Comanche Springs pupfish
(Cyprinodon elegans)
5-Year Status Review:
Summary and Evaluation

Photo: Kevin W. Conway, Dept. Ecology and Conservation Biology, Texas A&M University

U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
Austin, Texas
2 August 2024

5-YEAR REVIEW

Species reviewed: Comanche Springs pupfish (*Cyprinodon elegans*)

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1.0 GENERAL INFORMATION

1.1 Reviewers:

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Wade Wilson, Project Leader, Southwest Native Aquatic Resource and Recovery Center, Dexter, New Mexico, wade_wilson@fws.gov

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Cooperating Regional Office(s):
Not applicable

1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species ESA (ESA) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.3 Methodology used to complete the review:

The U.S. Fish and Wildlife Service (Service) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the Endangered Species Act (16 U.S.C. 1531 et seq.). The Service provides notice of status reviews via the Federal Register and requests new information on the status of the species (e.g., life history, habitat conditions, and threats). Data for this status review were solicited from interested parties through Federal Register notices announcing this review on May 5, 2021 (86 FR 23976) and January 25, 2024 (89 FR 4966). This review was conducted by the Austin Ecological Services Field Office and considered both new and previously existing information from federal and state agencies, non-governmental organizations, academia, and the public. The primary sources of information used in this analysis included information from the recovery plan, the 2013 Five-Year Status Review, peer-reviewed articles, agency reports, and other documents available in the Austin Ecological Services Field Office files. We engaged in discussions with staff from the Texas Parks and Wildlife Department, including those from the Inland Fisheries program and those from Balmorhea State Park. We also engaged in discussions with Service employees affiliated with the Fisheries and Aquatic Conservation program. Comments received were evaluated and incorporated as appropriate.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

86 FR 23976: May 5, 2021
89 FR 4966: January 25, 2024

1.4.2 Listing history:

<u>Original Listing</u>
FR notice: 32 FR 4001
Date listed: March 11, 1967
Entity listed: Species, *Cyprinodon elegans*
Classification: Endangered

1.4.3 Associated Rulemakings:

Not applicable.

1.4.4 Review History:

A five-year status review for the Comanche Springs pupfish was approved in August 2013. This was the first five-year review completed for the species. The recommendation resulting from the review was that no change was warranted to the classification of the species as Endangered.

1.4.5 Species' Recovery Priority Number at start of 5-year review:

11

1.4.6 Recovery Plan or Outline

Name of plan or outline: Comanche Springs Pupfish Recovery Plan
Date issued: April 20, 1981
Dates of previous plans/amendment or outline, if applicable: Not applicable

2.0 REVIEW ANALYSIS

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The ESA defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The ESA requires that we determine whether a species meets the definition of "endangered species" or "threatened species" due to any of the five factors described below.

Section 4(a) of the Act describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Service recommends whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

2.1 Distinct Population Segment (DPS) policy (1996):

Not applicable; the Comanche Springs pupfish is not listed as a DPS.

2.2 Updated Information and Current Species Status

2.2.1 Biology and Habitat

2.2.1.1 New information on the species' biology and life history:

At the time of the last five-year review in 2013, a study on the status of Comanche Springs pupfish at Balmorhea State Park was underway (Hargrave 2013, p. 2). Interim results were included in the prior review; we report findings from the final report here. The effort included a diet study that examined not only Comanche Springs pupfish, but also the co-occurring species Pecos gambusia (*Gambusia nobilis*), largespring gambusia (*G. geiseri*), and Texan tetra (*Astyanax argentatus*). According to the findings, the predominant food item found in Comanche Springs pupfish in both San Solomon Ciénega and Clark Hubbs Ciénega (a ciénega is a desert marsh or wetland) was algae, with benthic invertebrates and other items making up a consistently minor proportion of the species' overall diet (Hargrave 2013, pp. 12, 18). However, a concurrent stable isotope analysis found that biomass accumulation for Comanche Springs pupfish and the other species, in both ciénegas, came primarily from benthic invertebrates (Hargrave 2013, pp. 24–27). There was some degree of temporal trends in algal consumption and diet overlap, especially in fishes from the Clark Hubbs Ciénega, but given the weakness of the signal and the stable isotope results, there are no definitive conclusions drawn from the temporality results (Hargrave 2013, pp. 12, 18–19, 24)

Hargrave (2017, pp. 1–5) conducted monitoring of Comanche Springs pupfish and habitat conditions at five ciénegas (San Solomon, Clark Hubbs, East Sandia Springs, Phantom Cave, and Giffin Spring Ciénegas) in the vicinity of Balmorhea, Texas, from 2013 to 2017 and conducted habitat experiments in controlled environments at Sam Houston State University. The density of Comanche Springs pupfish was found to be positively correlated with vertical vegetative structure and coarser substrates (Hargrave 2017, pp. 8–9). The author suggests that these habitat characteristics are correlated with higher rates of primary production and benthic invertebrates, implying that the increasing food resources explain the increased densities of Comanche Springs pupfish (Hargrave 2017, p. 9). Findings from the manipulative and controlled experiments conducted as part of the larger study supported this hypothesis, but indicated that additional drivers exist in the wild that were not captured in the experimental design (Hargrave 2017, p. 9). For example, competition with other species likely reduces the total abundance and the density of Comanche Springs pupfish in the wild (Hargrave 2017, p. 9). In addition, the fact that female

Comanche Springs pupfish lay eggs on algal mat substrates or on large rocks may indicate that coarser substrates also provide a higher amount of suitable territories and egg laying locations, which in turn impacts total population size (Hargrave 2017, pp. 3–4).

Acre et al. (2020, p. 199) assessed the relationship between ciénega restoration at Balmorhea State Park and Comanche Springs pupfish abundance. The natural ciénega that existed historically could be characterized as a dynamic system in which water depth, temperature, and cover of macroalgae (*Chara* spp.) vary over time (Acre et al. 2020, p. 205). The researchers demonstrated that Comanche Springs pupfish abundance was higher in the ciénegas restored to these conditions compared to other localities within the Park that had not undergone restoration (Acre et al. 2020, pp. 204–206).

Observations on water temperature tolerance are available from the Southwestern Native Aquatic Resources and Recovery Center (SNARRC) in Dexter, New Mexico. SNARRC staff estimate the temperature range tolerated by Comanche Springs pupfish held in refuge ponds at that facility is wide and includes lows of approximately 2–3° Celsius (° C) (35.6–37.4° Fahrenheit (° F)) in winter and highs of approximately 33–34° C (91.4–93.2° F) in the summer (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). At SNARRC, saltgrass (*Distichlis spicata*), spiny holly (*Berberis* spp.), cattails (*Typha domingensis*), and chara (*Chara* spp.) grow in the refuge ponds (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). At Uvalde National Fish Hatchery (NFH), brushy pond weed (*Najas guadalupensis*), stargrass (*Hypoxis hirsute*), chara, and filamentous algae grow in the refuge ponds (Uvalde National Fish Hatchery 2024, p. 1).

2.2.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, birth rate, seed set, germination rate, age at mortality, mortality rate, etc.), or demographic trends:

Monitoring of Comanche Springs pupfish across its range has been fairly consistent since before the last five-year status review was published in 2013. A series of efforts spanning 2009 to 2013 (Hargrave 2013, pp. 7–8), 2014 to 2015 (Hargrave 2017, pp. 12–17), 2017 to 2018 (Norris et al. 2022, pp. 43–52), and 2019 (Acre et al. 2020, p. 201) collected sufficient data to estimate Comanche Springs pupfish population size and density at each locality with the species' range. We compiled the data across all years and present a summarized version of the results in Table 1, Table 2, Table 3, and Table 4. In general, Comanche Springs pupfish densities were largest in the Clark Hubbs Ciénega, followed by the Phantom Lake Spring refugium and the San Solomon Ciénega. Both ciénegas contain fairly large populations of Comanche Springs pupfish with estimates ranging from the low hundreds to tens of thousands; point-in-time estimates fluctuate within and across years.

Table 1. Density estimates for Comanche Springs pupfish monitoring using seining as the methodology for the period 2009–2018. Values for East Sandia Spring only from March 2017–December 2018 are minnow trap catch per unit effort (fish/hour) values. Here we reproduce point estimates for density (number of fish per square meter) from three studies. Additional context and the 95% confidence intervals or standard deviations for these estimates are available in the original reports or papers (Hargrave 2013, pp. 7–8, 28–30; 2017, p. 12; Norris et al. 2022, pp. 48–51). An m-dash (—) indicates that no data were reported for that event.

Monitoring Dates	San Solomon Ciénega	Clark Hubbs Ciénega	Refuge Canal	Phantom Lake Spring	East Sandia Spring	Giffin Spring	Balmorhea Pool
March 2009	0.3	—	1.9	—	—	—	—
July 2009	0.9	—	1	—	—	—	—
Dec 2009	1	0.9	—	—	—	—	—
April 2010	1.1	0.2	—	—	—	—	—
July 2010	1.1	5	—	—	—	—	—
Dec 2010	1.2	15.2	—	—	—	—	—
March 2011	0.6	4.4	—	—	—	—	—
Aug 2011	1.6	17.8	—	—	—	—	—
Jan 2012	0.9	10.2	—	—	—	—	—
April 2012	0.8	6.5	—	—	—	—	—
Aug 2012	1.1	19.2	—	—	—	—	—
Dec 2012	1.5	18.6	—	—	—	—	—
April 2013	0.5	10.7	—	—	—	—	—
Summer 2014	0.3	9.6	—	2.5	0.27	0	—
Winter 2014	3.3	4.2	—	3	0	0	—
Summer 2015	5.5	15.6	—	3.3	0	0	—
Winter 2015	2.2	5.1	—	3.6	0	0	—
March 2017	0.1	0.1	0.1	0.1	0	—	—
June/July 2017	1.1	0.7	0.3	1.8	0	—	—
Sept 2017	1	4.3	0.8	—	0	—	—
Dec 2017	0.3	1.4	0.1	2.2	0	—	—
April 2018	0	0.1	0.1	—	—	—	—
June 2018	0.7	1.2	0.2	2.4	0	—	—
Sept 2018	0.4	0.8	0.3	—	0	—	—
Dec 2018	0.4	0.7	0.1	—	0	—	—

Table 2. Population size estimates for Comanche Springs pupfish monitoring using seining as the methodology for the period 2009–2018. Here we reproduce the point estimate for population size (Number of fish) from three studies. Additional context and the 95% confidence intervals or standard deviations for these estimates are available in the original reports or papers (Hargrave 2013, pp. 7–8, 28–30; 2017, p. 17; Norris et al. 2022, pp. 48–51). An m-dash (—) indicates that no data were reported for that event.

