Big Bend Gambusia
Gambusia gaigei

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
Austin, Texas
February 2012

5-YEAR REVIEW

Species reviewed: Big Bend Gambusia, *Gambusia gaigei*

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5-YEAR REVIEW

Big Bend Gambusia, *Gambusia gaigei*

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Purpose of 5-year Reviews

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of this 5-year review is to ensure that the Big Bend gambusia has the appropriate level of protection under the Act. The review documents a determination by the Service as to whether its status has changed since the time of listing, or since completion of the most recent 5-year review. In the 5-year review, we first review the best available scientific and commercial data on the species, focusing on any new information obtained since the species was listed or last reviewed. We then consider the five threat factors described in section 4(a)(1) of the Act to determine whether the species' status should remain the same or be changed from threatened to endangered, endangered to threatened, or be removed from the endangered species list. The conclusion of this review will either be a recommendation for the species to remain classified as endangered or a recommendation for downlisting or delisting. However, recommended status changes only become final through a separate rule-making process that includes public review and comment. The review also provides updated information on the current threats to the species, ongoing conservation efforts, and the priority needs for future conservation actions.

1.3 Methodology Used to Complete the Review

The U.S. Fish and Wildlife Service (Service) conducts status reviews for species on the List of Endangered and Threatened Wildlife and Plants List (50 CFR 17.12) as required by section 4(c)(2)(A) of the Act. The Service provides notice of the reviews via the Federal Register (FR) and requests information or input on the status of the species under review. This review was conducted by the Austin Ecological Services Field Office staff using information from the 1984 Big Bend Gambusia Recovery Plan (USFWS 1984), peer-reviewed articles, agency reports, and other documents available in the Austin Ecological Services Field Office files.

1.4 Background

The Big Bend gambusia (*Gambusia gaigei* Hubbs 1929) is a small fish in the family Poeciliidae that bears its young live and has an extremely restricted range in west Texas. Campbell (2003, pp. 2-3) and Hubbs et al. (2002, p. 82) provide summary overviews of the life history and ecology of the Big Bend gambusia. Its entire natural range is limited to one small spring system in Big Bend National Park (Park). The fish has been of conservation concern since 1956 (Hubbs and Broderick 1963, p. 47) and its Federal protection predates the current (1973) Act.

The Big Bend gambusia is restricted to two constructed spring ponds (Spring 1 and Spring 4 refuge ponds) in the Rio Grande Village area of Big Bend National Park (Figure 1). At least one other population, the type locality, previously existed at nearby Boquillas Spring. The population inhabiting Boquillas Spring is extinct and the population in Spring 4 was extirpated in the 1950s and was restored from the descendants of only three individual fish restocked into the Spring 4 pond. A captive population is also maintained at the Dexter National Fish Hatchery and Technology Center (Dexter NFHTC) in Dexter, New Mexico (USFWS 2010, p. 5).

The original listing of the Big Bend gambusia was under the Endangered Species Preservation Act of 1966 (80 Stat. 926; 16 U.S.C. 668aa(c)). Big Bend gambusia was listed by the State of Texas in 1974. The American Fisheries Society's Endangered Species Committee lists the Big Bend gambusia as endangered due to the threatened destruction or reduction of habitat, a narrowly restricted range, and other factors such as competition (Jelks et al. 2008, p. 401). Nature Serve designates its status as G1, critically imperiled (www.natureserve.org, accessed December 2011).

A recovery plan was prepared by the Rio Grande Fishes Recovery Team and approved by the Service in 1984 (USFWS 1984). Some section 7 interagency consultations with Big Bend National Park have occurred; no section 10 Habitat Conservation Plans have been developed; and no previous status reviews have been done for this species. Because it was added to the list of protected species prior to the Act, the status of the fish was not previously analyzed using the five listing factors (32 FR 4001). As a result, this 5-year review represents the first analysis of the threats to the species based on the five listing factors.

