	Tornillo Creek	1998	0	2011	Absent	Miyazono and Taylor 2016

Appendix 2.5 First records and recent abundances of Plateau Shiner *Cyprinella lepida* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1939	0	2009	Absent	Perkin and Bonner 2011
Nueces	Nueces	1951	<0.1	2015	Rare	Craig, unpublished data
	Frio	1858	0.4	2015	Rare	Craig, unpublished data
	Mill Creek	1953	0.1	2015	Rare	Craig, unpublished data
	Sabinal	1953	1	2015	Rare	Craig, unpublished data

Appendix 2.6 First records and recent abundances of Red Shiner *Cyprinella lutrensis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1891	7.6	2010	Occasional	Labay 2010
	San Gabriel	1952	59	2010	Common	Labay 2010
	Rocky Creek	1938	0.5	1988	Rare	Linam et al. 2002
Colorado	South Concho	1961	0	1999	Absent	Hubbs 2004
	Llano Middle Reach	1961	0	2012	Absent	Curtis 2012
	Llano Lower Reach	1956	5.9	2012	Occasional	Curtis 2012
	James River	1956	10	2012	Occasional	Curtis 2012
	Barton Creek	1993	0.3	2008	Rare	Labay et al. 2011
	Onion Creek	1930	0	1988	Absent	Linam et al. 2002
	San Saba	1952	0	2009	Absent	Higgins 2009
	Pedernales	1939	26	2010	Frequent	Shattuck 2010
	Barons Creek	1998	29	2010	Frequent	Shattuck 2010
	North Grape Creek	1970	2	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1925	1.1	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1891	0	2015	Absent	Behen 2013
	Comal	1884	0	2015	Absent	Scanes 2015
	Blanco	1891	<0.1	2007	Rare	Bean et al. 2007
	Little Blanco	1974	0	2007	Absent	Bean et al. 2007
	Cypress Creek	1952	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1854	<0.1	2014	Rare	Ruppel, unpublished data

Appendix 2.6 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Upper San Antonio	1977	46	2015	Frequent	Craig et al. 2016
Nueces	Frio	2008	0	2015	Absent	Craig, unpublished data
	Sabinal	2008	0	2015	Absent	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1928	0.2	2011	Rare	Bonner, unpublished data
	Spring Reach of Pecos	1940	10	2011	Occasional	Bonner, unpublished data
	Delaware River	1968	29.4	2016	Frequent	Bonner 2016.
	Independence Creek	1949	0.5	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1954	0	1990	Absent	Linam et al. 2002
	Phantom Cave Spring	1929	0	1999	Absent	Hubbs 2004
	Diamond-Y Spring	1965	0	1999	Absent	Hubbs 2004
	Rio Grande Big Bend	1938	71	2011	Common	Bonner, unpublished data
	Terlingua Creek	1938	33	2011	Frequent	Miyazono and Taylor 2016
	Alamito Creek	1963	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1967	39	2011	Frequent	Miyazono and Taylor 2016
	Rio Grande Downstream	1914	29	2011	Frequent	Bonner, unpublished data
	Devils River	1903	0	2011	Absent	Kollaus and Bonner 2011
	Pinto Creek	1938	22	2004	Occasional	Garrett et al. 2004
	Sycamore Creek	1965	0.5	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1990	13	1989	Occasional	Garrett et al. 1992
	San Felipe Creek	1951	0	1989	Absent	Garrett et al. 1992

Appendix 2.7 First records and recent abundances of Proserpine Shiner *Cyprinella proserpina* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Saline Reach of Pecos	1987	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1952	31	2011	Frequent	Bonner, unpublished data
	Independence Creek	1961	12	2002	Occasional	Bonner et al. 2002
	Live Oak Creek	1976	1.2	1990	Rare	Linam et al. 2002
	Rio Grande Downstream	1954	0	2011	Absent	Bonner, unpublished data
	Devils River	1851	6.2	2011	Occasional	Kollaus and Bonner 2011
	Pinto Creek	1851	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1987	0	1989	Absent	Garrett et al. 1992
	Las Moras Creek	1893	0	1989	Absent	Garrett et al. 1992
	San Felipe Creek	1951	7.9	1989	Occasional	Garrett et al. 1992

Appendix 2.8 First records and recent abundances of Blacktail Shiner *Cyprinella venusta* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1928	40	2010	Frequent	Labay 2010
	San Gabriel	1951	<0.1	2010	Rare	Labay 2010
	Oatmeal Creek	1988	23	1988	Occasional	Linam et al. 2002
	Rocky Creek	1938	30	1988	Frequent	Linam et al. 2002
Colorado	South Concho	1953	0.3	1999	Rare	Hubbs 2004
	Spring Creek	1984	65	1990	Common	Linam et al. 2002
	Llano Upper Reach	1952	41	2012	Frequent	Curtis 2012
	Llano Middle Reach	1972	54	2012	Common	Curtis 2012
	Llano Lower Reach	1956	60	2012	Common	Curtis 2012
	North Llano	1939	42	2012	Frequent	Curtis 2012
	James River	1956	58	2012	Common	Curtis 2012
	Johnson Fork	1892	42	2012	Frequent	Curtis 2012
	Barton Creek	1884	9.4	2008	Occasional	Labay et al. 2011
	Little Barton Creek	1988	48	1988	Frequent	Linam et al. 2002
	Onion Creek	1930	39	1988	Frequent	Linam et al. 2002
	San Saba	1860	50	2009	Frequent	Higgins 2009
	Clear Creek Downstream	1956	0	1999	Absent	Hubbs 2004
	Pedernales	1939	42	2010	Frequent	Shattuck 2010
	Live Oak Creek	1998	59	2010	Common	Shattuck 2010
	North Grape Creek	1970	58	2010	Common	Shattuck 2010

Appendix 2.8 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Cypress Creek	1951	9.3	2010	Occasional	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	47	2009	Frequent	Perkin and Bonner 2011
	Upper San Marcos	1949	3.6	2015	Rare	Behen 2013
	Comal	2016	<0.1	2015	Rare	Scanes 2015
	Blanco	1949	43	2007	Rare	Bean et al. 2007
San Antonio	Medina	1950	6.6	2014	Occasional	Ruppel, unpublished data
	Upper San Antonio	1978	0	2015	Absent	Craig et al. 2016
Nueces	Nueces	1938	0.4	2015	Rare	Craig, unpublished data
	Frio	1853	48	2015	Frequent	Craig, unpublished data
	Mill Creek	1953	6.6	2015	Occasional	Craig, unpublished data
	Sabinal	1854	19	2015	Occasional	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1965	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1965	5.1	2011	Occasional	Bonner, unpublished data
	Independence Creek	1968	0.2	2002	Rare	Bonner et al. 2002
	Rio Grande Big Bend	1990	8.1	2011	Occasional	Bonner, unpublished data
	Rio Grande Downstream	1980	52	2011	Common	Bonner, unpublished data
	Devils River	1968	4.8	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1990	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1965	0.7	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1979	20	1989	Occasional	Garrett et al. 1992
	San Felipe Creek	1951	0	1989	Absent	Garrett et al. 1992

Appendix 2.9 First records and recent abundances of Manantial Roundnose Minnow *Dionda argentosa* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Saline Reach of Pecos	1987	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1858	8.7	2011	Occasional	Bonner, unpublished data
	Independence Creek	1949	30	2002	Frequent	Bonner et al. 2002
	Live Oak Creek	1954	88	1990	Abundant	Linam et al. 2002
	Rio Grande Downstream	1993	0	2011	Absent	Bonner, unpublished data
	Devils River	1854	30	2011	Frequent	Kollaus and Bonner 2011
	Sycamore Creek	1965	24	1989	Occasional	Garrett et al. 1992
	Las Moras Creek	1893	0	1989	Absent	Garrett et al. 1992
	San Felipe Creek	1854	17	1989	Occasional	Garrett et al. 1992

Appendix 2.10 First records and recent abundances of Devils River Minnow *Dionda diaboli* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Devils River	1953	5.1	2015	Occasional	Kollaus and Bonner 2011
	Pinto Creek	2002	2	2015	Rare	Schlechte and Fleming 2015
	Las Moras	1951	0	1989	Absent	Garrett et al. 1992
	San Felipe	1955	<1.0	1989	Rare	Garrett et al. 1992

Appendix 2.11 First records and recent abundances of Roundnose Minnow *Dionda episcopa* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Saline Reach of Pecos	1858	0	2011	Absent	Bonner, unpublished data
	Phantom Cave Spring	1929	<0.1	1999	Rare	Hubbs 2004
	East Sandia Spring	1988	0	1999	Absent	Hubbs 2004
	Diamond-Y Spring	1938	0	1999	Absent	Hubbs 2004
	Comanche Springs	1854	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1978	<0.1	2011	Rare	Bonner, unpublished data
	Alamito Creek	1964	0	2011	Absent	Miyazono and Taylor 2016