Monitoring Dates	San Solomon Ciénega	Clark Hubbs Ciénega	Refuge Canal	Phantom Lake Spring	East Sandia Spring	Giffin Spring	Balmorhea Pool
March 2009	208.9	—	1139.5	—	—	—	—
July 2009	569.5	—	583.7	—	—	—	—
Dec 2009	667	800	—	—	—	—	—
April 2010	691	189	—	—	—	—	—
July 2010	680	4,371	—	—	—	—	—
Dec 2010	782	13,249	—	—	—	—	—
March 2011	370	3,791	—	—	—	—	—
Aug 2011	825	18,789	—	—	—	—	—
Jan 2012	289	9,568	—	—	—	—	—
April 2012	423	5,655	—	—	—	—	—
Aug 2012	670	20,235	—	—	—	—	—
Dec 2012	1,050	16,461	—	—	—	—	—
April 2013	351	947	—	—	—	—	—
Summer 2014	112	3,600	—	2.5	101	0	—
Winter 2014	1,237	1,575	—	3	0	0	—
Summer 2015	2,062	5,850	—	3.3	0	0	—
Winter 2015	825	1,912	—	3.6	0	0	—
March 2017	2,154	74	143	0.1	—	—	—
June/July 2017	4,920	598	190	1.8	—	—	—
Sept 2017	4,554	3,922	806	—	—	—	—
Dec 2017	1,185	1,315	107	2.2	—	—	—
April 2018	207	118	133	—	—	—	—
June 2018	3,082	1,123	158	2.4	—	—	—
Sept 2018	1,650	716	321	—	—	—	—
Dec 2018	208.9	—	1139.5	—	—	—	—

Table 3. Density estimates generated from sampling events using visual counts or minnow traps as the methodology in 2019. Here we reproduce point estimates for density (number of fish per square meter) from Acre et al. (2020, p. 203). Additional context and the 95% confidence interval for these estimates are available in the original paper (Acre et al. 2020, p. 203). An m-dash (—) indicates that no data were reported for that event.

Monitoring Dates	Survey Method	San Solomon Ciénega	Clark Hubbs Ciénega	Refuge Canal	Balmorhea Pool
March 2019	Visual Count	—	5.58	0.11	0.35
March 2019	Minnow Trap	—	4.81	0.16	0.23
October 2019	Visual Count	11.93	16.90	0.34	0.21
October 2019	Minnow Trap 3-night	1.25	6.40	—	0.08
October 2019	Minnow Trap 4-night	1.15	5.54	0.37	0.07

Table 4. Population size estimates generated from sampling events using visual counts or minnow traps as the methodology in 2019. Here we reproduce the point estimate for population size (Number of fish) from Acre et al. (2020, p. 203). Additional context and the 95% confidence interval for these estimates are available in the original paper (Acre et al. 2020, p. 203). An m-dash (—) indicates that no data were reported for that event.

Monitoring Dates	Survey Method	San Solomon Ciénega	Clark Hubbs Ciénega	Refuge Canal	Balmorhea Pool
March 2019	Visual Count	—	5,145	311	1,930
March 2019	Minnow Trap	—	4,435	439	1,281
October 2019	Visual Count	44,724	15,591	935	1,145
October 2019	Minnow Trap 3-night	4,701	5,901	—	443
October 2019	Minnow Trap 4-night	4,327	5,114	1,021	427

Comanche Springs pupfish rarely live more than one to two years in the wild, and are capable of producing large numbers of offspring (Garrett and Price 1993, pp. 5–6; U.S. Fish and Wildlife Service 2009a, p. 4). Sampling Comanche Springs pupfish and other small-bodied desert fishes sufficiently to obtain high quality population estimates is challenging, and the detection of trends in density and population estimates is extremely difficult (U.S. Fish and Wildlife Service 1981, p. 11; Maunder and Punt 2004, pp. 155–156). While the available data preclude definitive statements about the trends in Comanche Springs pupfish population size at any of the localities where they remain extant, we do not find any concerning declines, or increasing trajectories, in either estimated population sizes or densities across the 2009–2018 period of study in which seining was employed. Significant investments in monitoring occurred over that time frame, and researchers did not report any concerns with age structure, sex ratios, body condition, or survival rates (Hargrave 2013, entire; 2017, entire; Acre et al. 2020, entire; Norris et al. 2022, entire). Overall, Comanche Springs pupfish populations in San Solomon and Clark Hubbs Ciénegas in Balmorhea State Park are currently stable and exhibit unsurprising seasonal variation in which total abundance increases in the spring and summer and decreases in the winter (Norris et al. 2022, pp. 89–90).

The most important change to Comanche Springs pupfish abundance is the total loss of the Phantom Lake Spring population due to the drying of the refugium. Staff from the Texas Fish and Wildlife Conservation Office (FWCO), Texas Parks and Wildlife Department (TPWD), and researchers from the Texas A&M University system visited the refugium in February 2023 and confirmed the loss of the Comanche Springs pupfish population there (Montagne 2023, pp. 1–2).

Captive populations of Comanche Springs pupfish are maintained at the SNARRC in Dexter, New Mexico, and at Uvalde NFH in Uvalde, Texas. In 2013, 3,500 individuals were transferred from SNNARC to Uvalde NFH (U.S. Fish and Wildlife Service 2015, p. 16). The population at SNNARC numbers 5,000–8,000 in a single 0.04 hectare (ha) (0.1-acre (ac)) rubber-lined pond, and the population at Uvalde NFH numbers 1,000–2,000 in each of two 0.2–0.4 ha (0.5-1.0 ac) earthen ponds (Uvalde National Fish Hatchery 2024, p. 1). These populations are stable and no demographic concerns were reported at either station.

2.2.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

A genetic assessment of Comanche Springs pupfish was performed as part of a TPWD baseline biomonitoring effort (Norris et al. 2022, p. 28). Samples were collected from San Solomon Ciénega, Clark Hubbs Ciénega, Phantom Lake

Spring, and East Sandia Springs in 2017 (Lutz-Carrillo 2018, p. 1; Norris et al. 2022, p. 36). The goals of the assessment were to establish assays for working with the species, determine if any hybridization with sheepshead minnow has occurred, and evaluate genetic structuring among Comanche Springs pupfish localities (Norris et al. 2022, p. 36). Assays were successfully established, and it was determined that no hybridization with sheepshead minnow has occurred in those four localities (Norris et al. 2022, pp. 36, 54). The Phantom Lake Spring population exhibited fewer alleles than the other locations, which could be due either to population declines or a past bottleneck; both likely contributed (Norris et al. 2022, pp. 54–55). The San Solomon Ciénega and Clark Hubbs Ciénega populations were not genetically distinct from one another (Norris et al. 2022, p. 55). There were small differences in alleles between the Phantom Lake Spring population and the Balmorhea State Park populations, likely due to bottlenecking at Phantom Lake Spring and the very small population size at that location (Norris et al. 2022, pp. 54–55)

A more comprehensive genomic assessment of Comanche Springs pupfish is currently underway using Traditional Section 6 grant funding, with results anticipated in 2025 (Portnoy and Conway 2023, p. 7). This project will assess the current genetic diversity and population structure of the species, including among and between the wild and captive populations, determine whether there is any historical or current hybridization with sheepshead minnow, and identify whether external morphology indicates hybridization (Portnoy and Conway 2023, p. 2).

The SNARRC updated the *Comanche Springs pupfish (Cyprinodon elegans) Refuge Population and Genetics Management Plan* in 2015 (U.S. Fish and Wildlife Service 2015, entire). The plan assessed the genetic diversity in the two captive populations, which were founded using fish from the Phantom Lake Spring refugium, and the Phantom Lake Spring population. This past effort concluded that allelic richness is highest in the SNARRC captive population, followed by the Uvalde NFH captive population, then the Phantom Lake Spring population (U.S. Fish and Wildlife Service 2015, pp. 15–16). The caveat to these conclusions is that sample sizes were small and genotyping occurred across only five microsatellite markers (U.S. Fish and Wildlife Service 2015, p. 16). The plan set goals of completing genetic monitoring every 2–3 years, to augment the Phantom Lake Spring population with fish from both the SNARRC and Uvalde NFH captive ponds, and to move Comanche Springs pupfish between SNARRC and Uvalde NFH in order to maintain genetic diversity (U.S. Fish and Wildlife Service 2015, p. 16). Comanche Springs pupfish were transferred between Uvalde NFH and SNARRC in 2013 and 2014 (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). No transfers or genetic assessments have occurred since then (Southwest Native Aquatic Resources Recovery Center 2024, p. 1; Uvalde National Fish Hatchery 2024, p. 1).

2.2.1.4 Taxonomic classification or changes in nomenclature:

There have not been any questions or concerns regarding the taxonomic classification or nomenclature of the Comanche Springs pupfish since the previous five-year review was approved in 2013.

2.2.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, pollinator availability, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

Figure 1 shows the current Comanche Springs pupfish range and denotes the status of the species at each known locality.