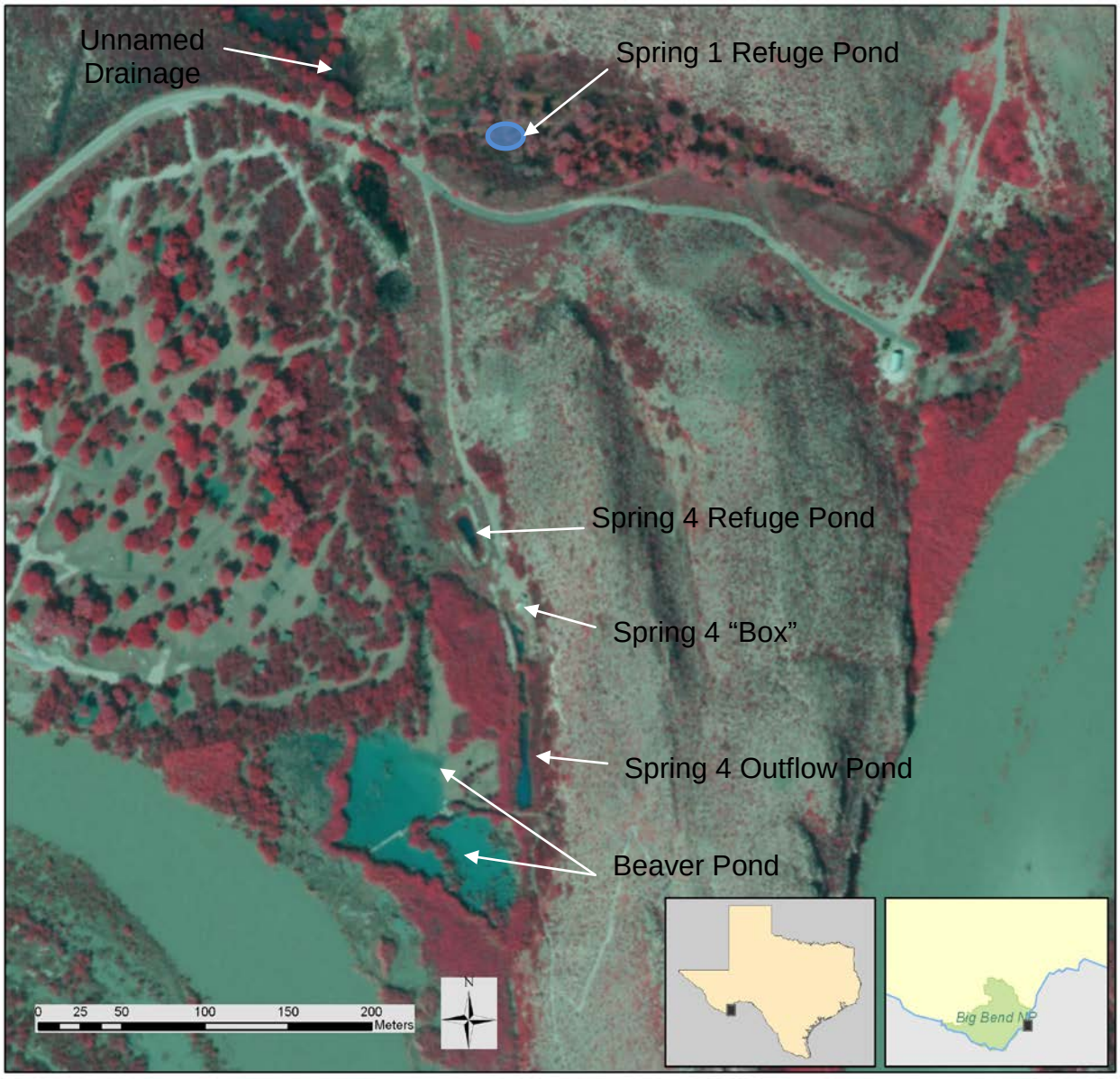


Figure 1. Range map of Big Bend gambusia at Rio Grande Village in Big Bend National Park, Texas. Big Bend gambusia occurs in Spring 1 refuge pond and Spring 4 refuge pond (Spring 4 "Box" is the spring source). The status of the fish is uncertain, but may be present in very low abundance, in the Spring 4 outflow pond and the Beaver Pond (2008 aerial photography is from the Texas Natural Resources Information System).

1.3.1 FR Notice citation announcing initiation of this review:

March 20, 2008 (73 FR 14996), 90-day request for information period closed June 18, 2008. No comments were received.

1.3.2 Listing history:

Original Listing
FR notice: 32 FR 4001
Date listed: 03/11/1967
Entity listed: Species, *Gambusia gaigei*
Classification: Endangered.
This was the original listing of the Big Bend gambusia under the Endangered Species Preservation Act of 1966. The species is now listed under the Act. No critical habitat is designated.

1.3.3 Associated rulemakings: None.

1.3.4 Review History: No other 5-year reviews have been prepared for this species.

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

The Big Bend gambusia had a Recovery Priority Number of 2, indicating a full species with a high degree of threat and a high potential for recovery (48 FR 43098).

1.3.6 Current Recovery Plan or Outline

Name of plan or outline: Big Bend Gambusia Recovery Plan
Date issued: 09/19/1984
Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

__X__ ***Yes***
_____***No***

2.1.2 Is the species under review listed as a DPS?

____ ***Yes***
__X__ ***No***

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

____ ***Yes***
__X__ ***No*** (recovery plan does not have criteria [USFWS 1984, p. 14])

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

The 1984 Recovery Plan does not include delisting or downlisting criteria. The goal of the plan is to "secure survival" of the Big Bend gambusia. The plan states that because of the extremely limited distribution and tenuous habitat, it may never be downlisted or delisted (USFWS 1984, p. 14).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:
Summaries of biological information on Big Bend gambusia can be found in USFWS (1984, pp. 1-6) and Hubbs et al. (2002, p. 82). No substantial new life history or biological information has been reported.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Some "several thousand" Big Bend gambusia occur in the small, isolated spring pond habitats at one location near Rio Grande Village in Big Bend National Park (Figures 1 and 2; Hubbs et al. 2002, p. 82). No population trends have been reported. A captive stock of about 2,500 individuals (USFWS 2010, p. 5) is maintained at Dexter NFHTC .

Adult Big Bend gambusia are live-bearers. Females are generally larger than males and reach about 43 mm standard length (about 1.7 inches) and likely only live for one year (Hubbs and Mosier 1985, p. 1063). Fecundity of the fish varies seasonally with reproduction occurring from 5 to 8 months a year. Broods were found to contain from 16 and up to 50 young in peak late spring periods, and interbrood intervals ranged from 24 to 29 days (Hubbs and Mosier 1985, pp. 1063-1064).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
Impacts from habitat alteration and competition with western mosquitofish (*Gambusia affinis*) in the 1950s resulted in the survival of only three individuals of the species (one female and two males) (Hubbs and Broderick 1963, pp. 46-

48). This and other subsequent genetic bottlenecks (Johnson and Hubbs 1989, p. 311) have resulted in virtually no detectable genetic variation within the population (Echelle et al. 1989, pp. 221, 224; USFWS 2010, pp. 8-11). The lack of genetic variability, however, may pre-date the bottlenecking events in the 1950s and has not resulted in any apparent deleterious effects (Echelle et al. 1989, p. 224; Johnson and Hubbs 1989, p. 311).

2.3.1.4 Taxonomic classification or changes in nomenclature:
No changes in the classification or nomenclature have occurred. The fish continues to be recognized as a distinct species (Hubbs et al. 2008, p. 38).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):
The Big Bend gambusia is known only from an area in the Chihuahuan Desert of west Texas near Boquillas and Rio Grande Village in Big Bend National Park (Figure 2). It historically occurred in two separate spring systems. The type locality of the species is from Boquillas Spring (also in Big Bend National Park), located about 1 mile (1.6 km) east of the springs at Rio Grande Village. This population was lost in the 1950s due to drying of the spring and subsequent invasion of western mosquitofish when water returned (Hubbs and Springer 1957, p. 305; Hubbs and Broderick 1963, pp. 47-48). The fish now only exists in two constructed refuge ponds from Spring 1 and Spring 4 located at Rio Grande Village (Figure 1).

Spring 1 refuge pond was constructed in 1957 and, following a 1975 winter fish kill, has been augmented with well-water from an electric pump since 1976 (Hubbs and Williams 1979, p. 635; Johnson and Hubbs 1989, p. 310-311; USFWS 1984, p. 11). The Spring 1 refuge pond continues to maintain a robust population of the Big Bend gambusia with many individuals of all sizes and no other fish species (Edwards 2010, p. 1).

The outflow of Spring 4 (labeled as "Box" on Figure 1) was formerly a more extensive marsh that was inhabited by both Big Bend gambusia and western mosquitofish (Hubbs et al. 1986, p. 122). Much of the area is now flooded by a beaver dam and the resulting pond was invaded by non-native blue tilapia (*Oreochromis aureus*) in the 1990s. Very few Big Bend gambusia have been found in the beaver pond in recent years (Edwards 2010, p. 1). The narrow Spring 4 outflow pond has traditionally contained mainly Big Bend gambusia and a few western mosquitofish; however, since the flood of September 2008, blue tilapia have also become established in that pond and Big Bend gambusia have not been collected there since that time (Edwards 2009, p. 1; 2010, p. 1).