Appendix 2.12 First records and recent abundances of Guadalupe Roundnose Minnow *Dionda nigrotaeniata* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	South Concho	1954	0.7	1999	Rare	Hubbs 2004
	Spring Creek	1986	0	1990	Absent	Linam et al. 2002
	Llano Upper Reach	1939	2.1	2012	Rare	Curtis 2012
	Llano Middle Reach	1939	0.6	2012	Rare	Curtis 2012
	Llano Lower Reach	1939	<0.1	2012	Rare	Curtis 2012
	North Llano	1939	1.1	2012	Rare	Curtis 2012
	Johnson Fork	1939	0.2	2012	Rare	Curtis 2012
	Clear Creek Upstream	1956	7.4	1999	Occasional	Hubbs 2004
	Clear Creek Downstream	1957	7.7	1999	Occasional	Hubbs 2004
	Pedernales	1954	0.6	2010	Rare	Shattuck 2010
	Barons Creek	1998	0	2010	Absent	Shattuck 2010
	Cypress Creek	1976	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1931	0.1	2011	Rare	Perkin 2011
	Upper San Marcos	1898	1.7	2015	Rare	Behen 2013
	Comal	1884	1.3	2015	Rare	Scanes 2015
	Little Blanco	1898	1.8	2007	Rare	Bean et al. 2007
	Cypress Creek	1955	0.4	2007	Rare	Bean et al. 2007
San Antonio	Medina	1887	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1887	0	2015	Absent	Craig et al. 2016

Appendix 2.13 First records and recent abundances of Nueces Roundnose Minnow *Dionda serena* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Nueces	Nueces	1853	57	2015	Common	Craig, unpublished data
	Pulliam Creek	1982	29	2015	Frequent	Craig, unpublished data
	Frio	1951	10	2015	Occasional	Craig, unpublished data
	Mill Creek	1953	1.7	2015	Rare	Craig, unpublished data
	Sabinal	1954	0	2015	Absent	Craig, unpublished data

Appendix 2.14 First records and recent abundances of Speckled Chub *Macrhybopsis aestivalis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Saline Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Independence Creek	1979	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1937	1.3	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1940	0	2011	Absent	Miyazono and Taylor 2016
	Alamito Creek	1974	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1938	0	2011	Absent	Miyazono and Taylor 2016
	Rio Grande Downstream	1939	1.1	2011	Rare	Bonner, unpublished data

Appendix 2.15 First records and recent abundances of Texas Shiner *Notropis amabilis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	San Gabriel	1963	0	2010	Absent	Labay 2010
Colorado	South Concho	1983	12	1999	Occasional	Hubbs 2004
	Spring Creek	1964	1.3	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1955	13	2012	Occasional	Curtis 2012
	Llano Middle Reach	1961	7.7	2012	Occasional	Curtis 2012
	Llano Lower Reach	1968	0.1	2012	Rare	Curtis 2012
	North Llano	1931	37	2012	Frequent	Curtis 2012
	Barton Creek	1884	0	2008	Absent	Labay et al. 2011
	San Saba	1952	1.7	2009	Rare	Higgins 2009
	Pedernales	1977	6.8	2010	Occasional	Shattuck 2010
	Live Oak Creek	1998	0.3	2010	Rare	Shattuck 2010
	North Grape Creek	1970	0.2	2010	Rare	Shattuck 2010
	Cypress Creek	1951	10	2010	Occasional	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	10	2009	Occasional	Perkin and Bonner 2011
	Upper San Marcos	1891	22	2015	Occasional	Behen 2013
	Comal	1884	4.9	2015	Rare	Scanes 2015
	Blanco	1949	11	2007	Occasional	Bean et al. 2007
	Cypress Creek	1952	22	2007	Occasional	Bean et al. 2007
San Antonio	Medina	1939	49	2014	Frequent	Ruppel, unpublished data
	Upper San Antonio	1891	0	2015	Absent	Craig et al. 2016

Appendix 2.15 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Nueces	Nueces	1939	11	2015	Occasional	Craig, unpublished data
	Pulliam Creek	2008	28	2015	Frequent	Craig, unpublished data
	Frio	1951	14	2015	Frequent	Craig, unpublished data
	Mill Creek	1986	81	2015	Abundant	Craig, unpublished data
	Sabinal	1951	2.5	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1988	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1968	14	2011	Occasional	Bonner, unpublished data
	Independence Creek	1963	19	2002	Occasional	Bonner et al. 2002
	Rio Grande Downstream	1990	0	2011	Absent	Bonner, unpublished data
	Devils River	1854	17	2011	Occasional	Kollaus and Bonner 2011
	Pinto Creek	1939	4.6	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1977	3.3	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1893	5.5	1989	Occasional	Garrett et al. 1992
	San Felipe Creek	1854	0.3	2000	Rare	Hubbs 2004

Appendix 2.16 First records and recent abundances of Tamaulipas Shiner *Notropis braytoni* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Spring Reach of Pecos	1940	4.9	2011	Rare	Bonner, unpublished data
	Independence Creek	1949	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1938	0.4	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1940	24	2011	Occasional	Miyazono and Taylor 2016
	Alamito Creek	1963	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1938	26	2011	Frequent	Miyazono and Taylor 2016
	Rio Grande Downstream	1938	0	2011	Absent	Bonner, unpublished data
	Devils River	1953	0	2011	Absent	Kollaus and Bonner 2011
	Sycamore Creek	1965	1	1989	Rare	Garrett et al. 1992
	San Felipe Creek	2001	0	2000	Absent	Hubbs 2004

Appendix 2.17 First records and recent abundances of Ironcolor Shiner *Notropis chalybaeus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper San Marcos	1938	0.6	2010	Rare	Behen 2013

Appendix 2.18 First records and recent abundances of Chihuahua Shiner *Notropis chihuahua* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Rio Grande Big Bend	1938	<0.1	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1938	3.3	2011	Rare	Miyazono and Taylor 2016
	Alamito Creek	1963	0	2011	Absent	Miyazono and Taylor 2016

Appendix 2.19 First records and recent abundances of Rio Grande Shiner *Notropis jemezanus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Spring Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Rio Grande Big Bend	1937	0	2011	Absent	Bonner, unpublished data
	Terlingua Creek	1954	0	2011	Absent	Miyazono and Taylor 2016
	Rio Grande Downstream	1938	0.2	2011	Rare	Bonner, unpublished data
	Rio Grande below Falcon	1932	0	2011	Absent	Bonner, unpublished data
	Devils River	1954	0	2011	Absent	Kollaus and Bonner 2011
	San Felipe Creek	1969	0	1989	Absent	Garrett et al. 1992

Appendix 2.20 First records and recent abundances of Sand Shiner *Notropis stramineus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	South Concho	1986	0	1999	Absent	Hubbs 2004
	Spring Creek	1984	1.6	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1939	0	2012	Absent	Curtis 2012
	Llano Lower Reach	1963	1.7	2012	Rare	Curtis 2012
	James River	1956	11	2012	Occasional	Curtis 2012
	Barton Creek	1993	0	2008	Absent	Labay et al. 2011
	Onion Creek	2007	0	1988	Absent	Linam et al. 2002
	San Saba	1948	11	2009	Occasional	Higgins 2009
	Pedernales	2001	0.1	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1939	0	2009	Absent	Perkin and Bonner 2011
	Upper San Marcos	1970	0	2015	Absent	Behen 2013
	Blanco	1950	2.5	2007	Rare	Bean et al. 2007
	Little Blanco	1988	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1939	0	2014	Absent	Ruppel, unpublished data
Nueces	Nueces	2005	0	2015	Absent	Craig, unpublished data
	Frio	1951	0.5	2015	Rare	Craig, unpublished data
	Mill Creek	2001	0	2015	Absent	Craig, unpublished data
	Sabinal	1951	1.3	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1993	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1967	1.3	2011	Rare	Bonner, unpublished data

Appendix 2.20 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Independence Creek	1961	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1964	0	2011	Absent	Bonner, unpublished data
	Devils River	1935	3.6	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	2002	0.1	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1965	0	1989	Absent	Garrett et al. 1992