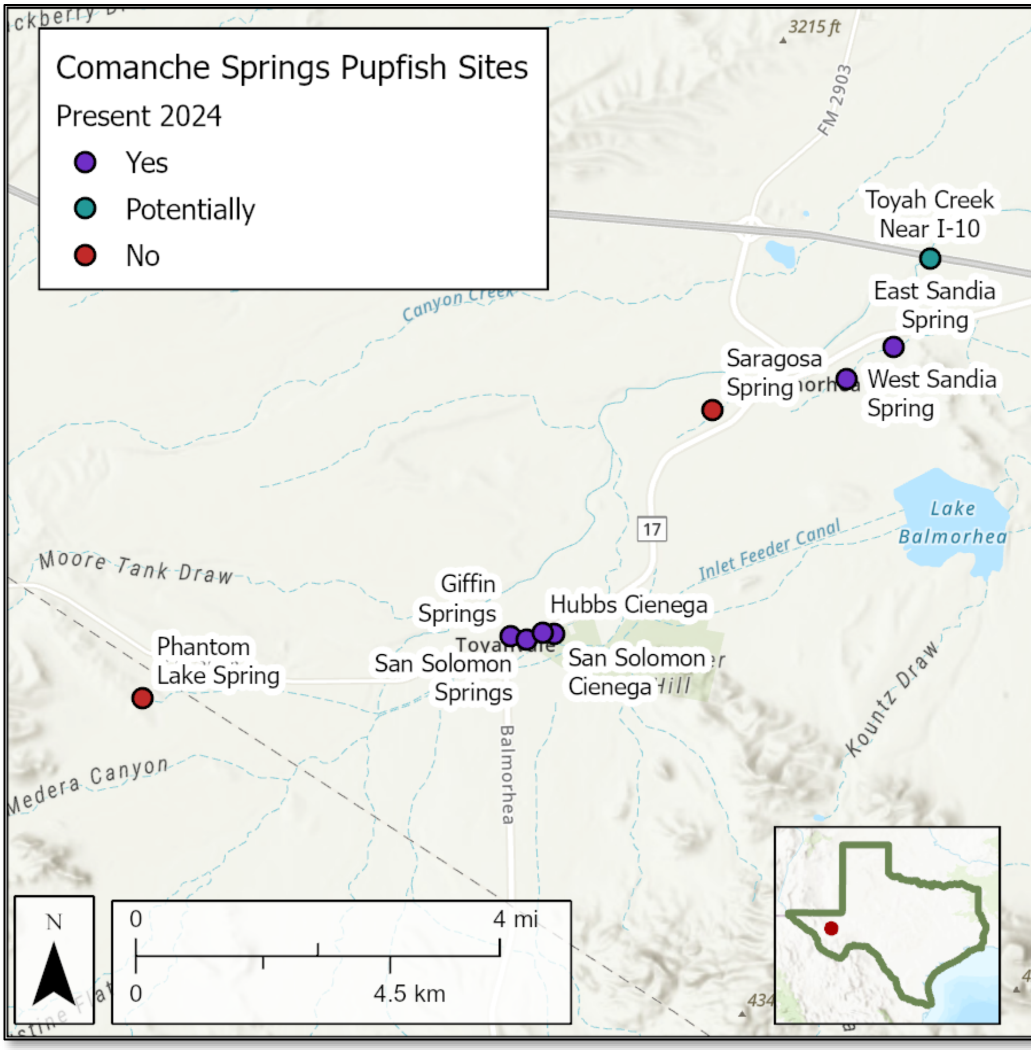

Figure 1. Springs and ciénegas known to have supported Comanche Springs pupfish. This image includes sites historically and currently occupied. The presence of Comanche Springs pupfish at each location as of 2024 is depicted by color: red indicates that Comanche Springs pupfish are not present, teal indicates that Comanche Springs pupfish are potentially present, and purple indicates that Comanche Springs pupfish are present.

As of 2024, Comanche Springs pupfish remain extant within spring-fed habitats at Balmorhea State Park, including the pool, the outflow canal from the pool, the San Solomon Ciénega, the Clark Hubbs Ciénega, and the outflow canals leaving the park. In East Sandia Spring, Comanche Springs pupfish were detected in 2014, 2021, and 2023 (Hargrave 2017, pp. 12, 17; Texas Parks and Wildlife Department 2021a, p. 9; 2024b, pp. 9–10). The TPWD Baseline Biomonitoring Report asserts that Comanche Springs pupfish are present in West Sandia Springs, although no sampling activity is reported (Norris et al. 2022, p. 23). Giffin Spring was sampled in 2014 and 2015, and still flows, but no Comanche Springs pupfish were detected (Hargrave 2017, pp. 12, 17). A personal communication from Ryan Smith of The Nature Conservancy attesting to the likely persistence of a small population there was cited by Acre et al. (2020, p. 199).

In some locations, the 2013 five-year status review was equivocal regarding the presence of Comanche Springs pupfish. That report suggested that Comanche Springs pupfish might still be present in Toyah Creek near the Interstate-10 bridge (U.S. Fish and Wildlife Service 2013, p. 8). However, the citation for their presence dates to 1993 and the actual sampling took place in 1990 (Garrett and Price 1993, pp. 14–15). As of this report, no new information is available on the status of Comanche Springs pupfish at this locality. None of the monitoring of the area from 2009–2019 visited this location. The most recent sampling effort, in 1991, did not detect Comanche Springs pupfish (Garrett and Price 1993, p. 15), but its extirpation remains unconfirmed. The Comanche Springs pupfish is now considered extirpated from Saragosa Spring because that spring does not reliably flow and has not for decades (O'Neil et al. 1995, pp. 4, 10), a change from "unlikely" to occur from the prior five-year status review.

Comanche Springs pupfish were present in the Phantom Lake Spring refugium when the last five-year review was conducted, (U.S. Fish and Wildlife Service 2013, p. 8) but have been extirpated from that location since spring of 2022 (Montagne 2023, pp. 1–2). A major restoration of the refugium was conducted from 2010 to 2012 (Texas Fish and Wildlife Conservation Office 2012, pp. 2–9). Monitoring from October 2012 found that both juvenile and adult Comanche Springs pupfish were present, indicating successful colonization of the new habitat (Texas Fish and Wildlife Conservation Office 2012, p. 10). Additional monitoring took place from 2014 to 2018 that indicated that Comanche Springs pupfish were continuing to persist in relatively stable numbers within the reconstructed refugium (Table 1 and Table 2). In early 2022, power to the pumps maintaining this refugium was turned off, which led to the refugium drying, likely in a matter of weeks (Montagne 2023, pp. 1–2). A visit to the property in February of 2023 confirmed that the refugium was totally dry and that Comanche Springs pupfish are now extirpated from this locality (Montagne 2023, pp. 1–2).

In summary, Comanche Springs pupfish remain extant at most of the localities where they were present at the time the 2013 five-year review was completed. One population (Saragosa Spring) that was considered questionable is now considered extirpated, and one population (Phantom Lake Spring) that was extant as recently as 2022 is now confirmed extirpated. No new populations of Comanche Springs pupfish have been introduced since 2013.

2.2.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Water Quality

In 2018, TPWD developed recommendations for baseline monitoring of water quantity and quality parameters as well as aquatic fauna of the San Solomon Spring System, which includes San Solomon Spring (underlying the swimming pool at Balmorhea State Park), Giffin Spring, East and West Sandia Springs, and Phantom Lake Spring (Texas Parks and Wildlife Department 2018, entire). Sampling efforts conducted by that agency and partners (e.g., Service and Texas State University) took place from 2017 to 2018 (Norris et al. 2022, pp. 41–42). Water quality of sampled springs was generally of good quality with few detectable contaminants (Norris et al. 2022, pp. 77–89). The San Solomon and Clark Hubbs Ciénegas tended to have higher water temperatures, pH, dissolved oxygen, and percent cover of filamentous algae (Norris et al. 2022, p. 62). East and West Sandia springs have lower water temperatures and higher specific conductivity than San Solomon and Phantom Lake springs (Norris et al. 2022, p. 75).

Water Quantity

Declining springflows are a major threat to Comanche Springs pupfish (U.S. Fish and Wildlife Service 2015, p. 6). As discussed above, declines in springflows lead to declines in aquatic habitat; the loss of some localities (e.g., Phantom Lake Spring) has already occurred due to declining springflows. Discharge data from San Solomon springs at Balmorhea State Park is available irregularly from 1920 to the present (Norris et al. 2022, p. 18; U.S. Geological Survey 2024a). A comparison of discharge is presented in Table 5. Discharge has declined steadily over time, including within the last decade. San Solomon Springs has never been documented to cease flowing (U.S. Fish and Wildlife Service 2013, pp. 18–19; Norris et al. 2022, p. 16).

Table 5. Discharge data for USGS gage “San Solomon Spgs at Toyahvale, TX.” This table is adapted from (Norris et al. 2022, p. 18) and presents the minimum, maximum, mean, and median values for stream discharge in cubic feet per second (ft^3/sec) from the USGS gage. The values for the period 2017–2018 reported here follow those reported in the baseline biomonitoring report for the San Solomon springs area (Norris et al. 2022, p. 73). Summary data in the final row are based on data from the USGS webpage for the gage (U.S. Geological Survey 2024a).

Years	Mean ft^3/sec	Median ft^3/sec	Min ft^3/sec	Max ft^3/sec
1920-1936	34.4	34.3	26.5	40.6
1931-1933	40.2	36	30	17
1941-1965	33.6	30.5	26	71
1965-1986	29.9	28.4	17.6	83.2
2001-2016	25.9	25.5	13	46.9
2017–2018	26.5	26.1	20.5	32.7
2017–2024	22.1	21.5	6.94	35.2

Discharge data from Giffin Spring is available from 1931–1933 and from 2002–present (U.S. Geological Survey 2024b). Summary statistics for the discharge data are presented in Table 6, and recorded data are displayed in Figure 2. Discharge has declined at this spring over time, but the rate of change is smaller than for San Solomon Springs. Like San Solomon Springs, Giffin Spring has never been documented to cease flowing (U.S. Fish and Wildlife Service 2013, pp. 18–19; Norris et al. 2022, p. 16).

Table 6. Discharge data for USGS gage “Giffin Spgs at Toyahvale, TX.” This table presents the minimum, maximum, mean, and median values for stream discharge in cubic feet per second (ft^3/sec) from the USGS gage. Summary data are based on data from the USGS webpage for the gage (U.S. Geological Survey 2024b).

Years	Mean ft^3/sec	Median ft^3/sec	Min ft^3/sec	Max ft^3/sec
1931-1933	4.8	4.8	3.6	6.1
2002–2024	4	4	0.74	12.3

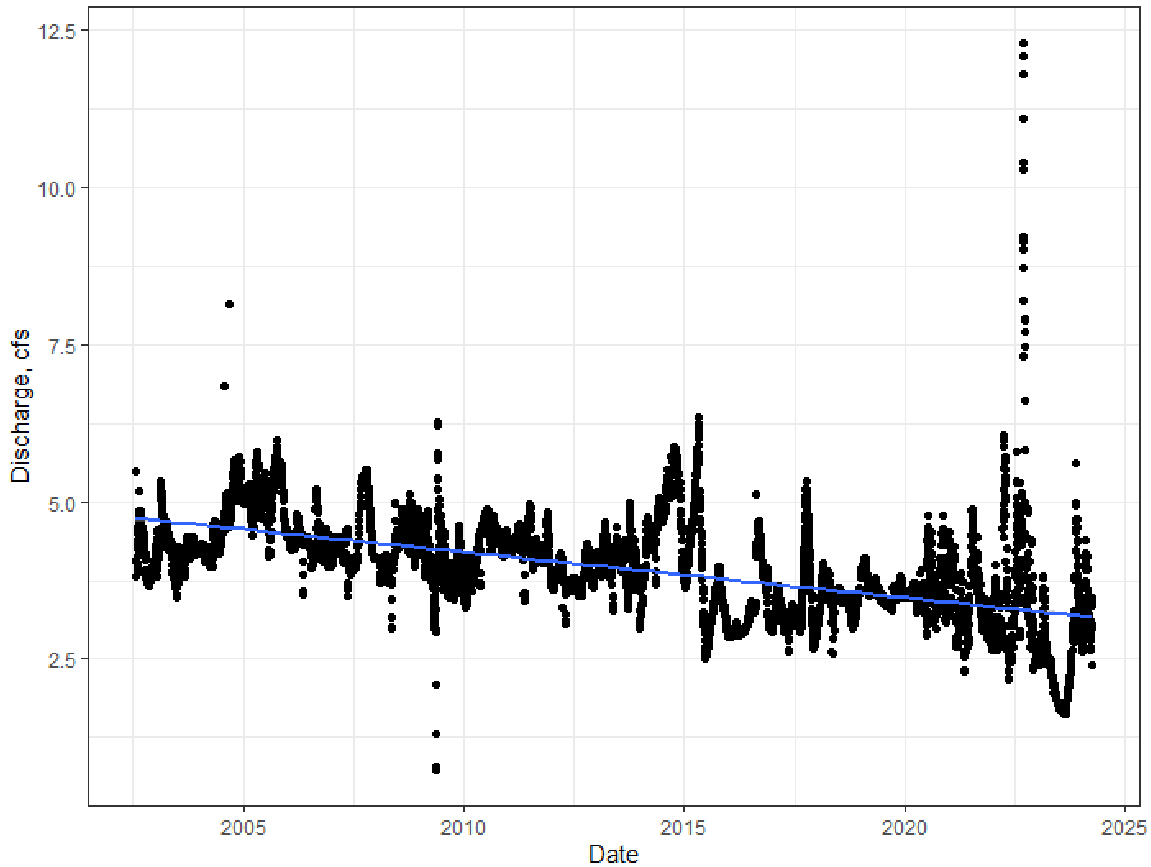

Figure 2. Discharge in cubic feet per second for Giffin Spring. Individual measurements are shown as points. The blue line indicates the average change over time based on a simple linear regression. The data used to create this plot were sourced from the USGS webpage for the gage (U.S. Geological Survey 2024b).