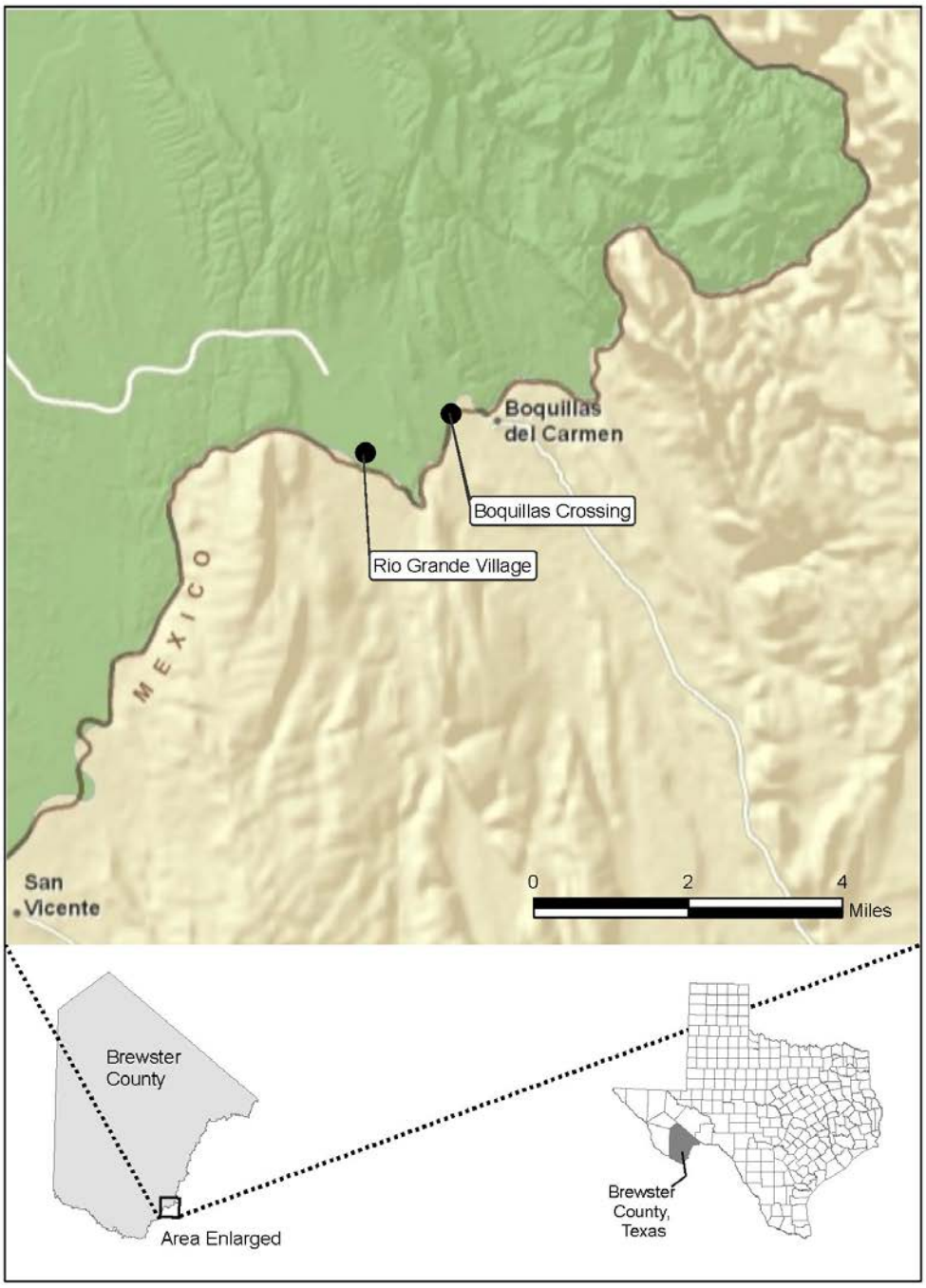


Figure 2: Map depicting Boquillas Crossing and Rio Grande Village in Big Bend National Park, Texas.

An additional Big Bend gambusia refuge pond was constructed upstream of Spring 4 in 2007 using some of the flow from Spring 4 (NPS 2005, p. 1; RGFRT 2007, p. 1). The purpose of the new pond was to provide a more secure habitat for the fish because the berm that creates the existing Spring 4 outflow pond was leaking and the pond is vulnerable to introduction of other fishes due to its accessibility to the public. Before Big Bend gambusia were introduced into the new refuge pond, the pond was inundated by the Rio Grande flood of September 2008 and became contaminated with fish from the river. The pond was later drained and all fish were removed in 2009 (Edwards 2009, p. 1). In May 2010, 100 Big Bend gambusia from the Spring 1 refuge pond were introduced to the new Spring 4 refuge pond. By August 2010, Big Bend gambusia of varying sizes were observed in the Spring 4 refuge pond. Also, in August 2010, an additional 200 fish were moved from the Spring 1 refuge pond to the Spring 4 refuge pond (Edwards 2010, p. 2).

The fish does not migrate and is not found in downstream riverine habitats in the Rio Grande due to habitat differences (such as highly variable water temperature) that favor the western mosquitofish (Hubbs and Broderick 1963, p. 47). Numerous efforts have been made to introduce the fish into other spring habitats within the Park, but none have been successful (Hubbs and Broderick 1963, pp. 47-48). Other spring habitats along the Rio Grande (in Texas and Mexico) have been searched for natural populations, but none have been found (Hubbs and Broderick 1963, p. 47).

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

The Big Bend gambusia is restricted to small, desert spring habitats. The spring ponds at Rio Grande Village that harbor the fish are clear warm water, stenothermal (constant temperature) springs. Hubbs (2001, pp. 315-316) documented the average outflow temperatures of Spring 4 and Spring 1 as 34.9 ºC (95 ºF) and 33.1 ºC (92 ºF), respectively, with very low variability. The Big Bend gambusia is often found associated with dense stands of *Chara* spp. (submerged plant) and emergent vegetation in the refuge ponds (Hubbs et al. 2002, p. 82).

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

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

<u>Range</u>

The Big Bend gambusia has an extremely limited range (Figure 1), which has been reduced since the species discovery in the 1920s. It has never been known from more than the two isolated locations in the area of Boquillas Crossing and near Rio Grande Village (Figure 2; Hubbs et al. 2008, p. 38). This narrow range, in combination with a short life span of one year, significantly increases the probability of extinction from either known or unknown threats (Johnson and

Hubbs 1989, p. 316) or stochastic events (Melbourne and Hastings 2008, p. 100). One future event that negatively impacts this population could easily result in the complete loss of the species in the wild. Therefore, any impacts on the fish from ongoing or future threats (described below) would be of high magnitude.

Threats to Habitat - Spring Flow

The spring outflows from Spring 1 and Spring 4 provide the water for the habitat for Big Bend gambusia. Any substantial declines in the rate of flow from the springs would alter the habitat and could negatively affect the ecosystem that supports the Big Bend gambusia population. In the extreme case, if the flow from these springs ceased (due either to pump failure at Spring 1, which is supplied solely by a pump, or loss of natural flow from groundwater decline at Spring 4), then the species' habitat would be lost and the species would be extinct in the wild.

Other springs in west Texas have been impacted by loss of spring flow due to groundwater pumping resulting in the elimination of the natural ecosystem and its fauna (for example, Comanche Springs and other springs near Fort Stockton, Hubbs 1990, p. 92; Scudday 1977, p. 516; Scudday 2003, pp. 136-137).