Appendix 2.21 First records and recent abundances of Bullhead Minnow *Pimephales vigilax* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1928	0.2	2010	Rare	Labay 2010
	San Gabriel	1951	36	2010	Frequent	Labay 2010
	Rocky Creek	1938	0.2	1988	Rare	Linam et al. 2002
Colorado	South Concho	1987	<0.1	1999	Rare	Hubbs 2004
	Spring Creek	1993	0	1990	Absent	Linam et al. 2002
	Llano Upper Reach	1971	0	2012	Absent	Curtis 2012
	Llano Middle Reach	1956	0.3	2012	Rare	Curtis 2012
	Llano Lower Reach	1963	1.9	2012	Rare	Curtis 2012
	North Llano	1963	0	2012	Absent	Curtis 2012
	James River	1956	0	2012	Absent	Curtis 2012
	Barton Creek	1884	0	2008	Absent	Labay et al. 2011
	Onion Creek	1933	0	1988	Absent	Linam et al. 2002
	San Saba	1940	1.1	2009	Rare	Higgins 2009
	Pedernales	1952	3.3	2010	Rare	Shattuck 2010
	Live Oak Creek	1998	0	2010	Absent	Shattuck 2010
	North Grape Creek	1970	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1925	<0.1	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1884	0.1	2015	Rare	Behen 2013
	Comal	1884	0	2015	Absent	Scanes 2015
	Blanco	1949	15	2007	Occasional	Bean et al. 2007

Appendix 2.21 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Cypress Creek	1952	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1925	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1978	10	2015	Occasional	Craig et al. 2016
Nueces	Nueces	1936	0	2015	Absent	Craig, unpublished data
	Frio	1955	0	2015	Absent	Craig, unpublished data
	Sabinal	1951	0	2015	Absent	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1979	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1952	7.9	2011	Occasional	Bonner, unpublished data
	Independence Creek	1966	0	2002	Absent	Bonner et al. 2002
	Rio Grande Big Bend	1978	0	2011	Absent	Bonner, unpublished data
	Rio Grande Downstream	1940	1.1	2011	Rare	Bonner, unpublished data
	Devils River	1938	0	2011	Absent	Kollaus and Bonner 2011
	Pinto Creek	1938	2.4	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1990	0.2	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1990	0.5	1989	Rare	Garrett et al. 1992

Appendix 2.22 First records and recent abundances of Longnose Dace *Rhinichthys cataractae* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Rio Grande Big Bend	1964	0.9	2011	Rare	Bonner, unpublished data
	Terlingua Creek	2006	0	2011	Absent	Miyazono and Taylor 2016
	Alamito Creek	1991	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1992	0	2011	Absent	Miyazono and Taylor 2016
	Rio Grande Downstream	1938	0	2011	Absent	Bonner, unpublished data

Appendix 2.23 First records and recent abundances of River Carpsucker *Carpiodes carpio* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1891	<0.1	2010	Rare	Labay 2010
	San Gabriel	1952	<0.1	2010	Rare	Labay 2010
Colorado	South Concho	1984	0	1999	Absent	Hubbs 2004
	Llano Upper Reach	1939	0	2012	Absent	Curtis 2012
	Llano Middle Reach	1972	0	2012	Absent	Curtis 2012
	Llano Lower Reach	1963	0.4	2012	Rare	Curtis 2012
	North Llano	1963	0	2012	Absent	Curtis 2012
	James River	2009	0.4	2012	Rare	Curtis 2012
	Johnson Fork	1939	0	2012	Absent	Curtis 2012
	San Saba	1952	0	2009	Absent	Higgins 2009
	Pedernales	1951	<0.1	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1979	<0.1	2009	Rare	Perkin and Bonner 2011
	Blanco	2006	0	2007	Absent	Bean et al. 2007
Nueces	Nueces	1953	0	2015	Absent	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1965	<0.1	2011	Rare	Bonner, unpublished data
	Independence Creek	2000	<0.1	2002	Rare	Bonner et al. 2002
	Rio Grande Big Bend	1937	3.4	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1938	0.6	2011	Rare	Miyazono and Taylor 2016
	Alamito Creek	1963	0	2011	Absent	Miyazono and Taylor 2016

Appendix 2.23 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Tornillo Creek	1998	2.3	2011	Rare	Miyazono and Taylor 2016
	Rio Grande Downstream	1903	0.1	2011	Rare	Bonner, unpublished data
	Devils River	1938	0.1	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1938	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1965	0	1989	Absent	Garrett et al. 1992

Appendix 2.24 First records and recent abundances of Gray Redhorse *Moxostoma congestum* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1938	2.6	2010	Rare	Labay 2010
	San Gabriel	1962	0	2010	Absent	Labay 2010
	Rocky Creek	1938	0	1988	Absent	Linam et al. 2002
Colorado	South Concho	1984	0	1999	Absent	Hubbs 2004
	Spring Creek	1984	0	1990	Absent	Linam et al. 2002
	Llano Upper Reach	1939	0.25	2012	Rare	Curtis 2012
	Llano Middle Reach	1939	0.35	2012	Rare	Curtis 2012
	Llano Lower Reach	1939	0.26	2012	Rare	Curtis 2012
	North Llano	1939	0.64	2012	Rare	Curtis 2012
	Johnson Fork	1939	0.81	2012	Rare	Curtis 2012
	Barton Creek	1884	2.8	2008	Rare	Labay et al. 2011
	Onion Creek	1978	0	1988	Absent	Linam et al. 2002
	San Saba	1952	0.13	2009	Rare	Higgins 2009
	Pedernales	1978	0.14	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1939	1.3	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1884	<0.1	2015	Rare	Behen 2013
	Comal	1884	0	2015	Absent	Scanes 2015
	Blanco	1961	0.27	2007	Rare	Bean et al. 2007
	Cypress Creek	1951	0.4	2007	Rare	Bean et al. 2007
San Antonio	Medina	1978	0	2014	Absent	Ruppel, unpublished data

Appendix 2.24 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Upper San Antonio	1999	0	2015	Absent	Craig, unpublished data
Nueces	Nueces	1938	0	2015	Absent	Craig, unpublished data
	Frio	1986	0	2015	Absent	Craig, unpublished data
	Sabinal	1934	0	2015	Absent	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	2006	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1928	0.21	2011	Rare	Bonner, unpublished data
	Independence Creek	1987	0.4	2002	Rare	Bonner et al. 2002
	Rio Grande Big Bend	1973	0	2011	Absent	Bonner, unpublished data
	Alamito Creek	1971	0	1989	Absent	Linam et al. 2002
	Rio Grande Downstream	1893	1.2	2011	Rare	Bonner, unpublished data
	Devils River	1938	<0.1	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1938	0.01	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1993	1.5	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1893	0	1989	Absent	Garrett et al. 1992
	San Felipe Creek	1979	0	1989	Absent	Garrett et al. 1992

Appendix 2.25 First records and recent abundances of Mexican Tetra *Astyanax mexicanus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1965	0.1	2010	Rare	Labay 2010
	San Gabriel	1976	0	2010	Absent	Labay 2010
Colorado	South Concho	1954	1.7	1999	Rare	Hubbs 2004
	Barton Creek	1952	1.6	2008	Rare	Labay et al. 2011
	San Saba	1956	0	2009	Absent	Higgins 2009
	Clear Creek Upstream	1956	0	1999	Absent	Hubbs 2004
	Pedernales	2003	0	2010	Absent	Shattuck 2010
	Cypress Creek	1977	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1953	<0.1	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1928	1.7	2015	Rare	Behen 2013
	Comal	1980	2.3	2015	Rare	Scanes 2015
	Blanco	1961	0.1	2007	Rare	Bean et al. 2007
	Cypress Creek	1955	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1939	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1956	1.6	2015	Rare	Craig et al. 2016
Nueces	Nueces	1938	3.9	2015	Rare	Craig, unpublished data
	Pulliam Creek	1952	4.5	2015	Rare	Craig, unpublished data
	Frio	1951	2	2015	Rare	Craig, unpublished data
	Sabinal	1854	2.8	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1929	0	2011	Absent	Bonner, unpublished data

Appendix 2.25 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Spring Reach of Pecos	1928	1.2	2011	Rare	Bonner, unpublished data
	Delaware River	1982	54	2016	Common	Bonner 2016.
	Independence Creek	1941	1.7	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1954	0.5	1990	Rare	Linam et al. 2002
	Phantom Cave Spring	1929	11	1999	Occasional	Hubbs 2004
	Comanche Springs	1938	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1937	1.1	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1940	1.6	2011	Rare	Miyazono and Taylor 2016
	Alamito Creek	1963	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1967	15	2011	Occasional	Miyazono and Taylor 2016
	Rio Grande Downstream	1914	3.8	2011	Rare	Bonner, unpublished data
	Devils River	1858	12	2011	Occasional	Kollaus and Bonner 2011
	Pinto Creek	1975	8.8	2004	Occasional	Garrett et al. 2004
	Sycamore Creek	1965	1.2	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1893	8.9	1989	Occasional	Garrett et al. 1992
	San Felipe Creek	1951	8.5	2000	Occasional	Hubbs 2004