East Sandia Spring has declined since European settlement in the area, but its flows are too low to support a gage and so that data is unavailable (U.S. Fish and Wildlife Service 2013, pp. 18–19; Norris et al. 2022, p. 16). There is no evidence that it has ceased to flow (U.S. Fish and Wildlife Service 2013, pp. 18–19; Norris et al. 2022, p. 16). West Sandia Spring has also declined, and has been observed to cease flowing during drought (U.S. Fish and Wildlife Service 2013, pp. 18–19; Norris et al. 2022, p. 16).

In a 2004 Biological Opinion, Toyah Creek was described as an intermittent tributary (U.S. Fish and Wildlife Service 2004, p. 16). Its intermittency was presumably due to groundwater pumping and decreased stream flows, because in the 1930s it was perennial for four spring-fed miles near Balmorhea (White et al. 1941, p. 86). No improvement in conditions at this location have been reported, indicating that the population at this location continues to be at a high risk of extirpation due to stream drying.

The refugium at the mouth of the cave at Phantom Lake Spring and the Comanche Springs pupfish living in it were lost in the first half of 2022. In November 2021, the Bureau of Reclamation requested Service concurrence on a determination that transferring the land parcel containing the cave and spring to the surrounding landowner would be not likely to adversely affect the Comanche Springs pupfish (Faler 2021, entire). The Austin Ecological Services Field Office issued a concurrence letter in January 2022 (U.S. Fish and Wildlife Service 2022, entire).

The Bureau of Reclamation signed over the property deed on February 18, 2022, and it was officially recorded on March 14, 2022 (Bachus 2024, p. 1). The Bureau of Reclamation notified the landowner that it would be necessary to claim the electric utility account if the pumps were to remain functional, and were told by the landowner that this would take place (Bachus 2024, p. 1). The agency closed their account with the electric company around that time and paid the last bill on April 22, 2022 (Bachus 2024, p. 1).

In early May, a staff member with the Bureau of Reclamation contacted the Texas FWCO to inform them that based on their camera feed, the pumps that maintain the refugium were not functioning (Montagne 2022a, p. 1). We infer that the electricity had been shut off between when the land transfer was finalized and when this notice was received. The Texas FWCO project leader and a Bureau of Reclamation staff member both attempted to contact the landowner and ranch manager (Montagne 2022a, p. 1). In a conversation in late spring 2022, the landowner stated that he had told his ranch manager to turn off the electricity to the pump system (Montagne 2024, p. 1). Based on that information and the history of the site, the Service determined in early June that the refugium dried up by the time that conversation took place (Montagne 2022b, p. 1). This status was confirmed via a site visit in February 2023 (Montagne 2023, pp. 1–2, Figures 3 and 4).

Figure 3. Phantom Lake Spring in February 2018. Photo by U.S. Fish and Wildlife Service staff.

Figure 4. Phantom Lake Spring in February 2023 after the pumps that maintained the water levels in the refugium were turned off. The site has been dewatered and the image reflects the current status quo for the site. Photo by Mike Montagne, U.S. Fish and Wildlife Service.

2.2.1.7 Other:

Climate Change

New climate projections have been developed since the previous five-year review was conducted in 2013. Downscaled climate projections for Reeves County were obtained from the U.S. Climate Resilience Toolkit and are presented in Table 7, Table 8, and Table 9 (U.S. Federal Government 2023). Details about the models and projects are available from the Climate Explorer website (National Oceanic and Atmospheric Administration 2020). Across both RCP 4.5 and RCP 8.5 scenarios, temperatures are projected to increase. Total annual precipitation is not projected to change significantly, but the number of days where no precipitation occurs is projected to increase under RCP 8.5.

Table 7. Future climate projections from the U.S. Climate Toolkit (U.S. Federal Government 2023). Baseline data for the projections is from 2005. Future projections are based on RCP 4.5 and RCP 8.5. The table enumerates the average number of days projected to have high temperatures above 105°F (40.6°C), low temperatures above 80° F (26.7°C), or no precipitation. Fractional days are shown because they are computed averages.

Year	**2005**	**2050**		**2099**	
Data Source	Baseline	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Days with a high temperature > 105°F	7	18.6	25.8	31.3	84.4
Days with a low temperature > 80°F	0.1	1.2	2.9	3.6	33
Days without precipitation	275.5	279.4	310.6	276.6	326.1

Table 8. Future climate projections from the U.S. Climate Toolkit (U.S. Federal Government 2023). Baseline data for the projections is from 2005. Future projections are based on RCP 4.5 and RCP 8.5. The table enumerates the average daily minimum temperature in degrees Fahrenheit (see Table 9 for Celsius conversions), the average daily maximum temperature in degrees Fahrenheit, and the average total annual precipitation in inches (see Table 9 for metric conversions).

Year	**2005**	**2050**		**2099**	
Data Source	Baseline	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Minimum temperature (°F)	50.1	52.4	54.2	54.4	59.4
Maximum temperature (°F)	81.9	84.5	85.5	86	91.5
Annual precipitation (inches)	10.98	11.2	11.65	11.23	10.09

Table 9. Future climate projections from the U.S. Climate Toolkit (U.S. Federal Government 2023). Baseline data for the projections is from 2005. Future projections are based on RCP 4.5 and RCP 8.5. The table enumerates the average daily minimum temperature in degrees Celsius (see Table 8 for Fahrenheit conversions), the average daily maximum temperature in degrees Celsius, and the average total annual precipitation in millimeters (see Table 8 for imperial conversions).

Year	**2005**	**2050**		**2099**	
Data Source	Baseline	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Minimum temperature (°C)	10.1°	11.3°	12.3°	12.4°	15.2°
Maximum temperature (°C)	27.7°	29.2°	29.7°	30.0°	33.1°
Annual precipitation (millimeters)	278.9	284.5	295.9	285.2	256.3

Increased variability in precipitation patterns and the concentration of precipitation events into fewer days is likely to lead to more and longer drought events in the future (Nielsen-Gammon et al. 2021, p. 15). Higher temperatures and increased aridity are likely to result in increased evaporation of lentic habitats (Nielsen-Gammon et al. 2021, p. 17), potentially compromising water quality and/or water quantity within Comanche Springs pupfish surface water habitats, especially if the inflows from springs decline simultaneously. Although groundwater is generally considered less directly pressured by climate change than surface water, groundwater pumping is related to water demand (Nielsen-Gammon et al. 2020, p. 9). Hotter and drier weather could lead to increased groundwater use due to increased water needs by users or due to a shift in water sourcing from surface water to groundwater as surface water supplies become unavailable or unreliable (Nielsen-Gammon et al. 2020, p. 9).

Hydrogeology

A report by the University of Texas at Austin's Bureau of Economic Geology (Nicot et al. 2021, entire) reviewed, synthesized, and updated information on the hydrogeology of all springs in the Balmorhea area. An abbreviated and condensed writeup of these efforts was also published as a peer-reviewed journal article (Nicot et al. 2022, entire). Using a variety of measurement techniques and data sources, the report concludes that the waters that eventually emerge as springs in the Balmorhea area, including San Solomon Springs, originate from the Salt Basin portion of the West Texas Bolsons (Nicot et al. 2021, p. i). The underground flow path follows a fault zone and receives contributions from the Capitan, Rustler, and Edwards Aquifers (Nicot et al. 2021, p. i). The actual Balmorhea-area springs emerge from fractures in the Cretaceous limestones of the Edwards Aquifer (Nicot et al. 2021, p. i). The report includes a map illustrating this important flowpath, reproduced here as the specific details on cross-formational flow and impacts of groundwater pumping remain unresolved, and the authors recommend additional modeling focusing on the Balmorhea-area complex of springs (Nicot et al. 2021, pp. 70–71).