Water from the springs originates from faults in the cretaceous limestone of the Santa Elena Formation (Brune 1981, p. 86; Wilson 1983, p. 12). The water is warm, reaching temperatures of 36ºC (97ºF) (Brune 1981, p. 86) and presumably comes from deep underground where geothermal warming occurs (Wilson 1983, p. 12). Brune (1981, p. 86) reports that flow rates from the springs at Rio Grande Village range from 6.2 to 26 liters/second (lps) (0.2 to 0.9 cubic feet/second, cfs), although precise measurements of spring flow are difficult to obtain (Wellman 2007, p. 2). The Park plans to implement a spring flow monitoring system in the future to better measure the current spring flow, including installing a weir for surface flow monitoring (Wellman 2007, p. 5; 2009, p. 1). Groundwater monitoring with pressure transducers near the springs has been maintained for several years, but no analyses of the data have been completed and the weir has not yet been installed (Skiles 2010, p. 2).

These small historic and current spring flow levels are sufficient to maintain habitat for the Big Bend gambusia as long as water temperatures remain high with low variability (USFWS 1984, p. 20) or as long as western mosquitofish are excluded from the ponds. However, any future spring flow declines could threaten the population with extinction due to habitat loss. Any alteration of the geologic structure (whether natural or man-induced) in the area of the Rio Grande Village could reduce or eliminate the spring flows. Another threat to spring flows comes from any significant increase in human groundwater use within the aquifer that supplies the springs. If groundwater was pumped out to such an extent to lower the groundwater levels around the spring openings, the flow rates could decline or cease all together.

Historically all the water for human use in the Rio Grande Village area came directly from the Spring 4 "Box." A pump and chlorination system was housed in a small concrete structure located immediately over the spring head. Water was pumped periodically as needed to a storage tank to the north for water supplies. In an attempt to reduce the potential impact on Big Bend gambusia of water withdrawal directly from Spring 4, in 2009-2010 the Park transitioned the Rio Grande Village water supply to a water well located roughly 760 m (2,500 ft) north of the springs (NPS 2006, pp. 5-6, 19-25). The Park first evaluated two other potential water sources, but they were not useable. The Spring 4 source is now only used to augment the well water or in an emergency.

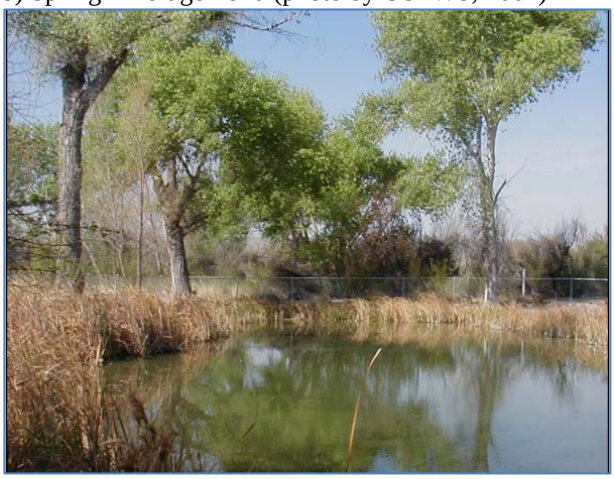
Although the new water supply well is likely drawing water from the same aquifer source that supplies the springs, the well is located in a different fault/fracture zone that is distant from the fault/fracture zone that serves the springs (Wellman 2007, p. 1). Also the well was completed over 200 m (700 ft) deep and penetrates the Santa Elena limestone formation and reaches the Sue Peaks limestone where water will be produced. Short term pump tests of the new well showed no effect on the water levels of the aquifer around Spring 4 (NPS 2006, p. 54). In addition, the Park relocated the chlorinator far away from the springs, thus reducing the potential risk of an accidental pollutant release that could potentially degrade water quality in Spring 4. Overall, this new well should reduce the potential impacts of domestic water use in Rio Grande Village on spring flows in Big Bend gambusia habitat.

The amenities at Rio Grande Village served by this water include a visitor center, a 100-site campground, a concessioner-operated 25-site RV full hook-up campground, a picnic area, a group campground, an amphitheater, a general store (with showers and laundry service), a gasoline station (roughly ¾ mi from gambusia habitat), and a self-guided nature trail (NPS 2004, p. 125). The area is open year-round with higher visitation in the winter, peaking in February and March. Providing a safe, reliable water supply to this developed area is an important function of the Park (NPS 2006, p. 1).

Consumptive domestic water use at Rio Grande Village (not including irrigation water, which is drawn from the Rio Grande) from 1994 to 2008 ranged from about 1.3 to 3.2 million gallons of water per year (about 4 to 10 acre-feet, af, or 5,000 to 12,000 cubic meters, m^3) (Figure 3). Based on Brune's (1981, p. 86) reported range of spring flows from Rio Grande Village (6.2 to 26.2 lps, approximately 160 to 660 af/year, 195,000 to 820,000 m^3/year), the domestic use since 1994 represents a very small amount of water (6 percent at most) compared to the total available spring flow.

a) Spring 1 Refuge Pond (photo by R. Edwards, 2003)

b) Spring 1 Refuge Pond (photo by USFWS, 2002)



c) Spring 4 Refuge Pond (photo by USFWS, 2010)

d) Spring 4 Refuge Pond (photo by USFWS, 2010)

e) Beaver Pond; Spring 4 Outflow Pond in foreground (photo by USFWS, 2002)

f) Spring 4 Outflow Pond (photo by USFWS, 2010)

Figure 3. Photos of Big Bend gambusia ponds at Rio Grande Village, Big Bend National Park.