Appendix 2.26 First records and recent abundances of Yellow Bullhead *Ameiurus natalis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1951	0.1	2010	Rare	Labay 2010
	San Gabriel	1972	0	2010	Absent	Labay 2010
Colorado	South Concho	1983	0	1999	Absent	Hubbs 2004
	North Llano	1933	0	2012	Absent	Curtis 2012
	Barton Creek	1971	1.3	2008	Rare	Labay et al. 2011
	Little Barton Creek	2008	0	1988	Absent	Linam et al. 2002
	San Saba	1956	0	2009	Absent	Higgins 2009
	North Grape Creek	1970	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	<0.1	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1949	0.1	2015	Rare	Behen 2013
	Comal	1951	0	2015	Absent	Scanes 2015
	Blanco	1898	0	2007	Absent	Bean et al. 2007
	Cypress Creek	1951	0.2	2007	Rare	Bean et al. 2007
San Antonio	Medina	1947	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1859	0.1	2015	Rare	Craig et al. 2016
Nueces	Nueces	1951	0.1	2015	Rare	Craig, unpublished data
	Pulliam Creek	1952	0	2015	Absent	Craig, unpublished data
	Frio	1951	0	2015	Absent	Craig, unpublished data
	Mill Creek	1986	0.2	2015	Rare	Craig, unpublished data
	Sabinal	1951	0	2015	Absent	Craig, unpublished data

Appendix 2.26 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Sycamore Creek	1979	1	1989	Rare	Garrett et al. 1992
	San Felipe Creek	1968	0.5	1989	Rare	Garrett et al. 1992

Appendix 2.27 First records and recent abundances of Headwater Catfish *Ictalurus lupus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas. See McClure-Baker et al. (2008) and Bean et al. (2011) for reaches with likely intergressed populations of Headwater Catfish and Channel Catfish *I. punctulatus*.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1938	0.2	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1968	0	2013	Absent	Behen 2013
Nueces	Nueces	1966	0	2015	Absent	Craig, unpublished data
	Frio	1960	0.2	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1940	<0.1	2011	Rare	Bonner, unpublished data
	Delaware River	1982	0.6	2016	Rare	Bonner 2016
	Independence Creek	1952	0.8	2002	Rare	Bonner et al. 2002
	Phantom Cave Spring	1929	0	1999	Absent	Hubbs 2004
	Comanche Springs	1938	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1940	0	2011	Absent	Bonner, unpublished data
	Terlingua Creek	1974	0	1989	Absent	Linam et al. 2002
	Rio Grande Downstream	1940	0	2011	Absent	Bonner, unpublished data
	Devils River	1963	<0.1	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1938	0.3	2004	Rare	Garrett et al. 2004
	San Felipe	1965	0	1989	Absent	Garrett et al. 1992

Appendix 2.28 First records and recent abundances of Channel Catfish *Ictalurus punctatus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1891	0.8	2010	Rare	Labay 2010
	San Gabriel	1972	0.3	2010	Rare	Labay 2010
Colorado	South Concho River	1984	0	1999	Absent	Hubbs 2004
	Spring Creek	1984	0.3	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1955	1.2	2012	Rare	Curtis 2012
	Llano Middle Reach	1976	0.4	2012	Rare	Curtis 2012
	Llano Lower Reach	1956	0.5	2012	Rare	Curtis 2012
	North Llano	1963	<0.1	2012	Rare	Curtis 2012
	James River	1956	<0.1	2012	Rare	Curtis 2012
	Barton Creek	1974	4.7	2008	Rare	Labay et al. 2011
	Little Barton Creek	2008	0.2	1988	Rare	Linam et al. 2002
	Onion Creek	1930	1.8	1988	Rare	Linam et al. 2002
	San Saba	1952	0.4	2009	Rare	Higgins 2009
	Pedernales	1952	0.9	2010	Rare	Shattuck 2010
	North Grape Creek	1970	1.2	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1951	1	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1884	0.1	2015	Rare	Behen 2013
	Comal	1951	0.1	2015	Rare	Scanes 2015
	Blanco	1898	0.4	2007	Rare	Bean et al. 2007
	Cypress Creek	1952	0.1	2007	Rare	Bean et al. 2007

Appendix 2.28 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
San Antonio	Medina	1925	0.2	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1891	0.2	2015	Rare	Craig et al. 2016
Nueces	Nueces	1937	0	2015	Absent	Craig, unpublished data
	Frio	1938	0.2	2015	Rare	Craig, unpublished data
	Mill Creek	1986	0	2015	Absent	Craig, unpublished data
	Sabinal	1854	0.4	2015	Rare	Craig, unpublished data
Rio Grande	Spring Reach of Pecos	1952	0.3	2011	Rare	Bonner, unpublished data
	Independence Creek	1966	<0.1	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1990	2	1990	Rare	Linam et al. 2002
	Phantom Cave Spring	1993	0	1999	Absent	Hubbs 2004
	Comanche Springs	1858	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1951	3.2	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1963	<0.1	2011	Rare	Miyazono and Taylor 2016
	Alamito Creek	1972	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1963	0	2011	Absent	Miyazono and Taylor 2016
	Rio Grande Downstream	1954	0.3	2011	Rare	Bonner, unpublished data
	Devils River	1858	0	2011	Absent	Kollaus and Bonner 2011
	Pinto Creek	1858	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1965	0	1989	Absent	Garrett et al. 1992
	Las Moras Creek	1979	1.3	1989	Rare	Garrett et al. 1992
	San Felipe Creek	1951	0	1989	Absent	Garrett et al. 1992

Appendix 2.29 First records and recent abundances of Plains Killifish *Fundulus zebrinus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	Llano Lower Reach	1958	<0.1	2012	Rare	Curtis 2012
	Live Oak Creek	1998	0	2010	Absent	Shattuck 2010
Rio Grande	Saline Reach of Pecos	1928	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1947	0	2011	Absent	Bonner, unpublished data
	Delaware River	1968	5.7	2016	Occasional	Bonner 2016
	Independence Creek	1949	0.5	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1954	0.7	1990	Rare	Linam et al. 2002
	Diamond-Y Spring	1965	0	1999	Absent	Hubbs 2004
	Rio Grande Big Bend	1963	0	2011	Absent	Bonner, unpublished data
	Terlingua Creek	1965	30	2011	Frequent	Miyazono and Taylor 2016
	Alamito Creek	1988	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1969	2.3	2011	Rare	Miyazono and Taylor 2016

Appendix 2.30 First records and recent abundances of Rainwater Killifish *Lucania parva* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	Clear Creek Downstream	1986	0.8	1999	Rare	Hubbs 2004
San Antonio	Upper San Antonio	1891	0	2015	Absent	Craig et al. 2016
Rio Grande	Saline Reach of Pecos	1954	47	2011	Frequent	Bonner, unpublished data
	Spring Reach of Pecos	1947	0.2	2011	Rare	Bonner, unpublished data
	Independence Creek	1968	0.5	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1976	0	1990	Absent	Linam et al. 2002
	Diamond-Y Spring	1965	0.4	1999	Rare	Hubbs 2004

Appendix 2.31 First records and recent abundances of Western Mosquitofish *Gambusia affinis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1952	9.7	2010	Occasional	Labay 2010
	San Gabriel	1951	0.7	2010	Rare	Labay 2010
	Rocky Creek	1988	8.8	1988	Occasional	Linam et al. 2002
Colorado	South Concho	1953	0.1	1999	Rare	Hubbs 2004
	Spring Creek	1984	2.2	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1936	12	2012	Occasional	Curtis 2012
	Llano Middle Reach	1961	7.7	2012	Occasional	Curtis 2012
	Llano Lower Reach	1975	9.1	2012	Occasional	Curtis 2012
	North Llano	1931	1.1	2012	Rare	Curtis 2012
	James River	1956	11	2012	Occasional	Curtis 2012
	Barton Creek	1884	9.7	2008	Occasional	Labay et al. 2011
	Little Barton Creek	1988	24	1988	Occasional	Linam et al. 2002
	Onion Creek	1930	9.4	1988	Occasional	Linam et al. 2002
	San Saba	1952	11	2009	Occasional	Higgins 2009
	Clear Creek Upstream	1967	0.1	1999	Rare	Hubbs 2004
	Clear Creek Downstream	1956	78	1999	Abundant	Hubbs 2004
	Pedernales	1951	6.9	2010	Occasional	Shattuck 2010
	North Grape Creek	1970	3.9	2010	Rare	Shattuck 2010
	Cypress Creek	2005	0.14	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	3.8	2009	Rare	Perkin and Bonner 2011