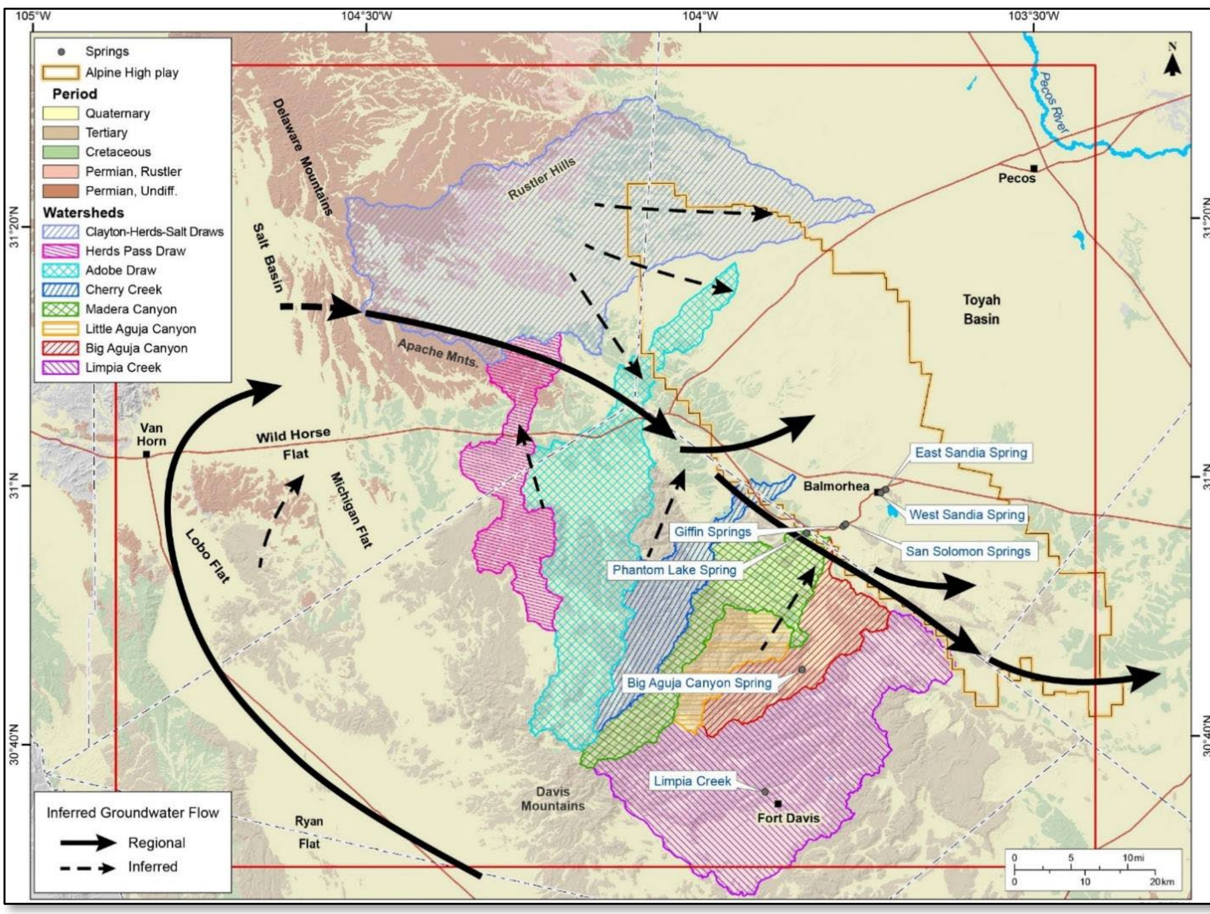

Figure 5. Map of watersheds, geology, and historical, generally agreed-upon groundwater flow systems. Image reproduced, with permission from the author, from Nicot et al. (Nicot et al. 2021, p. 92). Copyright J.P. Nicot.

Groundwater Conservation Districts and Regional Water Planning

The five-year review published in 2013 provided an overview of groundwater conservation districts within the flowpath of the groundwater that ultimately feeds San Solomon Springs and the other springs that historically and currently support Comanche Springs pupfish habitat (U.S. Fish and Wildlife Service 2013, pp. 21–24). At the time, the Culberson County Groundwater Conservation District (GCD), Jeff Davis County Underground Water Conservation District (UWCD), and Presidio County UWCD, existed (U.S. Fish and Wildlife Service 2013, p. 21). The Presidio County UWCD borders the regional flowpath leading to the San Solomon Springs complex but does not have a substantial influence (Nicot et al. 2021, p. 92), so we do not examine it further in this review. The Reeves County GCD was created by the Texas Legislature in 2013 and produced its first management plan in 2018 (Reeves County Groundwater Conservation District 2018, p. 2).

In 2013, the most recent available plans for these districts asserted that there was no need to consider endangered species in the development or execution of the plan because none existed (U.S. Fish and Wildlife Service 2013, p. 23). These assertions were based on the presence of such species within the surface boundary of the Districts, rather than on the question of whether there were endangered species that depend on the water resources within a given District. In fact, groundwater managed by these Districts does influence the spring flow at Comanche Springs pupfish habitat (Nicot et al. 2021, pp. i, 92).

A joint planning process occurred in 2021 under the umbrella of Groundwater Management Areas, which cover the spatial extent of multiple GCDs and UWCDs. The Districts for which changes in groundwater flows may impact Comanche Springs pupfish habitat include those above and are associated with two Groundwater Management Areas (3 and 4). Through the joint planning process, the Districts agreed to desired future conditions resulting in drawdowns for aquifers that contribute to springs within the Comanche Springs pupfish range (Groundwater Management Area 3 2021, pp. 1–2; Groundwater Management Area 4 2021, p. 1; see Table 8).

Table 10. Groundwater conservation district desired future conditions for managed aquifers.

District Name	Aquifer	Desired Future Condition: Drawdown meters (feet)
Culberson County GCD	Capitan Reef Complex	15 (50)
	Salt Basin portion of the West Texas Bolsons	24 (78)
	Igneous	20 (66)
Jeff Davis County UWCD	Igneous	6 (20)
	Salt Basin portion of the West Texas Bolsons	22 (72)
Reeves County GCD	Dockum	6 (20)
	Edwards-Trinity (Plateau) and Pecos Valley	2 (8)
	Rustler	12 (40)

The most recent management plans for the Culberson County GCD and Jeff Davis County UWCD continue to assert that no endangered species will be affected by the plan or their execution (Jeff Davis County Underground Water Conservation District 2018, p. 8; Culberson County Groundwater Conservation District 2021, p. 12). The 2023 plan for the Reeves County GCD and 2020 plan for the Middle Pecos GCD omit any discussion of fish or wildlife that may be dependent on the aquifer (Middle Pecos Groundwater Water Conservation District 2020, entire; Reeves County Groundwater Conservation District 2023, entire).We infer from this that the UWCDs and GCDs are not managing groundwater to ensure the persistence of springs in the Balmorhea Complex.

Planning for future water needs in Texas is guided by projections developed by 16 regional water planning groups (Freese and Nichols, Inc. 2020a, p. 1-1). The Texas Water Development Board generated water demand projections for the water planning groups covering the period 2020 to 2070, which were used to develop the 2020 Regional Water Plans (Freese and Nichols, Inc. 2020a, p. 2-1) Two water planning regions span the regional flow path that contributes groundwater to the San Solomon Spring System (Nicot et al. 2021, p. 92):

Region E (Far West Texas) and Region F (Freese and Nichols, Inc. 2020a, p. 1-2; Far West Texas Water Planning Group 2021, p. 1-1).

Groundwater is the dominant water source for west Texas (Freese and Nichols, Inc. 2020a, p.3-1; Far West Texas Water Planning Group 2021, p. 3-22). The primary groundwater use is irrigation; 87% of groundwater supplies in Culberson County, 49% in Jeff Davis County, and 90% in Reeves County are used for irrigation (Freese and Nichols, Inc. 2020b, p. 356; Far West Texas Water Planning Group 2021, pp. 3-4–3-6). Total demand for groundwater for irrigation, as well as all other uses, is projected to remain relatively stable in Culberson and Jeff Davis Counties through the planning horizon of 2070 (Far West Texas Water Planning Group 2021, pp. 2-7–2-8). However, water demand in Pecos and Reeves Counties, which is already significantly higher than Culberson and Jeff Davis Counties, is projected to increase substantially compared to 2010 levels (Freese and Nichols, Inc. 2020a, p. 2-8). This is due both to increases in demand for water for irrigation and in demand for water for "mining" (i.e. hydraulic fracturing) (Freese and Nichols, Inc. 2020a, p. 2-8). Water demand for oil and gas production in the shale oil plays in Reeves County is projected to increase through 2040 and then decline (Freese and Nichols, Inc. 2020a, p. 2-19). In Reeves County, the planning process identified a deficit between existing water supplies and projected demand for the town of Balmorhea and the mining industry throughout the planning horizon (Freese and Nichols, Inc. 2020b, p. 5E-54). Given the paucity of surface water supplies available in the area, groundwater development to address these shortages is likely to occur (Freese and Nichols, Inc. 2020b, p. 5E-59).

Both plans recognize drought as a persistent challenge to meeting future water needs but leave the specifics of drought planning to step-down plans (Freese and Nichols, Inc. 2020a, pp. 7-1–7-20; Far West Texas Water Planning Group 2021, pp. 7-1–7-38). However, Region E and F Water Planning Groups do not discuss or analyze the effects of climate change on groundwater supplies or demand. To address future water demand, Culberson County may develop groundwater from the West Texas Bolsons Aquifer, (Far West Texas Water Planning Group 2021, p. 5A-6), Jeff Davis County may develop groundwater from the Igneous Aquifer (Far West Texas Water Planning Group 2021, p. 5A-43), and Reeves County may develop groundwater from the Pecos Valley Aquifer (Freese and Nichols, Inc. 2020b, p. 411). Increased use of groundwater into the future would have the potential of reducing groundwater flow to the Solomon Spring System.

2.2.1.8 Conservation Measures:

Balmorhea State Park

The most important and largest remaining extant habitat for Comanche Springs pupfish occurs within Balmorhea State Park, consisting of the pool, outflow canal, San Solomon Ciénega, and Clark Hubbs Ciénega. Management of all of these habitats, given the presence of listed species, is regulated by a Habitat Conservation Plan (HCP) for Balmorhea State Park and its associated Incidental Take Permit (ITP) (Texas Parks and Wildlife Department 2009, entire; 2020, entire; U.S. Fish and Wildlife Service 2009b, entire; 2020b, entire).

At the time of the previous five-year review, an HCP and ITP were in place and presumed to be functioning well in the absence of any information that suggests otherwise. The ITP issued in 2009 was valid for a period of 10 years (U.S. Fish and Wildlife Service 2009b, entire). TPWD requested a renewal of the permit after the regulatory deadline for renewals had passed; as a result, the initial permit expired in 2019 (U.S. Fish and Wildlife Service 2020a, p. 1). TPWD updated the HCP and a new ITP was issued in 2020 and will be valid for 10 years (U.S. Fish and Wildlife Service 2020b, p. 1). TPWD is in compliance with the current ITP conditions, including submission of annual reports. A range of activities are completed at the Park, including repairs and maintenance to the pool and to the recreational facilities, with no adverse effects to Comanche Springs pupfish observed (Texas Parks and Wildlife Department 2021b, entire; 2022, entire; 2023, entire; 2024a, entire).

Phantom Lake Spring Refugium

A habitat restoration effort was planned by the Service's Texas Fish and Wildlife Conservation Office for 2021 with the intent of improving aquatic habitat relied on by the Comanche Springs pupfish and other listed species (U.S. Fish and Wildlife Service 2021, entire). A goal of the restoration was to reduce the site's reliance on a pump system to maintain adequate water levels within the refugium (U.S. Fish and Wildlife Service 2021, p. 3). The habitat restoration project would have deepened the entrance to the cave at Phantom Lake Spring to better connect spring outflow with adjacent aquatic habitat and created a more natural and secure state (U.S. Fish and Wildlife Service 2021, p. 3). However, the restoration did not prove feasible because excavation work encountered bedrock, which meant that the ciénega and cave pool could not be connected as intended (U.S. Fish and Wildlife Service 2022, p. 2). The site was restored to pre-construction conditions, which meant that the surface aquatic habitat of the refugium continued to be dependent on mechanically pumped water (U.S. Fish and Wildlife Service 2022, p. 2). As discussed above, the pumps were reported off in May 2022 and are apparently no longer maintained by the private landowner (Montagne 2022a, p. 1; 2023, pp. 1–2). A visit in February 2023 confirmed that surface aquatic habitat has been dewatered (Montagne 2023, pp. 1–2) (Figure 2). As a result, habitat for Comanche Springs pupfish at Phantom Lake Spring has been eliminated.