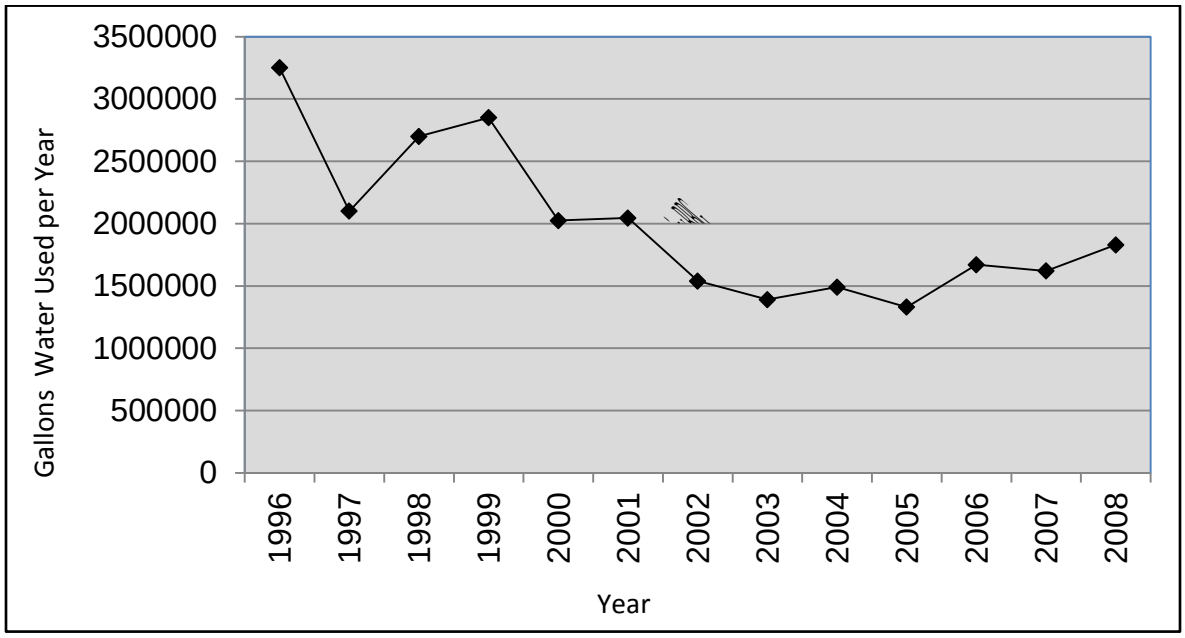


Figure 4. Annual water use in gallons at the Rio Grande Village, Big Bend National Park, Texas, as reported by Wellman (2009, p. 2).

Domestic water use at Rio Grande Village is not expected to increase substantially in the foreseeable future. The General Management Plan for Big Bend National Park calls for modest plans to add 5 to 10 additional RV hook-up sites at Rio Grande Village (NPS 2004, p. 62; NPS 2006, pp. 37, 56). So far no specific plans have been made to implement this expansion (Skiles 2010, p. 2). The Park expects that even if some expansion of the campground is undertaken, continued measures for water use efficiency and conservation are likely to offset any water use increases (Wellman 2007, p. 5).

In 2009, the Park initiated a plan to construct several new housing and operational facilities in Rio Grande Village that were not included in the 2004 General Management Plan (NPS 2008, p. 2). These plans were in response to increasing border security needs in the Park. The Park committed to ensuring that domestic water use at Rio Grande Village would remain within the range of recent years and has implemented ongoing water conservation actions including monitoring aquifer levels using pressure transducers to determine if there is a relationship between well use and spring flow, efficiency upgrades to appliances and fixtures, and an alternative shower facility at Panther Junction (Wellman 2009, pp. 1-3). Flow maintenance at Spring 1 requires augmentation from a nearby well and pump. This necessitates constant maintenance of the well and pump by the Park to ensure adequate water levels in the Spring 1 refuge pond. The pump periodically does fail, as was the case following the flood of September 2008

when the pump was not working for about five weeks (RGFRT 2009, pp. 4-5). This could have been the cause for Big Bend gambusia not being seen in the Spring 1 refuge pond during monitoring in December 2008 (RGFRT 2009, p. 5). Since then, Edwards (2010, pp. 1-2) has described the population in the Spring 1 refuge pond as thriving, robust, and stable. The potential for population extirpation from the Spring 1 refuge pond due to a pump failure is a constant threat.

It is difficult to assess the impact of water withdrawal from areas outside of the Rio Grande Village on the aquifer that provides spring flows for the gambusia's habitat. The specific areas of recharge or extent of regional flow systems have not been defined due to a lack of sufficient investigation. However, no additional groundwater use is likely within nearby areas of the Park and no large groundwater withdrawals are likely from this part of Brewster County, as it is a very remote and rural area. Therefore, the likelihood of the springs being affected by other groundwater pumping is presumed to be low.

In conclusion, based on a low probability of increases in groundwater use in the foreseeable future, habitat threats from decreasing flows due to increasing groundwater withdrawals do not appear to be imminent. The threat continues to be of high magnitude, however, because such a small amount of water supports the fish's habitat that any decreases in the spring flow rates could result in the extinction of Big Bend gambusia from the wild. In addition, the possibility of habitat loss due to pump failure at Spring 1 refuge pond is a constant ongoing threat of high magnitude.

Threats to Habitat - Water Quality

Maintaining the water quality of the springs is an important component of the ecosystem for Big Bend gambusia habitat. Hubbs (2001, p. 312) documented the water chemistry of the waters in Big Bend gambusia habitat based on samples in 1999 (Table 1). Maintaining constant water temperatures is required to ensure that Big Bend gambusia are not outcompeted by western mosquitofish (see additional discussion below under section 2.3.2.5). Maintaining natural spring flows from the warm water aquifers allows these stenothermal conditions to persist.

We are not aware of any other information indicating water quality problems that could threaten the Big Bend gambusia, although our review found little information on this topic. The species occurs in a very rural part of Texas that does not experience water quality problems associated with urban environments. Therefore, threats to the species' habitat from water quality degradation are considered low at this time.

Table 1. Average values (and Coefficient of Variation, COV) for seven water chemistry variables at two spring sites at Rio Grande Village, of the seven reported by Hubbs (2001, p. 312). Site BB-1 was at the Spring 1 refuge pond and site BB-5 was at the head of the Spring 4 outflow pond (Hubbs 2001, p. 306). [mg/L is milligrams per liter, NTU is nephelometric turbidity unit, ppt is parts per thousand].

Variable	Site BB-1 Average (COV) N=22	Site BB-5 Average (COV) N=8
Temperature, ºC	25.37 (0.27)	34.51 (0.04)
Dissolved oxygen, O_2 mg/L	4.35 (0.72)	3.78 (0.17)
Turbidity, NTU	40.72 (1.92)	6.50 (2.01)
pH	6.6 (0.34)	7.16 (0.01)
Ammonia, NH_4 mg/L	2.69 (0.81)	1.80 (0.72)
Nitrates, $N0_3$ mg/L	13.49 (1.32)	4.38 (0.29)
Salinity, ppt	0.66 (0.04)	0.66 (0.00)

Threats to Habitat - Local Conditions

The natural habitat conditions in the springs where Big Bend gambusia occurs have been altered significantly over time (USFWS 1984, pp. 9-10). Before establishment of the Park (authorized in 1935), farm development destroyed Big Bend's most extensive wetlands at Rio Grande Village. These wetlands were created by four warm springs emanating within 0.5 mile (0.8 km) of the Rio Grande near what is now Rio Grande Village. Pre-park agricultural development resulted in containment of springs, diversion into irrigation systems, and removal of beaver populations. When Rio Grande Village campground, roads, and maintenance facilities were established, they were placed in areas cleared by decades of agricultural use (NPS 2004, p. 112). Management and restoration by the Park has returned some natural functions to springs and wetlands. Management efforts have included applying prescribed fire, removing non-native vegetation, removing a service road and restoring the area with native wetland vegetation, and controlling nutria, a non-native mammal that destroys the integrity of berms and stream banks by burrowing (NPS 2006, pp. 36-37).