Appendix 2.31 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Upper San Marcos	1884	18.2	2015	Occasional	Behen 2013
	Comal	1884	3	2015	Rare	Scanes 2015
	Blanco	1939	8.1	2007	Occasional	Bean et al. 2007
	Little Blanco	1974	14	2007	Occasional	Bean et al. 2007
	Cypress Creek	1952	3.8	2007	Rare	Bean et al. 2007
San Antonio	Medina	1854	<0.1	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1854	4.9	2015	Rare	Craig et al. 2016
Nueces	Nueces	1938	12	2015	Occasional	Craig, unpublished data
	Pulliam Creek	1952	3.4	2015	Rare	Craig, unpublished data
	Frio	1939	3.5	2015	Rare	Craig, unpublished data
	Mill Creek	1953	0.1	2015	Rare	Craig, unpublished data
	Sabinal	1858	15	2015	Occasional	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1952	2.9	2011	Rare	Bonner, unpublished data
	Spring Reach of Pecos	1940	5.2	2011	Occasional	Bonner, unpublished data
	Independence Creek	1961	0	2002	Absent	Bonner et al. 2002
	Live Oak Creek	1975	1.5	1990	Rare	Linam et al. 2002
	Phantom Cave Spring	1970	<0.1	1999	Rare	Hubbs 2004
	East Sandia Spring	1988	0.1	1999	Rare	Hubbs 2004
	Diamond-Y Spring	1966	8.9	1999	Occasional	Hubbs 2004
	Comanche Springs	1956	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1954	1.6	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1998	0	2011	Absent	Miyazono and Taylor 2016

Appendix 2.31 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Alamito Creek	1964	0	2011	Absent	Miyazono and Taylor 2016
	Tornillo Creek	1998	15	2011	Occasional	Miyazono and Taylor 2016
	Rio Grande Downstream	1914	0.1	2011	Rare	Bonner, unpublished data
	Devils River	1938	0	2011	Absent	Kollaus and Bonner 2011
	Pinto Creek	1938	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1970	40	1989	Frequent	Garrett et al. 1992
	Las Moras Creek	1893	30	1989	Frequent	Garrett et al. 1992
	San Felipe Creek	1951	0	1989	Absent	Garrett et al. 1992

Appendix 2.32 First records and recent abundances of Largespring Gambusia *Gambusia geiseri* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	South Concho	1953	81	1999	Abundant	Hubbs 2004
Guadalupe	Upper Guadalupe	1956	0	2009	Absent	Perkin and Bonner 2011
	Upper San Marcos	1925	31	2015	Frequent	Behen 2013
	Comal	1933	3.3	2015	Rare	Scanes 2015
Rio Grande	Independence Creek	1979	29	2002	Frequent	Bonner et al. 2002
	Phantom Cave Spring	1993	27	1999	Frequent	Hubbs 2004
	East Sandia Spring	1988	23	1999	Occasional	Hubbs 2004
	Diamond-Y Spring	1938	1.4	1999	Rare	Hubbs 2004
	Comanche Spring	1938	0	1961	Absent	Brune 1981
	Devils River	1953	13	2011	Occasional	Kollaus and Bonner 2011

Appendix 2.33 First records and recent abundances of Clear Creek Gambusia *Gambusia heterochir* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	Clear Creek Upstream	1953	92	1999	Abundant	Hubbs 2004
	Clear Creek Downstream	1967	0	1999	Absent	Hubbs 2004

Appendix 2.34 First records and recent abundances of Spotfin Gambusia *Gambusia krumholzi* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	San Felipe Creek	1999	1.2	2000	Rare	Hubbs 2004

Appendix 2.35 First records and recent abundances of Pecos Gambusia *Gambusia nobilis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Phantom Cave Spring	1929	56	1999	Common	Hubbs 2004
	East Sandia Spring	1982	77	1999	Abundant	Hubbs 2004
	Diamond-Y Spring	1938	89	1999	Abundant	Hubbs 2004
	Comanche Springs	1858	0	1961	Absent	Brune 1981

Appendix 2.36 First records and recent abundances of Tex-Mex Gambusia *Gambusia speciosa* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Devils River	1890	0	2011	Absent	Kollaus and Bonner 2011
	Pinto Creek	2004	45	2004	Frequent	Garrett et al. 2004
	Sycamore Creek	1974	0	1989	Absent	Garrett et al. 1992
	San Felipe Creek	1951	83	1989	Abundant	Hubbs 2004

Appendix 2.37 First records and recent abundances of Leon Springs Pupfish *Cyprinodon bovinus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Diamond-Y Spring	1965	0.17	1999	Rare	Hubbs 2004

Appendix 2.38 First records and recent abundances of Comanche Springs Pupfish *Cyprinodon elegans* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Phantom Cave Spring	1929	6.1	1999	Occasional	Hubbs 2004
	Diamond-Y Spring	1938	0	1999	Absent	Hubbs 2004
	Comanche Springs	1938	0	1961	Absent	Brune 1981

Appendix 2.39 First records and recent abundances of Orange Spotted Sunfish *Lepomis humilis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1952	0	2010	Absent	Labay 2010
	San Gabriel	1952	<0.1	2010	Rare	Labay 2010
	Rocky Creek	1988	0.1	1988	Rare	Linam et al. 2002
Colorado	South Concho	1984	0	1999	Absent	Hubbs 2004
	Spring Creek	1993	0	1990	Absent	Linam et al. 2002
	Llano Lower Reach	1963	0	2012	Absent	Curtis 2012
	Onion Creek	1947	0	1988	Absent	Linam et al. 2002
	San Saba	1986	0	2009	Absent	Higgins 2009
	Pedernales	1939	0.3	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1953	0	2009	Absent	Perkin and Bonner 2011
	Upper San Marcos	1961	0	2015	Absent	Behen 2013
	Blanco	1961	0	2007	Absent	Bean et al. 2007

Appendix 2.40 First records and recent abundances of Bluegill *Lepomis macrochirus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1971	1.3	2010	Rare	Labay 2010
	San Gabriel	1951	<0.1	2010	Rare	Labay 2010
	Rocky Creek	1988	2.5	1988	Rare	Linam et al. 2004
Colorado	South Concho	1957	3	1999	Rare	Hubbs 2004
	Spring Creek	1984	9.8	1990	Occasional	Linam et al. 2004
	Llano Upper Reach	1952	0.2	2012	Rare	Curtis 2012
	Llano Middle Reach	1956	1.3	2012	Rare	Curtis 2012
	Llano Lower Reach	1963	1.7	2012	Rare	Curtis 2012
	North Llano	1963	0.2	2012	Rare	Curtis 2012
	Johnson Fork	1892	2.7	2012	Rare	Curtis 2012
	Barton Creek	1984	9.7	2008	Occasional	Labay et al. 2011
	Little Barton Creek	2008	0.7	1988	Rare	Linam et al. 2004
	Onion Creek	1930	0.4	1988	Rare	Linam et al. 2004
	San Saba	1952	5.1	2009	Occasional	Higgins 2009
	Clear Creek Downstream	1957	0.2	1999	Rare	Hubbs 2004
	Pedernales	1952	1.6	2010	Rare	Shattuck 2010
	North Grape Creek	1970	6.5	2010	Occasional	Shattuck 2010
	Cypress Creek	1977	1.8	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1939	1.7	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1928	0.1	2015	Rare	Behen 2013

Appendix 2.40 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Comal	1884	0.3	2015	Rare	Scanes 2015
	Blanco	1853	1.8	2007	Rare	Bean et al. 2007
	Cypress Creek	1952	0.2	2007	Rare	Bean et al. 2007
San Antonio	Medina	1853	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1977	5.5	2015	Occasional	Craig et al. 2016
Nueces	Nueces	1936	0.2	2015	Rare	Craig, unpublished data
	Frio	1939	0.3	2015	Rare	Craig, unpublished data
	Mill Creek	1986	3.7	2015	Rare	Craig, unpublished data
	Sabinal	1934	4.5	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1952	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1940	0.4	2011	Rare	Bonner, unpublished data
	Independence Creek	1966	<0.1	2002	Rare	Bonner et al. 2002
	Rio Grande Big Bend	1956	<0.1	2011	Rare	Bonner, unpublished data
	Terlingua Creek	1954	0	2011	Absent	Miyazono and Taylor 2016
	Rio Grande Downstream	1943	0.3	2011	Rare	Bonner, unpublished data
	Devils River	1861	0.4	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1938	1.3	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1979	0.2	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1893	3.9	1989	Rare	Garrett et al. 1992
	San Felipe Creek	2001	<0.1	1989	Rare	Garrett et al. 1992

Appendix 2.41 First records and recent abundances of Longear Sunfish *Lepomis megalotis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1951	13	2010	Occasional	Labay 2010
	San Gabriel	1951	0.2	2010	Rare	Labay 2010
	Oatmeal Creek	1988	15	1988	Occasional	Linam et al. 2002
	Rocky Creek	1938	4.7	1988	Rare	Linam et al. 2002
Colorado	South Concho	1953	0.2	1999	Rare	Hubbs 2004
	Spring Creek	1984	6	1990	Occasional	Linam et al. 2002
	Llano Upper Reach	1952	2.1	2012	Rare	Curtis 2012
	Llano Middle Reach	1972	5.3	2012	Rare	Curtis 2012
	Llano Lower Reach	1963	0.4	2012	Rare	Curtis 2012
	North Llano	1963	1	2012	Rare	Curtis 2012
	James River	2009	0.4	2012	Rare	Curtis 2012
	Johnson Fork	1955	1.2	2012	Rare	Curtis 2012
	Barton Creek	1988	8.5	2008	Occasional	Labay et al. 2011
	Little Barton Creek	1988	4.3	1988	Rare	Linam et al. 2002
	Onion Creek	1930	4.5	1988	Rare	Linam et al. 2002
	Clear Creek Upstream	1953	0	1999	Rare	Hubbs 2004
	Clear Creek Downstream	1956	2.6	1999	Rare	Hubbs 2004
	Pedernales	1939	4	2010	Rare	Shattuck 2010
	Live Oak Creek	1998	0.7	2010	Rare	Shattuck 2010
	Cypress Creek	1955	17	2010	Occasional	Shattuck 2010