Other Area Springs

East and West Sandia Springs are still owned and managed by The Nature Conservancy. TPWD continues to own and manage San Solomon Spring. Ownership by those entities provides protection to spring outflow channels and the surrounding surface habitat. However, ownership does not provide groundwater protections needed to ensure adequate and ongoing spring flow quantity and quality. Both Giffin and Phantom Lake Springs are in private ownership with no documented conservation planning to protect listed species or their habitat.

Captive Populations

Comanche Springs pupfish are kept in refugium at SNNARC and at Uvalde NFH. The original refuge population was founded in 1990 with 73 individuals from Phantom Lake Spring (Dexter National Fish Hatchery and Technology Center 2002, p. 3). The refuge population at SNARRC was founded in 2003 with 400 individuals from the Uvalde NFH population (Dexter National Fish Hatchery and Technology Center 2002, p. 3). In 2010, 28 wild Comanche Springs pupfish from the Phantom Lake Spring population were removed from the wild and brought to SNARRC (Dexter National Fish Hatchery and Technology Center 2002, p. 3).

Both facilities use cinder blocks placed throughout the refuge pond(s) to serve as territories and enhance mating and reproduction (Southwest Native Aquatic Resources Recovery Center 2024, pp. 1–2; Uvalde National Fish Hatchery 2024, p. 2). At SNARRC, approximately every two years, Comanche Springs pupfish are moved to a “fresh” pond that has been drained, disced, cleaned, releveled, and refilled (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). At Uvalde NFH, Comanche Springs pupfish stay in the same pond, which is not regularly drained and refilled (Uvalde National Fish Hatchery 2024, p. 2).

At SNARRC, as a hedge against the outdoor pond freezing or experiencing extremely low temperatures, about 1,000–2,000 individuals are trapped in the fall with minnow traps and brought inside the facility to a temperature-controlled environment (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). In the spring, these fish are returned to the outdoor pond (Southwest Native Aquatic Resources Recovery Center 2024, p. 1). Low temperatures are not a significant concern at Uvalde NFH so this process does not occur (Uvalde National Fish Hatchery 2024, p. 1). However, about 200 individuals are kept inside year-round for educational purposes and are available to permitted researchers as needed (Uvalde National Fish Hatchery 2024, p. 1). Every year, 60 individuals from SNARRC and 15-30 individuals from Uvalde NFH are sacrificed for the purpose of monitoring fish health (Southwest Native Aquatic Resources Recovery Center 2024, p. 2; Uvalde National Fish Hatchery 2024, p. 2).

Survey Methodology

Two studies investigating survey methodology were completed in 2019. Acre et al. (2020, p. 199) evaluated the effectiveness of minnow traps compared to visual counts for providing data to input into abundance models. The researchers found that visual counts following a structured protocol can produce density estimates that can evaluate population change over time (Acre et al. 2020, p. 207). In addition, the results suggest that in the future, underwater video cameras could be used to complete the visual counts, which would allow for consistency in monitoring over time (Acre et al. 2020, p. 207). Additional benefits of this approach include the minimization of disturbance to individual Comanche Springs pupfish, the elimination of the confounding variable of human presence in the sampled system, and the virtual avoidance of any "take" associated with monitoring the species in the future (Acre et al. 2020, p. 207).

Mollenhauer et al. (2024, entire) completed a systematic assessment of the utility of underwater video ("camera trapping") to estimate occurrence and abundance (Mollenhauer et al. 2024, pp. 6–8). Underwater video is a newer and promising methodology that is relatively inexpensive, minimally invasive and impactful to the focal species, and creates a permanent record of the survey (Mollenhauer et al. 2024, p. 6). In general, the methodology succeeded in detecting Comanche Springs pupfish when they were present, and predicting presence when they were not detected, using one 20-minute video, but more research would be needed to implement a monitoring protocol that relies primarily on underwater video (Mollenhauer et al. 2024, pp. 20–23). An additional finding from the research is that Comanche Springs pupfish are present throughout all of the habitats they can access within Balmorhea State Park, which underscores the importance of maintaining connectivity between the pool and ciénegas (Mollenhauer et al. 2024, p. 23).

2.2.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

2.2.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat loss due to declining spring flow and reduced surface water habitat was identified as a major threat to Comanche Springs pupfish in the 1981 Recovery Plan (U.S. Fish and Wildlife Service 1981, p. 4). The five-year status review completed in 2013 also discusses how reductions in aquifer recharge and groundwater pumping that exceeds recharge can lead to diminished spring flows and the loss of Comanche Springs pupfish habitat (U.S. Fish and Wildlife Service 2013, pp. 18–20). The confirmed loss of the Phantom Lake Spring and Saratoga Spring populations are associated with declining spring flows in the region that have resulted in the drying of the surface water habitat necessary for Comanche Springs pupfish to persist.

Comanche Springs pupfish remain extant at the pools associated with San Solomon Springs, East Sandia Springs, West Sandia Spring, and Giffin Spring, and are potentially extant in Toyah Creek (Section 2.2.1.5). However, spring flow at each of these locations is declining with no indication that this decline will slow or stop, much less reverse and produce an increase in spring flow (Section 2.2.1.6). Increasing temperatures and aridity will continue due to climate change and will almost certainly lead to increased demand for groundwater in the region that influences spring flow in the Comanche Springs pupfish range (Section 2.2.1.7). If declines in spring flows are not abated before the aquifer is so drawn down that San Solomon Springs cease to flow, the surface habitat the remaining populations depend on will cease to exist. The populations at Toyah Creek, West Sandia Spring, and Giffin Spring are the most vulnerable to extirpation, given the current low spring flows supporting these localities.

Consequently, the risk of population extirpation and eventual extinction of the species has increased since the last five-year status review. The risk is less from a potential catastrophic event that damages habitat, and more from the slow but monotonic decline in spring flow. The loss of habitat resulting in the loss of wild populations is the most important threat to the species at this time.

2.2.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

There is no evidence at this time that the Comanche Springs pupfish is threatened by overutilization. The only collections of the fish occur rarely for scientific purposes and are regulated by the Service pursuant to section 10(a)(1)(A) of the Act and TPWD (Title 31, Part 2, Chapter 69, subchapter J).

2.2.2.3 Disease or predation:

The previous five-year status review, completed in 2013, cited the introduced Red-rimmed melania (*Melanoides tuberculatus*) snail and its associated gill parasite (Ce*ntrocestus formosanus*) as potential threats to the species (U.S. Fish and Wildlife Service 2013, pp. 20–21), but no new information has been collected on these species or their impacts to Comanche Springs pupfish. Comanche Springs pupfish continue to occur in the San Solomon Spring system where these introduced species were previously found, but the relative impact on Comanche Springs pupfish populations in this area is unknown.

2.2.2.4 Inadequacy of existing regulatory mechanisms:

The inadequacy of existing regulatory mechanisms to ensure continued spring flows for the springs that are the source of Comanche Springs pupfish surface water habitat represents an ongoing threat to the species in the wild. Groundwater management in Texas is regulated via Groundwater Conservation Districts (sometimes called Underground Water Conservation Districts), but the Districts that regulate the groundwater in the flowpaths to and including the Balmorhea-area springs do not consider maintenance of spring flows as a goal or desired future condition for those groundwater resources (Section 2.2.1.7). They do not currently serve as a regulatory mechanism that protects Comanche Springs pupfish or its habitat.

The refugium at Phantom Lake Spring was dewatered after the land parcel that includes the spring and refugium was transferred from the Bureau of Reclamation to a private landowner (Section 2.2.1.6). An informal consultation determined that the transfer was not likely to adversely affect listed species or critical habitat, despite the fact that there was no plan, agreement, or funding in place to ensure the continued maintenance of the refugium after the transfer was complete (U.S. Fish and Wildlife Service 2022, p. 1). Therefore, the protections of the Endangered Species Act were not adequate to ensure the habitat supporting the Phantom Lake Spring population persisted. There is no regulatory mechanism that exists that could compel the restoration of this habitat and the reintroduction of any of the listed species that previously existed there, further illustrating the inadequacy of existing regulatory mechanisms.

The inadequacy of existing regulatory mechanisms resulted in new impacts to the species since the previous five-year review was completed, but there have not been any substantive changes in the regulatory environment itself that change the outlook for the species in terms of its risk of extinction.

2.2.2.5 Other natural or manmade factors affecting its continued existence:

Competition and hybridization with the introduced sheepshead minnow (*C. variegatus*) was identified as a threat to Comanche Springs pupfish in the previous five-year review and in the species' recovery plan (U.S. Fish and Wildlife Service 1981, pp. 4–6; 2013, pp. 24–25). The threat of hybridization is limited by the fact that both sexual isolation and intrinsic hybrid sterility/unviability are present, making it unlikely that Comanche Springs pupfish would rapidly hybridize with sheepshead minnow even if the latter were introduced into areas occupied by Comanche Springs pupfish (Tech 2006, pp. 1835–1836). Hybridization would still occur, but more slowly than that which took place between Pecos pupfish (*C. pecosensis*) and sheepshead minnow (Echelle and Connor 1989, pp. 725–726).

Given this, we suggest that competition with sheepshead minnow would impact Comanche Springs pupfish before hybridization would. The two species occupy similar trophic niches, and Comanche Springs pupfish would likely have a competitive advantage only near spring outflows. Few spring outflows remain, and it is very possible that sheepshead minnow would outcompete Comanche Springs pupfish within the ciénega habitats at Balmorhea State Park, where the largest Comanche Springs pupfish populations occur (U.S. Fish and Wildlife Service 1981, p. 5). We know that sheepshead minnow outcompetes Comanche Springs pupfish at Lake Balmorhea, that generalist species like western mosquitofish (*G. affinis*) outcompetes the spring-adapted specialists Pecos gambusia, Big Bend gambusia (*G. gaigei*), and Clear Creek gambusia (*G. heterochir*) where they co-occur away from spring outlets (Hubbs 1971, pp. 41–42; Bednarz 1979, pp. 319–321; Hubbs and Williams 1979, pp. 631–635; Echelle and Echelle 1980, p. 46; U.S. Fish and Wildlife Service 1981, p. 5). Currently, there are barriers to the migration of sheepshead minnow migrating into currently occupied Comanche Springs pupfish habitats. However, because these barriers are incomplete, contamination of Comanche Springs pupfish by sheepshead minnow via the canal system remains a threat. The scope and severity of this threat is essentially the same as when the previous five-year review was completed in 2013.

2.3 Synthesis

The best available scientific information indicates that the primary threats to the Comanche Springs pupfish are: 1) habitat loss from the loss of spring flow due to a decline in groundwater levels, and 2) hybridization or competition with sheepshead minnow due to further introductions into Comanche Springs pupfish populations. The threat of habitat loss is the more immediate and pressing of the two.