Besides direct habitat alteration, one of the indirect effects of the adjacent public recreational facilities (campgrounds and picnic areas) is the potential for introduction of harmful species to the habitats of Big Bend gambusia. A nature trail from the campground to the Rio Grande passes by the Spring 4 outflow pond. Over the years, numerous predatory fish (catfish and bass) have been found in the pond, presumably introduced by recreational anglers from catch in the river (USFWS 1984, p. 4). In addition, the newly constructed Spring 4 refuge pond is located very close to some camp sites (back loop of the Rio Grande Village campground, Figure 1). The Park has proposed to relocate those camp sites farther from the gambusia habitat (NPS 2004, p. 62); however, there are currently no active plans to do so (Skiles 2010, p. 2). Park regulations prohibit fishing from

or releasing fish into the ponds and the ponds are enclosed by chain link fence with secured gates (Skiles 2011, p. 1).

In conclusion, past habitat alteration in the local area of Rio Grande Village has reduced habitat availability for the Big Bend gambusia. The Park is now committed to maintaining and restoring the habitat at Rio Grande Village for Big Bend gambusia; however, the highly restricted range of the fish makes the magnitude of threats high.

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

There is no evidence at this time that Big Bend gambusia 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, Texas Parks and Wildlife Department (TPWD, Title 31, Part 2, Chapter 69, subchapter J), and the National Park Service (NPS).

2.3.2.3 Disease or predation:

Disease/parasites

Little is known about disease or pathogens associated with the Big Bend gambusia. Sixty Big Bend gambusia are sacrificed on an annual basis at Dexter NFH for fish health screening and the captive stock has consistently tested negative for pathogens of concern (USFWS 2010). In 2008, thirty wild fish were screened due to a flood event at the national park that required salvage and transport of the wild population to Dexter, where they underwent parasitology, virology and bacteriology screening. Though some bacteria were initially isolated, no serious health concerns were found (USFWS 2010, p. 6).

Predation

Predation does not likely occur from piscivorous fish in Springs 1 and 4 refuge ponds because Big Bend gambusia is the only fish in those habitats (Skiles 2011, p.1). Predatory fishes, such as largemouth bass (*Micropterus salmonides*), green sunfish (*Lepomis cyanellus*), and channel catfish (*Ictalurus punctatus*), have periodically been found in and removed from the Spring 4 outflow pond (Hubbs et al. 2002, p. 82; USFWS 1984, p. 4). Other potential predators include birds, crayfish, and frogs, but are not known to be a problem. As other threats occur, such as future habitat alteration or the introduction of other fishes into the refuge ponds, predation could be a confounding threat to the species and increases extinction probability.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Regulatory mechanisms, beyond those imposed by the Act, that are important for conservation of the Big Bend gambusia, include protections of the fish by the NPS and TPWD.

State listing
The State of Texas lists the Big Bend gambusia as endangered under Title 31 Part 2 of Texas Administrative Code. TPWD regulations prohibit the taking, possession, transportation, or sale of any animal species designated by state law as endangered or threatened without the issuance of a permit.

There is no protection by state law for habitat or minimum stream or springs flows for state-listed species. Therefore, only minimal protections are afforded the Big Bend gambusia by the State of Texas and these protections do not address the most significant threats to the species associated with habitat loss.

National Park Service
The Park's General Management Plan (2004) recognizes the significance of the Big Bend gambusia, and the Park is committed to preserving the species by protecting its habitat and considering conservation needs of the species in future actions that may affect it. The Park maintains control over all actions that occur in and near the habitat of the Big Bend gambusia. However, not all threats fall under the control of the Park, such as those associated with invasive species, flooding, pump failure, climate change, and stochastic events.

Summary
The threats to Big Bend gambusia from the lack of regulatory mechanisms are considered low at this time because the species occurs on Federal property that is owned and managed by the National Park Service which provides a strong level of protection for the factors under its control.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Hybridization
Hybridization is not known to be a threat. Big Bend gambusia has occurred with the closely related western mosquitofish and no hybridization between the two species has been reported (USFWS 2010, p. 12).

Competition
Competition with western mosquitofish appears to be a substantial threat to the existence of the Big Bend gambusia. Big Bend gambusia seem to outcompete mosquitofish in warm stenothermal habitats (constant water temperatures) (Hubbs 2003, p. 130; Hubbs et al. 1986, p. 122); however, they have been replaced by mosquitofish on numerous occasions in nearby eurythermal (varying temperature) habitats (Hubbs et al. 2002, p. 82; USFWS 1984, p. 6). Stenothermal conditions are present at spring outflows, but downstream water temperatures will vary with the influence of ambient air temperatures. Western mosquitofish are common in many riverine, spring, and small stream habitats throughout the nearby Rio Grande drainage, making them readily available to invade any available aquatic habitat. Future invasion of the Springs 1 and 4 refuge ponds by western

mosquitofish is a constant (imminent) and serious (high magnitude) threat to the continued existence of the Big Bend gambusia.

Non-native species

Non-native blue tilapia, green tree frogs (*Hyla cinerea*), and nutria (*Myocastor coypus*) occur sympatrically with the Big Bend gambusia. Blue tilapia and nutria could potentially cause extensive damage to the gambusia's habitat. The tilapia has invaded from the main-stem Rio Grande and has become common in the outflow pond of Spring 4 and the downstream beaver pond (Edwards 2010, p.1). Non-native tilapia (*Oreochromis* spp.) can cause extensive damage to natural ecosystems; some negative consequences on native species include competition for food and space, predation on the eggs and young of native fish, the spread of pathogens, and alteration of habitat including increased turbidity and reduction of vegetation (see Canonico et al. 2005 for review). Nutria cause severe environmental damage by burrowing into berms and stream banks (Drake 2005, p. 15). Nutria were noted to have removed emergent and riparian vegetation in the Spring 1 refuge pond, thereby reducing the amount of vegetative structure that is an important component of the physical habitat for Big Bend gambusia. Green tree frogs were discovered in the Rio Grande Village ponds and have become quite abundant (Leavitt and Fitzgerald 2009, p. 541). It is not known what effects the tree frogs may have on the gambusia.

Flooding

Flooding from the Rio Grande or from the dry unnamed drainage from north of the springs (Figure 1) poses a constant threat to the species (USFWS 1984, p. 8). Extensive runoff could completely destroy the small pond habitats through sedimentation or erosion. Flooding from the Rio Grande could provide a vector for western mosquitofish (or other undesirable species) to invade gambusia ponds and eliminate the fish from its habitat. In September 2008 the Rio Grande reached a record flood stage. The new Spring 4 refuge pond was overtopped and inundated with backwater from the river. As a result, several undesirable species of fish became established in the pond. The pond had not yet been stocked with Big Bend gambusia, so the pond was drained and fish were removed prior to moving Big Bend gambusia there in May and August 2010. The flood also inundated the Spring 4 outflow pond (RGFRT 2009, p. 4) and apparently allowed blue tilapia to become established there (Edwards 2009, p. 1). Blue tilapia are now abundant in the Spring 4 outflow pond and Big Bend gambusia have not been collected in this pond since the flood (Edwards 2010, p. 1). This level of flooding is relatively rare, but represents an ongoing threat of high magnitude.