Appendix 2.41 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1938	1.8	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1891	<0.1	2015	Rare	Behen 2013
	Comal	1884	0.1	2015	Rare	Scanes 2015
	Blanco	1853	1.4	2007	Rare	Bean et al. 2007
	Little Blanco	1974	6	2007	Occasional	Bean et al. 2007
	Cypress Creek	1952	2.7	2007	Rare	Bean et al. 2007
San Antonio	Medina	1853	<0.1	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1977	0.5	2015	Rare	Craig et al. 2016
Nueces	Nueces	1858	1.3	2015	Rare	Craig, unpublished data
	Pulliam Creek	1952	6.7	2015	Occasional	Craig, unpublished data
	Frio	1951	3.7	2015	Rare	Craig, unpublished data
	Mill Creek	1953	1.9	2015	Rare	Craig, unpublished data
	Sabinal	1854	3.2	2015	Rare	Craig, unpublished data
Rio Grande	Saline Reach of Pecos	1940	0	2011	Absent	Bonner, unpublished data
	Spring Reach of Pecos	1940	1.3	2011	Rare	Bonner, unpublished data
	Independence Creek	1961	0.5	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1955	4.7	1990	Rare	Linam et al. 2002
	Comanche Springs	1938	0	1961	Absent	Brune 1981
	Rio Grande Big Bend	1954	<0.1	2011	Rare	Bonner, unpublished data
	Rio Grande Downstream	1861	0.8	2011	Rare	Bonner, unpublished data
	Devils River	1903	0.7	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1951	3.3	2004	Rare	Garrett et al. 2004

Appendix 2.41 continued

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Sycamore Creek	1965	1.8	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1898	4.7	1989	Rare	Garrett et al. 1992
	San Felipe Creek	1955	<0.1	1989	Rare	Garrett et al. 1992

Appendix 2.42 First records and recent abundances of Redspotted Sunfish *Lepomis miniatus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	South Concho	1953	0	1999	Absent	Hubbs 2004
	Llano Upper Reach	1975	0	2012	Absent	Curtis 2012
	Barton Creek	1984	3.1	2008	Rare	Labay et al. 2011
	Onion Creek	1980	0	1988	Absent	Linam et al. 2002
	Clear Creek Upstream	1956	0	1999	Absent	Hubbs 2004
	Clear Creek Downstream	1957	0.4	1999	Rare	Hubbs 2004
Guadalupe	Upper Guadalupe	1938	0.7	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1938	1.1	2015	Rare	Behen 2013
	Comal	1891	1.5	2015	Rare	Scanes 2015
	Blanco	1949	0	2007	Absent	Bean et al. 2007
	Cypress Creek	1952	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1951	0	2014	Absent	Ruppel, unpublished data
	Upper San Antonio	1891	<0.1	2015	Rare	Craig et al. 2016
Nueces	Nueces	1955	0.1	2015	Rare	Craig, unpublished data
	Frio	1960	0	2015	Absent	Craig, unpublished data
Rio Grande	Rio Grande Downstream	1990	0	2011	Absent	Bonner, unpublished data
	Devils River	1953	0.1	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1990	0	2004	Absent	Garrett et al. 2004

Appendix 2.43 First records and recent abundances of Guadalupe Bass *Micropterus treculii* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas. See Littrell et al. (2007) and Bean et al. (2013) for reaches with likely intergressed populations of Guadalupe Bass and Smallmouth Bass *M. dolomieu*.

Drainage	Reach	First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas River	1951	1	2010	Rare	Labay 2010
	San Gabriel	1961	0	2010	Rare	Labay 2010
Colorado	South Concho	2001	0	1999	Absent	Hubbs 2004
	Llano Upper Reach	1952	1.8	2012	Rare	Curtis 2012
	Llano Middle Reach	1968	1.2	2012	Rare	Curtis 2012
	Llano Lower Reach	1968	0.8	2012	Rare	Curtis 2012
	North Llano	1955	6	2012	Rare	Curtis 2012
	Barton Creek	1977	1.6	2008	Rare	Labay et al. 2011
	Little Barton Creek	1988	1.1	1988	Rare	Linam et al. 2002
	Onion Creek	1947	0	1988	Absent	Linam et al. 2002
	San Saba	1948	0	2009	Absent	Higgins 2009
	Pedernales	1951	0.4	2010	Rare	Shattuck 2010
	North Grape Creek	1970	1.7	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	1.4	2000	Rare	Perkin 2011
	Upper San Marcos River	1949	<0.1	2015	Rare	Behen 2013
	Blanco	1949	<0.1	2007	Rare	Bean et al. 2007
	Little Blanco	2007	0.1	2007	Rare	Bean et al. 2007
San Antonio	Medina	1859	0.2	2014	Rare	Ruppel, unpublished data
Nueces	Nueces	1955	<0.1	2015	Rare	Craig, unpublished data

Appendix 2.43 continued

Drainage	Reach	First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Frio	1955	0.2	2015	Rare	Craig, unpublished data
	Sabinal	1854	0	2015	Absent	Craig, unpublished data

Appendix 2.44 First records and recent abundances of Fountain Darter *Etheostoma fonticola* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper San Marcos River	1884	5.8	2015	Occasional	Behen 2013
	Comal	1897	36	2015	Frequent	Scanes 2015

Appendix 2.45 First records and recent abundances of Rio Grande Darter *Etheostoma grahami* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Spring Reach of Pecos	1975	0.6	2011	Rare	Bonner, unpublished data
	Independence Creek	1961	1.2	2002	Rare	Bonner et al. 2002
	Rio Grande Downstream	1990	0.4	2011	Rare	Bonner, unpublished data
	Devils River	1854	1.2	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1854	0	2004	Absent	Garrett et al. 2004
	Sycamore Creek	1965	0.5	1989	Rare	Garrett et al. 1992
	San Felipe Creek	1951	5.9	1989	Occasional	Garrett et al. 1992

Appendix 2.46 First records and recent abundances of Greenthroat Darter *Etheostoma lepidum* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Colorado	South Concho	1984	0.1	1999	Rare	Hubbs 2004
	Spring Creek	1984	0	1990	Absent	Linam et al. 2002
	Llano Upper Reach	1939	1.6	2012	Rare	Curtis 2012
	Llano Middle Reach	1939	0.4	2012	Rare	Curtis 2012
	Llano Lower Reach	1939	<0.1	2012	Rare	Curtis 2012
	North Llano	1939	1.6	2012	Rare	Curtis 2012
	James River	1956	0.2	2012	Rare	Curtis 2012
	Johnson Fork	1939	0.5	2012	Rare	Curtis 2012
	Barton Creek	1884	1.6	2008	Rare	Labay et al. 2011
	Onion Creek	2007	0	1988	Absent	Linam et al. 2002
	San Saba	1952	1.7	2009	Rare	Higgins 2009
	Clear Creek Upstream	1953	0.2	1999	Rare	Hubbs 2004
	Clear Creek Downstream	1957	0.3	1999	Rare	Hubbs 2004
	Pedernales	1951	0.6	2010	Rare	Shattuck 2010
	Live Oak Creek	1998	8.3	2010	Occasional	Shattuck 2010
	North Grape Creek	1970	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1925	0.9	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1891	0	2015	Absent	Behen 2013
	Comal	1884	4.5	2015	Rare	Scanes 2015
	Blanco	1971	0	2007	Absent	Bean et al. 2007

Appendix 2.46 continued

Drainage	Reach	First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Cypress Creek	2003	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1925	0.9	2015	Rare	Ruppel, unpublished data
Nueces	Nueces	1938	6.8	2015	Occasional	Craig, unpublished data
	Pulliam Creek	1952	11	2015	Occasional	Craig, unpublished data
	Frio	1951	0	2015	Rare	Craig, unpublished data
	Sabinal	1951	0.3	2015	Rare	Craig, unpublished data