The total number of populations of Comanche Springs pupfish continues to decline, reducing its redundancy. Although the flow at San Solomon Springs continues to be substantial, it is declining. The pool and ciénegas in the park support a large number of Comanche Springs pupfish, but could all suffer from a single catastrophic event, limiting their resiliency. The other springs supporting Comanche Springs pupfish are declining and the pools they supply are shallow and at a greater risk of drying than the habitats within Balmorhea State Park. The loss of the unique genetic line with the drying of the Phantom Lake Spring refugium is partially ameliorated by the fact that this lineage still exists within the captive populations at SNARRC and Uvalde NFH. However, at this time there is not a prospective location to reintroduce this lineage into the wild. Sheepshead minnow are not present where Comanche Springs pupfish are present currently, but the barriers to their movement are not complete, such that the introduction of sheepshead minnow in the future remains a real risk to Comanche Springs pupfish, one that could be difficult or impossible to address if it occurs.

Important conservation work has been conducted in order to advance recovery of Comanche Springs pupfish. The Texas FWCO and TPWD have engaged in major efforts to restore and enhance Comanche Springs pupfish habitat, and The Nature Conservancy has protected important remaining habitats within the species' range. Two Service facilities, SNARRC and Uvalde NFH, maintain captive populations. However, the threats to the species discussed above continue to exert pressure on Comanche Springs pupfish in every place it occurs, despite ongoing recovery efforts. Overall, the viability of Comanche Springs pupfish has declined since the previous five-year review, and its primary threats have increased. Consequently, the species continues to be in danger of extinction, and we recommend that it remain classified as Endangered.

3.0 RESULTS

3.1 Recommended Classification:

No change is needed

3.2 New Recovery Priority Number (indicate if no change; see 48 FR 43098):

11C

Brief Rationale:

The primary threat to the species is habitat loss, the primary mechanism for the loss of habitat is declining spring flow, and the primary cause of declining spring flow is the extraction of groundwater for use in economic activities. In addition, the largest populations of Comanche Springs pupfish occur on the grounds of Balmorhea State Park, which is extremely popular as a recreational destination. Therefore, there is significant competition for the use of the spring flows that provide Comanche Springs pupfish habitat, and it is appropriate to acknowledge this with the use of the conflict code C.

3.3 Listing and Reclassification Priority Number, if reclassification is recommended (see 48 FR 43098):

Reclassification (from Threatened to Endangered) Priority Number: Not applicable
Reclassification (from Endangered to Threatened) Priority Number: Not applicable
Delisting (Removal from list regardless of current classification) Priority Number: Not applicable

Brief Rationale: Reclassification is not recommended.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The Comanche Springs pupfish recovery plan was last updated in 1981, and its associated recovery team last met in 2010. We recommend revising the recovery plan, if possible given workload constraints, and developing or enhancing relationships with appropriate partners, including governmental agencies and stakeholders, in order to carry out actions that will prevent the extinction of the species and promote its recovery. This will be a multi-year process. In the meantime, we recommend individual actions to be taken in coordination with Balmorhea State Park, The Nature Conservancy, TPWD, and other partners.

Several currently occurring actions should continue. They include the Park’s ongoing management of the Balmorhea Pool, San Solomon Ciénega, and Clark Hubbs Ciénega, as well as the canals connecting them, as delineated within the Park’s Habitat Conservation Plan. SNARRC and Uvalde NFH should continue to manage their Comanche Springs pupfish populations and monitor them for fish health and genetic concerns. These recommendations align with actions 1.2, 1.4, 1.5, 2.1, and 2.2 from the 1981 recovery plan.

In addition to the ongoing actions, we also recommend revitalizing or initiating other actions to support the Comanche Springs pupfish and potentially recover the species to the point where it could be downlisted to Threatened, including but not limited to those listed below.

1) Reestablish regular and standardized monitoring of Comanche Springs pupfish populations. Determine the frequency and type of monitoring of the species and its habitat needed to identify the presence of an imminent extinction risk. Identify entities who can reliably conduct monitoring over the long-term. Develop a written protocol guiding future monitoring. These recommendations align with actions 1.1, 1.2, and 1.3 from the 1981 recovery plan.
2) Restore and enhance Comanche Springs pupfish habitat. Evaluate the possibility of restoring the Phantom Lake Spring refugium. Evaluate options for increasing the reliability of barriers between the Park and the irrigation canals, and anywhere else that sheepshead minnow could access habitats where they are currently not present. These recommendations align with actions 1.1, 1.2, 1.4, and 1.5 from the 1981 recovery plan.
3) Collaborate internally to maintain and advance captive stock management (currently at SNARRC and Uvalde NFH). Develop management plans that include target population abundance, clearly identify the purpose of the captive populations, and include specific genetic management recommendations, such as the type of analyses to conduct and at what interval. These plans should also identify a process for exchanging fish between the two facilities and for supplementing wild stocks. These recommendations align with action 2.0 from the 1981 recovery plan.
4) Develop a catastrophic response plan for the Park populations of Comanche Springs pupfish that addresses both contamination and drying events. This recommendation aligns with action 1.5 from the 1981 recovery plan.
5) Evaluate the potential for eDNA monitoring of Comanche Springs pupfish habitat for Comanche Springs pupfish, sheepshead minnow, and other species of interest. This recommendation aligns with actions 1.1 and 1.2 from the 1981 recovery plan.
6) Conduct genetic assessments of Comanche Springs pupfish populations from all extant wild locations and the SNARRC and Uvalde NFH captive ponds using techniques targeted to understand genetic variability among and within highly inbred populations. This recommendation aligns with actions 1.1 and 2.0 from the 1981 recovery plan.
7) Develop a genetic management plan for the species as a whole, inclusive of both wild and captive populations. The plan should include a consideration of biobanking options. This recommendation aligns with actions 1.54 and 2.0 from the 1981 recovery plan.
8) Conduct experiments and monitoring to understand what management actions would maximize Comanche Springs pupfish abundance, in both the wild and in captivity. This recommendation aligns with actions 1.1, 1.2, 2.1, and 2.2 from the 1981 recovery plan.

9) Complete hydrogeological studies to better understand groundwater/surface water interactions. For example, improve understanding of where groundwater development within the flowpath supplying the Balmorhea-area springs would be likely to deplete flows at those springs and where such development would be unlikely to affect spring flow. This recommendation aligns with action 1.53 from the 1981 recovery plan.
10) Continue, refine, or update the predictive modeling effort by Hargrave (2017, entire). This recommendation aligns with actions 1.1 and 1.2 from the 1981 recovery plan.
11) Continue research into the viability of underwater video for monitoring Comanche Springs pupfish populations across the range of the species. This recommendation aligns with action 1.1 from the 1981 recovery plan.
12) Evaluate options for establishing barriers to preclude the movement of sheepshead minnow into Comanche Springs pupfish populations and implement strategies likely to be effective. This recommendation aligns with action 1.5 from the 1981 recovery plan.

5.0 REFERENCES

Acre, Matthew R., Joshuah S. Perkin, and Megan G. Bean. 2020. "Multiple Survey Methods Reveal Greater Abundance of Endangered Pupfish in Restored Habitats." *Aquatic Conservation: Marine and Freshwater Ecosystems* 31 (1): 198–209. https://doi.org/10.1002/aqc.3491.

Bachus, Jennifer. 2024. "Email: 'Phantom Spring Land Transfer Documents.'" Bureau of Reclamation.

Bednarz, James C. 1979. "Ecology and Status of the Pecos Gambusia, Gambusia Nobilis (Poeciliidae), in New Mexico." *The Southwestern Naturalist* 24: 311–322.

Culberson County Groundwater Conservation District. 2021. "Culberson County Groundwater Conservation District Management Plan." Culberson County Groundwater Conservation District.

Dexter National Fish Hatchery and Technology Center. 2002. "Comanche Springs Pupfish (*Cyprinodon elegans*): A Genetic Reserve Population and Stock Management Process." Dexter, New Mexico: U.S. Fish and Wildlife Service.

Echelle, Anthony A., and Patrick J. Connor. 1989. "Rapid, Geographically Extensive Genetic Introgression After Secondary Contact Between Two Pupfish Species (*Cyprinodon*, Cyprinodontidae)." *Evolution* 43 (4): 717–727. https://doi.org/10.1111/j.1558-5646.1989.tb05171.x.

Echelle, Anthony A., and Alice F. Echelle. 1980. "Status of the Pecos Gambusia (*Gambusia nobilis*)." Albuquerque, NM: U.S. Fish and Wildlife Service.

Faler, Jennifer. 2021. "Memo: 'Disposal of Phantom Lake Spring Property, Balmorhea Project.'" Bureau of Reclamation.

Far West Texas Water Planning Group. 2021. "Far West Texas Water Plan." Texas: Region E Water Planning Group.

Freese and Nichols, Inc. 2020a. "2021 Region F Water Plan: Final Plan." Volume 1. Texas: Region F Water Planning Group.

———. 2020b. “2021 Region F Water Plan: Final Plan.” Volume 2. Texas: Region F Water Planning Group.

Garrett, G.P., and A.H. Price. 1993. “Comanche Springs Pupfish (*Cyprinodon elegans*) Status Survey.” Texas Parks and Wildlife Department.

Groundwater Management Area 3. 2021. “Summary of Desired Future Conditions for GMA 3.” Austin, Texas: Texas Water Development Board.

Groundwater Management Area 4. 2021. “Summary of Desired Future Conditions for GMA 4.” Austin, Texas: Texas Water Development Board.

Hargrave, Chad. 2013. “Conservation Status of Comanche Springs Pupfish (*Cyprinodon elegans*) and Pecos Gambusia (*Gambusia nobilis*) in the Ciénegas of Balmorhea State Park, Texas.” Final Report for Grant No. TX E-118-R. Austin, Texas: Texas Parks and Wildlife Department.

———. 2017. “Developing a Predictive Habitat Model for the Comanche Springs Pupfish (*Cyprinodon elegans*) to Be Used in Species Recovery.” Final Report for Grant No. TX E-159-R. Austin, Texas: Texas Parks and Wildlife Department.

Hubbs, Clark. 1971. “Competition and Isolation Mechanisms in the *Gambusia affinis X G. heterochir* Hybrid Swarm.” *Bulletin of the Texas Memorial Museum* 19: 47.

Hubbs, Clark, and John G. Williams. 1979. “A Review of Circumstances Affecting the Abundance of *Gambusia gaigei*, an Endangered Fish Endemic to Big Bend National Park.” In *Proceedings of the First Conference on Scientific Research in the National Parks*, edited by Robert M. Linn. Vol. 1. New Orleans, Louisiana. Accessed from http://npshistory.com/series/symposia.htm.

Jeff Davis County Underground Water Conservation District. 2018. “Jeff Davis County Underground Water Conservation District Management Plan 2018-2023.” Jeff Davis County Underground Water Conservation District.