Climate change

According to the Intergovernmental Panel on Climate Change (IPCC 2007, p. 1), "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th

century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007, p. 1). It is very likely that over the past 50 years cold days, cold nights, and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007, p. 1). Data suggest that heat waves are occurring more often over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007, p. 1).

The IPCC (2007, pp. 6-7) predicts that changes in the global climate system during the 21st century are very likely to be larger than those observed during the 20th century. For the next two decades a warming of about 0.2 °C (0.4 °F) per decade is projected (IPCC 2007, p. 6). Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007, p. 6). Various emission scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6 °C to 4.0 °C (1.1 °F to 7.2 °F) with the greatest warming expected over land (IPCC 2007, pp. 6-8).

Localized projections suggest the southwest U.S. may experience the greatest temperature increase of any area in the lower 48 states (IPCC 2007, p. 8), with warming increases in southwestern states greatest in the summer. The IPCC also predicts an increase in hot extremes and heat waves, and a decrease in water resources (IPCC 2007, p. 8). Karl et al. (2009, p. 12) suggest that warming of the United States climate is already happening and is increasing. Large climate change impacts on water resources in the desert southwestern U.S. are expected as rising temperatures and decreasing precipitation (Karl et al. 2009, p. 83) exacerbate a region already plagued by low rainfall, high temperatures, and unsustainable water use practices.

Expected future warming from climate change could decrease overall availability of water recharging to aquifers in western Texas as climate change forecasts suggest warming and drying trends. However, aquifers such as the one supplying Big Bend gambusia spring habitats, are suggested to only be minimally affected in terms of water quantity because of lower responsiveness to rainfall and recharge events and low amounts of existing pumping relative to recharge (Mace and Wade 2008, p. 665).

Other potential effects of climate change on the physical and biological environment of the Big Bend gambusia are possible but difficult to predict, as no vulnerability assessment for the species has been completed. The Big Bend gambusia may be highly sensitive to the effects of climate change based on the species' high vulnerability to any change in water temperature variation in spring outflows. This could be a serious concern to the fish because it is closely dependent on water with low temperature variability.

We lack sufficient information to reliably predict how climate change might specifically affect this species. An assortment of indirect effects of climate

change is possible, such as changes to water quality, increases of non-native species, changes in disease susceptibility, and other factors. Because of the extremely small range and dependence on specific environmental conditions of this habitat specialist fish, any changes to its environment could result in the extinction of the species.

The Big Bend gambusia also has no opportunity to migrate and it is unlikely it could be successfully relocated to alternate environments in response to climate change. As a result, its capability to adapt to environmental changes from climate change or other factors is presumed low. Therefore, although the imminence of the threats related to climate change can be considered low, the magnitude of any potential effects to the Big Bend gambusia is considered high.

Small Population Size and Stochastic Events

The Big Bend gambusia may be susceptible to threats associated with small population size and impacts from stochastic events. The risk of extinction for any species is known to be highly indirectly correlated with population size (O'Grady et al. 2004, pp. 516, 518; Pimm et al. 1988, pp. 774-775). In other words, the smaller the population the greater the overall risk of extinction. True population size estimates have not been generated for this species, but the small area of suitable habitat in the spring ponds severely limits the number of possible individuals. Small population sizes can also act synergistically with other traits (such as being a habitat specialist and exhibiting a limited distribution, as in the Big Bend gambusia) to greatly increase risk of extinction (Davies et al. 2004, p. 270). Stochastic events from either environmental factors (random events such as severe weather) or demographic factors (random causes of births and deaths of individuals or unfavorable ratios of females and males) are also heightened threats to the Big Bend gambusia because of the limited range and small population sizes (Melbourne and Hastings 2008, p. 100). Finally, the small range of this fish does not provide any opportunity for natural recolonization if any of these factors resulted in a local extirpation event (Fagan et al. 2002, p. 3255).

2.4 Recent Conservation Actions

The Big Bend gambusia has benefitted from lengthy and involved past conservation efforts to avoid extinction. Summaries of some of those efforts are recorded in Hubbs and Broderick (1963, pp. 46-48), Hubbs and Williams (1979, pp. 631-635), and Johnson and Hubbs 1989 (pp. 310-312). Listed below are some conservation actions that have occurred since the completion of the recovery plan in 1984.

2.4.1 Rio Grande Fishes Recovery Team

The Rio Grande Fishes Recovery Team (RGFRT) has continued to make recommendations to the Service regarding recovery implementation for the Big Bend gambusia (e.g. RGFRT 2009, pp. 4-5). The RGFRT meets routinely (about annually) to discuss conservation needs of threatened and endangered fishes in western Texas and

southeastern New Mexico. This voluntary team has been serving continually since 1978 (USFWS 2009, p. 1).

2.4.2 Monitoring

The late Dr. Clark Hubbs (deceased in 2008), RGFRT Team Leader from 1978 until his death and Professor at the University of Texas at Austin, periodically monitored the Big Bend gambusia for roughly 50 years. Water chemistry and population data for Big Bend gambusia collected during the 1990s were published in Hubbs (2001, pp. 312, 315-16, 318-20, 323). Much of this work was supported by funding from the Texas Water Development Board.

Semi-annual fish population monitoring for Big Bend gambusia is now being carried out by Dr. Robert Edwards, University of Texas-Pan American (Edwards 2007, 2008, 2009, 2010).

2.4.3 Captive refuge stock

A captive population of Big Bend gambusia has been maintained at Dexter NFHTC in New Mexico since 1974 (USFWS 2010, p. 6). In 2008, record flooding in the Rio Grande at Big Bend presented a substantial threat to the existing wild population (USFWS 2010, p. 6). The Dexter stock had received no wild fish since 1987 and had not been genetically analyzed since 1983 (USFWS 2010, p. 5). Therefore, in September 2008, 677 fish were collected from the Spring 1 refuge pond and transported to Dexter NFHTC as a precaution. Fish were held in quarantine until a fish health survey and genetic analysis had been completed. The analyses showed the fish to be free of health concerns and genetically identical at neutral markers to the captive stock. Therefore, the wild fish were added to the captive stock as a supplement (USFWS 2010, p. 12).

2.4.4 New water use well

The facilities at Rio Grande Village had historically received water for domestic consumptive use from the Spring 4 outlet. A chlorination system was located at the spring head. For some time the Park had sought out an alternative water source that would be more reliable and less threatening to the habitat of the gambusia. After considering a range of potential water sources, the best alternative was to drill a new water well to partially relieve these concerns. Although the new well likely obtains water from the same aquifer source as the spring flow and Spring 4 remains a backup water source for the Park, it reduces the overall impacts of domestic water use on spring flow (see section 2.3.2.1). The Service completed an informal consultation with the Park regarding the action.