Appendix 2.47 First records and recent abundances of Orangethroat Darter *Etheostoma spectabile* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas	1891	6.9	2010	Occasional	Labay 2010
	San Gabriel	1951	0	2010	Absent	Labay 2010
	Rocky Creek	1938	0.9	1988	Rare	Linam et al. 2002
Colorado	South Concho	1986	<0.1	1999	Rare	Hubbs 2004
	Llano Upper Reach	1952	0	2012	Absent	Curtis 2012
	Llano Middle Reach	1968	0	2012	Absent	Curtis 2012
	Llano Lower Reach	1956	0	2012	Absent	Curtis 2012
	North Llano	1963	0	2012	Absent	Curtis 2012
	James River	1956	0	2012	Absent	Curtis 2012
	Onion Creek	1971	0	1988	Absent	Linam et al. 2002
	San Saba	1952	1.1	2009	Rare	Higgins 2009
	Pedernales	1952	0.3	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1938	2.9	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1884	0.1	2015	Rare	Behen 2013
	Comal	1891	0	2015	Absent	Scanes 2015
	Blanco	1951	1.7	2007	Rare	Bean et al. 2007
	Cypress Creek	1952	3.6	2007	Rare	Bean et al. 2007
San Antonio	Medina	1939	6.8	2014	Occasional	Ruppel, unpublished data

Appendix 2.48 First records and recent abundances of Guadalupe Darter *Percina apristis* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Guadalupe	Upper Guadalupe	1951	0	2009	Absent	Perkin and Bonner 2011
	Upper San Marcos	1884	0.5	2015	Rare	Behen 2013
	Comal	1884	0	2015	Absent	Scanes 2015
	Blanco	1977	<0.1	2007	Rare	Bean et al. 2007

Appendix 2.49 First records and recent abundances of Texas Logperch *Percina carbonaria* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	Lampasas River	1952	0.1	2010	Rare	Labay 2010
	San Gabriel	1972	0.1	2010	Rare	Labay 2010
Colorado	South Concho	1984	0	1999	Absent	Hubbs 2004
	Llano Upper Reach	1956	4.4	2012	Rare	Curtis 2012
	Llano Middle Reach	1956	5.3	2012	Occasional	Curtis 2012
	Llano Lower Reach	1956	0.3	2012	Rare	Curtis 2012
	North Llano	1956	0.6	2012	Rare	Curtis 2012
	James River	1956	0	2012	Absent	Curtis 2012
	Barton Creek	2008	0.3	2008	Rare	Labay et al. 2011
	Onion Creek	1961	0	1988	Absent	Linam et al. 2002
	San Saba	1948	1.5	2009	Rare	Higgins 2009
	Pedernales	1952	1.1	2009	Rare	Shattuck 2010
	Live Oak Creek	1998	0	2010	Absent	Shattuck 2010
Guadalupe	Upper Guadalupe	1925	1.3	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1949	1.4	2015	Rare	Behen 2013
	Blanco	1955	0.1	2007	Rare	Bean et al. 2007
	Cypress Creek	1952	0	2007	Absent	Bean et al. 2007
San Antonio	Medina	1858	0	2014	Absent	Ruppel unpublished 2014
	Upper San Antonio	1996	0	2015	Absent	Craig et al. 2016
Nueces	Nueces	1967	0	2015	Absent	Craig unpublished 2015

Appendix 2.49 continued

Drainage	Reach	First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
	Frio	1979	0	2015	Absent	Craig unpublished 2015

Appendix 2.50 First records and recent abundances of Rio Grande Cichlid *Herichthys cyanoguttatus* within Chihuahuan Desert, Edwards Plateau, and South Texas Plains ecoregions of Texas.

Drainage	Reach	Date of First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Brazos	San Gabriel	1978	0	2010	Absent	Labay 2010
Colorado	South Concho	1970	<0.1	1999	Rare	Hubbs 2004
	Spring Creek	1990	0.3	1990	Rare	Linam et al. 2002
	Llano Upper Reach	1952	1.5	2012	Rare	Curtis 2012
	Llano Middle Reach	1961	1.6	2012	Rare	Curtis 2012
	North Llano	1963	0.2	2012	Rare	Curtis 2012
	Barton Creek	2004	7.5	2008	Occasional	Labay et al. 2011
	Onion Creek	1977	0	1988	Absent	Linam et al. 2002
	San Saba	1963	0	2009	Absent	Higgins 2009
	Pedernales	2003	0.2	2010	Rare	Shattuck 2010
Guadalupe	Upper Guadalupe	1939	0.3	2009	Rare	Perkin and Bonner 2011
	Upper San Marcos	1938	0.2	2015	Rare	Behen 2013
	Comal	1942	0.3	2015	Rare	Scanes 2015
	Blanco	1949	1.2	2007	Rare	Bean et al. 2007
	Cypress Creek	1952	3.1	2007	Rare	Bean et al. 2007
San Antonio	Medina	1953	0.3	2014	Rare	Ruppel, unpublished data
	Upper San Antonio	1948	4.1	2015	Rare	Craig et al. 2016
Nueces	Nueces	1939	0.1	2015	Rare	Craig, unpublished data
	Frio	1951	0.2	2015	Rare	Craig, unpublished data
	Sabinal	1951	0.1	2015	Rare	Craig, unpublished data

Appendix 2.50 continued

Drainage	Reach	First Collection	Relative Abundances	Date of Relative Abundances	Abundance Scale	Citation
Rio Grande	Saline Reach of Pecos	1987	0.2	2011	Rare	Bonner, unpublished data
	Spring Reach of Pecos	1940	0.3	2011	Rare	Bonner, unpublished data
	Independence Creek	1961	1	2002	Rare	Bonner et al. 2002
	Live Oak Creek	1955	1.6	1990	Rare	Linam et al. 2002
	Rio Grande Downstream	1954	0.2	2011	Rare	Bonner, unpublished data
	Devils River	1858	1.6	2011	Rare	Kollaus and Bonner 2011
	Pinto Creek	1938	3.2	2004	Rare	Garrett et al. 2004
	Sycamore Creek	1971	1	1989	Rare	Garrett et al. 1992
	Las Moras Creek	1893	2.6	1989	Rare	Garrett et al. 1992
	San Felipe Creek	1951	<0.1	1989	Rare	Garrett et al. 1992

REFERENCES

Bean, P. T., T. H. Bonner, and B. M. Littrell. 2007. Spatial and temporal patterns in the fish assemblage of the Blanco River, Texas. Texas Journal of Science 59:179-200.

Bean, P. T., J. T. Jackson, D. J. McHenry, T. H. Bonner, M. R. J. Forstner. 2011. Rediscovery of headwater catfish, Ictalurus lupus (Ictaluridae) in a western gulf slope drainage. Southwestern Naturalist 56:285-289.

Behen, K. P. K. 2013. Influence of connectivity and habitat on fishes of the upper San Marcos River. Master's thesis. Texas State University, San Marcos, Texas.

Bonner, T. H., C. Thomas, C. S. Williams, and J. P. Karges. 2005. Temporal assessment of a west Texas stream fish assemblage. Southwestern Naturalist 50:74-78.

Brune, G. 1981. Springs of Texas, Volume 1. Branch-Smith. Inc., Fort Worth, Texas.

Clark, K. E., J. E. Applegate, L. J. Niles, and D. R. Dobkin. 2006. An objective means of species status assessment: adapting the Delphi technique. Wildlife Society Bulletin 34(2):419-425.

Connor J. V. and R. D. Suttkus. 1986. Zoogeography of freshwater fishes of the western gulf slope of North America. Pages 413-456 *in* C. H. Hocutt and E. O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley & Sons, New York.

Craig, C. A. and T. H. Bonner. In review. Historical and contemporary perspectives of an urban fish community related to stream rehabilitation efforts. Urban Ecosystems.

Craig, C.A., K. A. Kollaus, K. P. K. Behen, and T.H. Bonner. 2016. Relationships among spring flow, habitats, and fishes within evolutionary refugia of the Edwards Plateau. Ecosphere 7:1-13.

Craig, C. A., B. M. Littrell, and T. H. Bonner. 2017. Population status and life history attributes of the Texas shiner Notropis amabilis. American Midland Naturalist 177(2):277-288.

Curtis, S. 2012. Effects of dry baseflow conditions in a declining hydrograph on instream habitats and fish communities in a semi-arid karstic stream. Master's thesis. Texas State University, San Marcos, Texas.

Donlan, C. J., D. K. Wingfield, L.B. Crowder, and C. Wilcox. 2010. Using expert opinion surveys to rank threats to endangered species: a case study with sea turtles. Conservation Biology 24:1586-1595.

Echelle, A. A., M. de Lourdes Lozano Vilano, S. Baker, W.D. Wilson, A. F. Echelle, G. P. Garrett, and R. J. Edwards. 2013. Conservation genetics of Gambusia krumholzi (Teleostei: Poeciliidae) with assessment of the species status of G. clarkhubbsi and hybridization with G. speciosa. Copeia 2003(1):72-79.