Lutz-Carrillo, Dijar. 2018. “West Texas Project – *C. elegans* Genetics Study Summary Report.” Austin, Texas: Texas Parks and Wildlife Department.

Maunder, Mark N., and André E. Punt. 2004. “Standardizing Catch and Effort Data: A Review of Recent Approaches.” *Fisheries Research* 70 (2–3): 141–159. https://doi.org/10.1016/j.fishres.2004.08.002.

Middle Pecos Groundwater Water Conservation District. 2020. “Middle Pecos Groundwater Conservation District Management Plan.” Middle Pecos Groundwater Conservation District.

Mollenhauer, Robert, Megan G. Bean, Dominik Chilleri, and Preston T. Bean. 2024. “Applications of Underwater Video for Imperiled Fish Species Population Monitoring [Manuscript].” *Journal of Fish and Wildlife Management* 15 (1): xx–xx. https://doi.org/10.3996/JFWM-23-036.

Montagne, Mike. 2022a. “Email: ‘Phantom.’” U.S. Fish and Wildlife Service.

———. 2022b. “Email: ‘Followups on Pecos Pupfish and Phantom Spring.’” U.S. Fish and Wildlife Service.

———. 2023. “Trip Report - Rillito Spring, Salt Creek, Phantom Cave Spring, Balmorhea State Park.” San Marcos, Texas: Texas Fish and Wildlife Conservation Office.

———. 2024. "Email: 'Followups on Pecos Pupfish and Phantom Spring.'" U.S. Fish and Wildlife Service.

National Oceanic and Atmospheric Administration. 2020. "About The U.S. Climate Resilience Toolkit Climate Explorer (Version 3.1)." The Climate Explorer. 2020. Accessed from https://crt-climate-explorer.nemac.org/about.php.

Nicot, Jean-Philippe, Rebecca C Smyth, Roxana Darvari, Tara Bongiovanni, Jon Paul Pierre, S Tyson McKinney, Brad D Wolaver, and Patrick J Mickler. 2021. "Revisiting Hydrogeology of a West Texas Desert Spring Cluster: A Data-Rich Geochemical and Physical Study of the Trans-Pecos Balmorhea-Area Springs." Austin, Texas: University of Texas at Austin, Bureau of Economic Geology.

Nicot, Jean-Philippe, Rebecca C. Smyth, Roxana Darvari, and S. Tyson McKinney. 2022. "New Hydrogeochemical Insights on a West Texas Desert Spring Cluster: Trans-Pecos Balmorhea-Area Springs." *Applied Geochemistry* 142 (July): 105331. https://doi.org/10.1016/j.apgeochem.2022.105331.

Nielsen-Gammon, John, Sara Holman, Austin Buley, Savannah Jorgensen, Jacob Escobedo, Catherine Ott, Jeramy Dedrick, and Ali Van Fleet. 2021. "Assessment of Historic and Future Trends of Extreme Weather in Texas, 1900-2036: 2021 Update." Document OSC-202101. College Station, Texas: Office of the State Climatologist, Texas A&M University.

Nielsen-Gammon, John W., Jay L. Banner, Benjamin I. Cook, Darrel M. Tremaine, Corinne I. Wong, Robert E. Mace, Huilin Gao, et al. 2020. "Unprecedented Drought Challenges for Texas Water Resources in a Changing Climate: What Do Researchers and Stakeholders Need to Know?" *Earth's Future* 8 (8): e2020EF001552. https://doi.org/10.1029/2020EF001552.

Norris, Chad, Marty Kelly, Weston Nowlin, Megan G. Bean, Nina Noreika, Dijar Lutz-Carillo, Peter H. Diaz, and Randy Gibson. 2022. "Baseline Biomonitoring of Springs Associated with the San Solomon Springs System." Texas Parks and Wildlife Department.

O'Neil, Marty, Kevin Pasternak, James Rudnicki, Stefan K. Schuster, and Jennifer Wilson. 1995. "Hydrologic Investigation in the Toyah Basin near Balmorhea, Texas." Austin, Texas: University of Texas at Austin. Accessed from https://tpwd.texas.gov/business/grants/wildlife/section-6/docs/habitats/e1_j58_final_report.pdf.

Portnoy, David, and Kevin Conway. 2023. "Funding Proposal: Conservation Genomics of the Comanche Springs Pupfish (*Cyprinodon elegans*)." Texas Parks and Wildlife Department.

Reeves County Groundwater Conservation District. 2018. "Reeves County Groundwater Conservation District Management Plan." Reeves County Groundwater Conservation District.

———. 2023. "Reeves County Groundwater Conservation District Management Plan." Reeves County Groundwater Conservation District.

Southwest Native Aquatic Resources Recovery Center. 2024. "SNARRC Responses to Comanche Springs Pupfish Refugia Questions." U.S. Fish and Wildlife Service.

Tech, C. 2006. "Postzygotic Incompatibilities between the Pupfishes, *Cyprinodon elegans* and Cyprinodon Variegates: Hybrid Male Sterility and Sex Ratio Bias." *Journal of Evolutionary Biology* 19 (6): 1830–1837.

Texas Fish and Wildlife Conservation Office. 2012. "Phantom Springs Cienega Restoration Project." San Marcos, Texas: U.S. Fish and Wildlife Service.

Texas Parks and Wildlife Department. 2009. "Habitat Conservation Plan for Balmorhea State Park." Austin, Texas: Texas Parks and Wildlife Department.

———. 2018. "San Solomon Springs Biomonitoring Plan." Austin, Texas: Texas Parks and Wildlife Department.

———. 2020. "Habitat Conservation Plan for Balmorhea State Park." Austin, Texas: Texas Parks and Wildlife Department.

———. 2021a. "Texas Parks & Wildlife 2021 Annual Report." Section 10 Recovery Permit Report for Permit Number TE814933. Austin, Texas: Texas Parks and Wildlife Department.

———. 2021b. "Balmorhea State Park HCP Annual Report for Calendar Year 2020." Alpine, Texas: Texas Parks and Wildlife Department.

———. 2022. "Balmorhea State Park HCP Annual Report for Calendar Year 2021." Alpine, Texas: Texas Parks and Wildlife Department.

———. 2023. "Balmorhea State Park HCP Annual Report for Calendar Year 2022." Alpine, Texas: Texas Parks and Wildlife Department.

———. 2024a. "Balmorhea State Park HCP Annual Report for Calendar Year 2023." Alpine, Texas: Texas Parks and Wildlife Department.

———. 2024b. "Texas Parks & Wildlife 2023 Annual Report." Section 10 Recovery Permit Report for Permit Number TE814933. Austin, Texas: Texas Parks and Wildlife Department.

U.S. Federal Government. 2023. "U.S. Climate Resilience Toolkit Climate Explorer." National Oceanic and Atmospheric Administration. Accessed from https://crt-climate-explorer.nemac.org/.

U.S. Fish and Wildlife Service. 1981. "Comanche Springs Pupfish Recovery Plan." Albuquerque, New Mexico: U.S. Fish and Wildlife Service.

———. 2004. "Biological Opinion on USDA Assistance Programs on Lands Owned and Managed by the Members of the Reeves County Water Improvement District #1 (Consultation No. 2-15-03-F-480) with Cover Letter." Austin, Texas: U.S. Fish and Wildlife Service.

———. 2009a. "Biological Opinion on Section 10(a)(1)(B) Permit (TE-183172-0) for the Incidental Take of the Comanche Springs Pupfish (*Cyprinodon elegans*) Pecos Gambusia (*Gambusia nobilis*), and the Candidate Species Phantom Springsnail (*Tryonia cheatumi*), Diminutive Amphipod (*Gammarus hyalleloides*), and Phantom Cave Snail (*Cochliopa texana*) to Texas Parks and Wildlife Department for the Management of the Balmorhea State Park in Reeves County, Texas." Austin, Texas: U.S. Fish and Wildlife Service.

———. 2009b. "Signed Incidental Take Permit for Balmorhea State Park HCP." U.S. Fish and Wildlife Service.

———. 2013. “Comanche Springs Pupfish (*Cyprinodon elegans*) 5-Year Review.” Austin, Texas: U.S. Fish and Wildlife Service.

———. 2015. “Comanche Springs Pupfish (*Cyprinodon elegans*) Refuge Population and Genetics Management Plan For Southwestern Native Aquatic Resources and Recovery Center (First Revision).” Dexter, New Mexico: U.S. Fish and Wildlife Service.

———. 2020a. “Findings and Recommendations on Issuance of a Habitat Conservation Plan for the Balmorhea State Park Management Plan Located in Reeves County, Texas.” Austin, Texas: U.S. Fish and Wildlife Service.

———. 2020b. “Signed Incidental Take Permit for Balmorhea State Park HCP.” U.S. Fish and Wildlife Service.

———. 2021. “Intra-Service Section 7 Biological Opinion on the Reconstruction of the Ciénega at Phantom Lake Spring, Creating Refugia for the Comanche Springs Pupfish (*Cyprinodon elegans*), the Pecos Gambusia (*Gambusia nobilis*), the Phantom Tryonia (*Tryonia cheatumi*) and Its Critical Habitat, the Phantom Springsnail (*Pyrgulopsis texana*) and Its Critical Habitat, and the Diminutive Amphipod (*Gammarus hyalelloides*) and Its Critical Habitat.” Austin, Texas: U.S. Fish and Wildlife Service.

———. 2022. “Memorandum: Section 7 Concurrence (Consultation Number 02ETAU00-2022-I-0704) for the Bureau of Reclamation’s Land Disposal Phantom Lake Spring, Jeff Davis County, Texas.” Austin, Texas: U.S. Fish and Wildlife Service.

U.S. Geological Survey. 2024a. “San Solomon Spgs at Toyahvale, TX.” Accessed from https://waterdata.usgs.gov/monitoring-location/08427500/.

———. 2024b. “USGS Current Conditions for USGS 08427000 Giffin Spgs at Toyahvale, TX.” Accessed from https://waterdata.usgs.gov/nwis/uv?site_no=08427000&legacy=1.

Uvalde National Fish Hatchery. 2024. “Uvalde Responses to Comanche Springs Pupfish Refugia Questions.” U.S. Fish and Wildlife Service.

White, Walter N., Hoyt S. Gale, and S.Spencer Nye. 1941. “Geology and Ground-Water Resources of the Balmorhea Area Western Texas.” Washington, D.C.: U.S. Geological Survey. Accessed from https://pubs.usgs.gov/wsp/0849c/report.pdf.

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Comanche Springs pupfish (*Cyprinodon elegans*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

FIELD OFFICE APPROVAL:

Acting Field Supervisor, Fish and Wildlife Service, Austin Ecological Services Field Office

Approve CATHERINE YEARGAN Digitally signed by CATHERINE YEARGAN Date: 2024.08.02 17:52:31 -05'00' ____