2.4.5 New spring pond

The dike that forms the outflow pond of Spring 4 has been leaking substantially for some time. The pond also has easy access to the public as it is located adjacent to a nature trail,

which is frequented by visitors when the boardwalk over the beaver pond is functioning. The Park constructed a new refuge pond in 2008 to provide more secure habitat for the Big Bend gambusia. The Spring 4 refuge pond receives gravity flow of water from Spring 4 (Box) and is located about 20 m (60 feet) from Spring 4 and about 200 m (600 feet) down gradient from the Spring 1 refuge pond (Figure 2). The Service completed an informal consultation with the Park regarding the action. Big Bend gambusia from the Spring 1 refuge pond were introduced to the new pond in 2010. Fish abundance will be monitored in the new pond to ensure that the population becomes established (Edwards 2010, p. 1).

2.5 Synthesis of species status

The best available information indicates that the primary threats to the Big Bend gambusia are: 1) habitat loss from the potential loss of spring flow due to a decline in groundwater levels or pump failure, 2) competition with invasive western mosquitofish, and 3) flood events.

The information reviewed does not indicate that impacts to spring flows from a significant increase in groundwater use or declines in recharge are imminent (defined here as likely to occur in the next 15 years) at this time. However, diminished spring flows could occur over the foreseeable future of 50 to 100 years as a result of climate change or to meet increased human needs for more water resources. The magnitude of impact on the Big Bend gambusia if this threat were realized is extremely high. Because the range of the species is limited to a small, isolated location, habitat modification due to a decline in spring flows could result in its extinction in the wild.

The threat from competition with western mosquitofish is high and ongoing, and the magnitude of the impact of this threat on the species is also high. Additional threats include habitat modification from water quality degradation, local habitat changes, and the introduction of a disease, parasite, or non-native species.

Climate change is another source of potential threats to the species. All possible impacts associated with future climate change cannot presently be reliably assessed. However, accelerating climate change could exacerbate any of the threats already considered or could result in entirely new threats that are not conceived at this time. Either way, subtle but significant changes in the ecosystem of the Big Bend gambusia resulting from climate change in the foreseeable future of 50 to 100 years could cause the species' extinction in the wild and present a high magnitude threat.

All of these threats, both primary and secondary, must be considered in the context of a fish with an extremely small range, no opportunity for movement, a relatively small population size, and a short life span. Therefore, the magnitude of impact of any potential threat or future stochastic event is exceptionally high. Any events negatively affecting the species or its habitat could result in extinction of the Big Bend gambusia in the wild.

3.0 RESULTS

3.1 Recommended Classification

____ Downlist to Threatened

____ Uplist to Endangered

____ Delist

____ *Extinction*

____ *Recovery*

____ *Original data for classification in error*

_X_ No change is needed

3.2 New Recovery Priority Number: We propose that the Big Bend gambusia, currently with a recovery priority number of 2, be assigned a new Recovery Priority Number of 5.

Brief Rationale: The Big Bend gambusia's entire range is limited to one small spring system. Any decreases in spring flow rates or any future events that negatively impact the gambusia could easily result in the complete loss of the species in the wild. Additionally, there are no other areas where the gambusia can likely be established because it is a very narrow habitat specialist. Numerous efforts have been made to introduce gambusia to spring habitats within the Park, but none have been successful (Hubbs and Broderick 1963, pp. 47-48), providing the gambusia a low recovery potential.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The following recommendations are provided to direct actions in the coming years to further the recovery of the Big Bend gambusia. They are generally listed in priority order, and are based on the species recovery plan (USFWS 1984) and recent considerations by the Rio Grande Fishes Recovery Team (RGFRT 2009, pp. 4-5), TPWD, NPS, and the Service. The recommended actions are to:

1) Cooperate with Big Bend National Park to protect habitat,
2) Maintain captive stock,
3) Monitor fish populations,
4) Monitor water quality and spring discharge,
5) Minimize campground impact,
6) Conduct climate change vulnerability analysis, and
7) Update the recovery plan.

Cooperate with Big Bend National Park to protect habitat.

Most of the conservation actions for the Big Bend gambusia require the participation of the Park. Therefore, it is vital to maintain open dialogue and regular communications between the Service, Park, TPWD, and any other partners interested in conservation and recovery of the species.

Maintain captive stock.

Because of the precarious nature of the wild population of Big Bend gambusia, it is critical for its conservation to maintain a captive stock of the fish in a secure facility. Dexter NFHTC has maintained the species in captivity since 1974 and should continue to hold a population of the species (USFWS 2010, p. 12). Ideally this species should be maintained in more than one captive breeding facility. (Recovery Task 3.0 [USFWS 1984, p. 27])

Monitor fish populations.

Regular, routine monitoring (at least annually, preferably more often) of the Big Bend gambusia population in the Spring 1 and Spring 4 refuge ponds, as well as the beaver pond and Spring 4 outflow pond, should be carried out. (Recovery Task 1.2 [USFWS 1984, p. 19]) If funding becomes available, additional monitoring including fish health testing (annual or bi-annual) and/or genetics analysis (every 3-5 years) would be helpful to better assess the health of the wild population.

Monitor water quality and spring discharge.

Water quality monitoring should be undertaken for the spring outflows and downstream to confirm maintenance of constant water temperatures. The Park has initiated monitoring of shallow groundwater levels near the springs and water level monitoring in the Santa Elena well. These data should continue to be collected and should be analyzed on an annual basis to evaluate any changes in groundwater levels over time and any potential effects of pumping from the well. Similarly, spring flow rates from Spring 4 should be monitored over time to detect any potential changes and determine if there is a relationship between pumping from the well and spring flow. This has been proposed by the Park (Wellman 2009, p. 1), but has yet to be implemented (Skiles 2010, p. 2). (Recovery Tasks 1.2 [USFWS 1984, p. 19])

Minimize campground impact

As recommended in the Recovery Plan (Service 1984, p. 23) and the Park's General Management Plan (NPS 2004, p. 62), the easternmost campsites at Rio Grande Village that are adjacent to Spring 4 refuge pond should be relocated to a greater distance away from the habitat of Big Bend gambusia. (Recovery Task 1.36 [USFWS 1984, p. 23])

Conduct climate change vulnerability analysis.

Studies should be initiated to evaluate the vulnerability of Big Bend gambusia to the future impacts associated with climate change. For example, direct studies should be undertaken to determine thermal preferences and tolerances and effects of temperature on life history parameters that influence Big Bend gambusia's population dynamics. Studies

should consider the effects of accelerating climate change on future groundwater levels and water temperatures at the spring outlets.

Update the recovery plan.

The recovery plan should be updated to include objective and measurable criteria that take into consideration all of the threats to the species, including climate change. This is currently considered the lowest priority action because other conservation actions described in this 5-year review should be conducted first to accomplish tangible benefits for conservation of the species.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Big Bend gambusia, *Gambusia gaigei*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By: Angie Reisch, Austin ESFO

FIELD OFFICE APPROVAL:

Acting
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Approve Adam M. Zerrenner Date 1-19-12

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Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Region 2

Approve Michelle Shaughnessy Date 2/9/12