Garrett, G. P. and R. J. Edwards. 2003. New species of Gambusia (Cyprinodontiformes: Poeciliidae) from Del Rio, Texas. Copeia 2003(4):783-788.

Garret, G. P., R. J. Edwards, and C. Hubbs. 2004. Discovery of a new population of Devils River Minnow (Dionda diaboli), with implications for conservation of the species. Southwestern Naturalist 49(4):435-441.

Garrett, G. P., R.J. Edwards, and A. H. Price. 1992. Distribution and status of the Devils River Minnow, Dionda diaboli. Southwestern Naturalist 37(3):259-267.

Given, D. R. and D. A. Norton. 1993. A multivariate approach to assessing threat and for priority setting in threatened species conservation. Biological Conservation 64:57-66.

Gleick, P. H. 2010. Roadmap for sustainable water resources in southwestern North America. Proceedings of the National Academy of Sciences 107(50):21300-21305.

Goldstein, R. M. and T. P. Simon. 1999. Toward a united definition of guild structure for feeding ecology of North American freshwater fishes. Pages 123-202 *in* T.P. Simon, editor. Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, Florida.

Griffith, G., S. Bryce, J. Omernik, and A. Rogers. 2007. Ecoregions of Texas. Project Report to Texas Commission on Environmental Quality. Austin, Texas.

Halpern, B. S., K. A. Selkoe, F. Micheli, and C. V. Kappel. 2007. Evaluating and Ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology 21:1301-1315.

Hendrickson, D. A., and A. E. Cohen. 2015. “Fishes of Texas Project Database (Version 2.0)” doi:10.17603/C3WC70. Accessed (2017).

Higgins, C. L. 2009. Spatiotemporal variation in functional and taxonomic organization of stream-fish assemblages in central Texas. Aquatic Ecology 43:1133-1141.

Hubbs, C. 2004. Differences in spring vs stream fish assemblages. Pages 376-395 *in*: C.A. Hoyt and J. Karges (editors). Proceedings of the Sixth Symposium on the Natural Resources of the Chihuahuan Desert Region. October 14–17. Chihuahuan Desert Research Institute, Fort Davis, Texas.

Hubbs, C., R. J. Edwards, and G. P. Garrettt. 2008. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species. Second Edition. Texas Academy of Science.

Hudy, M., T. M. Thieling, N. Gillespie, and E. P. Smith. 2008. Distribution, status, land use, characteristics of subwatersheds within the native range of brook trout in the eastern United States. North American Journal of Fisheries Management 28:1069-1085.

Kollaus, K. A. and T. H. Bonner. 2012. Habitat associations of a semi-arid fish community in a karst spring-fed stream. Journal of Arid Environments 76:72-79.

Linam, G. W., L. J. Kleinsasser, and K. B. Mayes. 2002. Regionalization of the index of biotic integrity for Texas streams. River Studies Report No. 17. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Labay, B. J. 2010. The influence of land use, zoogeographic history, and physical habitat on fish community diversity in the lower Brazos watershed. Master's thesis. Texas State University, San Marcos, Texas.

Labay B., A. E. Cohen, B. Sissel, D. A. Hendrickson, F. D. Martin, S. Sarkar. 2011. Assessing historical fish community composition using surveys, historical collection data, and species distribution models. PLoS ONE 6(9):e25145.

Master, L. L., D. Faber-Langendoen, R. Bittman, G. A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, VA.

Maxwell, R. J. 2012. Patterns of endemism and species richness of fishes of the western gulf slope. Master's thesis. Texas State University, San Marcos, Texas.

McClure-Baker, S. A., A. A. Echelle, R. A. van den Bussche, A. F. Achelle, D. A. Hendrickson, and G. P. Garrett. 2010. Genetic status oh Headwater Catfish in Texas and New Mexico: a perspective from mtDNA and morphology. Transactions of the American Fisheries Society 139(6):1780-1791.

McGeoch, M. A., D. Spear, A. J. Kleynhans, and E. Marais. 2012. Uncertainty in invasive alien species listing. Ecological Applications 22(3):959-971.

Miller, R. R., W. L. Minckley, and S. M. Norris. 2005. Freshwater Fishes of Mexico. University of Chicago Press, Chicago.

Miyazono, S. and C. M. Taylor. 2016. Fish species incidence patterns in naturally fragmented Chihuahuan Desert streams. Ecology of Freshwater Fish 25:545-552.

Moyle, P. B., J. V. E. Katz, and R. M. Quiñones. 2011. Rapid decline of California's native inland fishes: a status assessment. Biological Conservation 144: 2414-2423.

Faber-Langendoen, D., J. Nichols, L. Master, K. Snow, A. Tomaino, R. Bittman, G. Hammerson, B. Heidel, L. Ramsay, A. Teucher, and B. Young. 2012. NatureServe Conservation Status Assessments: Methodology for Assigning Ranks. NatureServe, Arlington, VA.

NatureServe. 2017. NatureServe Explorer: An online encyclopedia of life [online database]. Version 7.1. NatureServe, Arlington, Virginia. Available: http//explorer.natureserve.org.

O'Grady, J. J., M. A. Burgman, D. A. Keith, L.L. Master, S. J. Andelman, B. W. Brook, G. A. Hammerson, T. Regan, and R. Frankham. 2004. Correlations among extinction risks assessed by different systems of threatened species categorization. Conservation Biology 18(6):1624-1635.

Perkin, J. S. and T. H. Bonner. 2011. Long-term changes in flow regime and fish assemblage composition in the Guadalupe and San Marcos Rivers of Texas. River Research and Applications 27:566-579.

Rauchenberger, M. 1989. Systematics and biogeography of the genus Gambusia (Cyprinodontiformes, Poecilidae). American Museum of Natural History 2951. New York.

Runyan, D. 2007. Fish assemblage changes in Gulf Slope drainages; an historical perspective and Occurrence and distribution of age-0 fishes in the Rio Grande. Master's thesis. Texas State University, San Marcos, Texas.

Sanchez, J. L., S. B. Stoops, N. L. Allan, J. C. Cureton II, G. P. Garrett, C. W. Kroll, R. H. Lewis, E. March-Matthews, J. West, and R. Deaton. 2013. Current distribution of the introduced Largespring Gambusia, Gambusia geiseri, in Texas. Southwestern Naturalist 58(4):497-502.

Scanes, C. M. 2016. Fish community and habitat assessments within an urbanized spring complex of the Edwards Plateau. Master's thesis. Texas State University, San Marcos, Texas.

Schlechte, J. W. and B. P. Fleming. 2015. Response of the Devils River Minnow and other fish in Pinto Creek, Kinney County, Texas during a severe draught. Southwestern Naturalist 60(1)45-55.

Shaffer, M. L. and B. A. Stein. 2000. Safeguarding our precious heritage. Pages 301-321 *in* B. A. Stein, L. S. Kutner, and J. S. Adams, editors. Precious heritage the status of biodiversity in the United States. Oxford University Press, New York.

Shattuck, Z. 2010. Spatiotemporal patterns of fish and aquatic insects in an urbanized watershed of central Texas. Master's thesis. Texas State University, San Marcos, Texas.

Stiers, I., N. Crohain, G. Josens, L. Triest. 2011. Impact of three aquatic invasive species on native plants and macroinvertebrates in temperate ponds. Biological Invasions 13:2715-2726.

Sylvia, D. A., and W. E. Galloway. 2006. Morphology and stratigraphy of the late Quaternary lover Brazos valley: implications for paleo climate, discharge, and sediment delivery. Sedimentary Geology 190:159-175.

Texas Parks and Wildlife Department. 2012. Texas Conservation Action Plan 2012 – 2016: Overview. Editor Wendy Connally, Texas Conservation Action Plan Coordinator. Austin, Texas.

Texas Parks and Wildlife Department. 2005. Texas Comprehensive Wildlife Conservation Strategy 2005 – 2011. S. Bender, S. Shelton, K.C. Bender, and A. Kalmbach, Editors. Austin, Texas.

Texas Parks and Wildlife Department. In Press. Texas Conservation Action Plan 2017 – 2021: Overview. Austin, Texas.

Thomas, C., T. H. Bonner, and B. G. Whiteside. 2007. Freshwater Fishes of Texas: A Field Guide. Texas A&M University Press. College Station, Texas.

U.S. Fish and Wildlife Service. 2016. USFWS Species Status Assessment Framework: an integrated analytical framework for conservation.

U.S. Fish and Wildlife Service. 2014. Species Status Assessment Report for the Sharpnose Shiner (*Notropis oxyrhynchus*) and Smalleye Shiner (*N. buccula*).

Wong, C. I., J. L. Banner, and M. Musgrove. 2015. Holocene climate variability in Texas, USA: an integration of existing paleoclimate data and modeling with a new, high-resolution speleothem record. Quaternary Science Reviews 127:155-173.