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INTRODUCTION

The reach of Bonita Creek, Graham County, Arizona, between the City of Safford infiltration gallery dike and a constructed fish exclusion barrier was chemically renovated with the piscicide rotenone in 2008 to eliminate nonnative fishes as part of a multi-agency native fish restoration project (Robinson *et al*., 2009) (Figure 1). Following the renovation, salvaged native fishes (the extant fish fauna) including endangered Gila chub (*Gila intermedia*), longfin dace (*Agosia chrysogaster*), speckled dace (*Rhinichthys osculus*), Sonora sucker (*Catostomus insignis*), and desert sucker (*Pantosteus clarkii*) were returned to the renovated reach. In addition, federally-listed loach minnow (*Tiaroga cobitis)*, spikedace (*Meda fulgida*), desert pupfish (*Cyprinodon macularius*), and Gila topminnow (*Poeciliopsis occidentalis*) were translocated to and stocked into the stream (Table 1). Fish for translocations and stockings were obtained from Aquatic Research and Conservation Center (ARCC) and The Nature Conservancy's Lower San Pedro River Preserve (TNC-LSPRP) ponds.

After the native fish stockings in 2008, nonnative fishes were discovered in the renovated portion of Bonita Creek. Western mosquitofish (*Gambusia affinis*) and green sunfish (*Lepomis cyanellus*) in 2009, fathead minnow (*Pimephales promelas*) in 2010, and yellow bullhead (*Ameiurus natalis*) in 2011. Of the four nonnatives, green sunfish and yellow bullhead are piscivorous and hence will have the greatest negative impacts on the native species. Because of the negative impacts to the native fish assemblage, mechanical removal of nonnative fish was initiated in 2009. The goal is to remove enough individuals to reduce the population to levels where the native fish species can successfully reproduce and recruit.

Annual monitoring of the fish assemblage in Bonita Creek was ongoing prior to barrier construction and native fish stocking and continued afterwards. The purpose of the annual monitoring is to document and detect changes in the fish assemblage and to identify those biotic and abiotic factors that influence assemblage dynamics, and after fish were stocked, to determine if they had established populations. The first post-stocking annual monitoring was completed in April 2009 at fixed monitoring locations and an inter-agency monitoring effort throughout the entire treated reach was completed between August 31 and September 02, 2009. The multi-agency monitoring effort was documented in Boyarski, *et al*., 2011. This report summarizes the results of the Bonita Creek native fish monitoring conducted during March 19-23, 2016 and March 29-30, 2016.

PROJECT AREA

Bonita Creek originates in the Gila Mountains on the San Carlos Apache Indian Reservation (Reservation) and flows southeasterly from its headwaters approximately 46 miles to its confluence with the Gila River. The Bonita Creek watershed drains approximately 236,000 acres (370 square miles) and is a mixture of federal, city, tribal, and private lands. From the reservation boundary downstream, Bureau of Land Management (BLM) manages approximately

92% of the lands and the remaining 8% are City of Safford and private holdings. Five springs are located within the basin. Tule Spring is the largest and is located on the Reservation. The other four, Cottonwood, Lion, Hackberry, and Farrell, are minor springs (measured discharge of 1-10 gallons per minute) and are located on BLM lands. Stream flow in Bonita Creek is essentially intermittent with only the lower 15 miles chiefly perennial. Within the perennial section, continuous surface flows may not always be present below the City of Safford's infiltration gallery, especially during drought periods when water system wells are pumped to supplement withdrawals from the creek during times of increased water demand. The tributaries that drain into Bonita Creek contribute only ephemeral flow.

Approximately five miles above the mouth of Bonita Creek, the City of Safford's infiltration gallery dike collects water for a 24-mile long pipeline that extends down the creek and across the Gila River Valley to Solomon, Safford, and Thatcher for public supply. The infiltration gallery effectively separates Bonita Creek into a lower and upper reach and has acted as a barrier against nonnative fish migration upstream from the Gila River since 1939. However, the integrity of the infiltration gallery dike is unknown, and if it failed, nonnative fishes could move upstream, jeopardizing the upstream native fishery. Aquatic and riparian habitat in upper Bonita is less affected by recreation than downstream areas due to poor road conditions. In addition, upper Bonita Creek also does not experience the dewatering that is associated with the infiltration gallery.

A Bureau of Reclamation funded fish barrier was built approximately 1.3 miles upstream of the confluence with the Gila River during the summer of 2008 to protect an additional 1.7 miles of aquatic habitat and prevent upstream movement of nonnative species from the Gila River. There was a lack of sufficient fill material for effective backfilling of the stream channel, so the area behind the barrier became impounded with water after barrier construction. The impoundment created ideal habitat for nonnative fishes, which reappeared a year after the barrier was constructed. This threat was eliminated in 2011, when the impounded area above the barrier was drawn down and fill materials were transported to the site and spread out over the depression to prevent future ponding during normal flow periods.

METHODS - MONITORING PROTOCOL

Seven fixed 200-meter (m) long monitoring sites were established in Bonita Creek in 2005 based on access and habitat type. Three sites were established below the infiltration gallery dike and four above. Sites below the infiltration gallery are named Serna Cabin (also known as Below Barrier), Upper Site 1, and the Gallery. The Serna Cabin site is downstream of the reach that was chemically renovated in 2008, and typically goes dry except for a few pools associated with the west bank. Upper Site 1 and the Gallery are located within the reach that was renovated. Sites above the infiltration gallery are named Lee Trail, Red Knolls, Midnight Canyon, and Reservation Boundary (Figure 1). In 2015, the Gallery monitoring site went dry due to pumping from City of Safford.

Aquatic and riparian habitat conditions have changed throughout Bonita Creek due to an increase in beaver abundance and distribution. As a result of beaver dam building activities, much of the aquatic habitat in Bonita Creek (including the monitoring sites) have transitioned from lotic to lentic with beaver dam-and-pond complexes dominating the landscape.

In 2016, annual monitoring was completed during March 19-23 and 29-30, 2016. Gear types used to sample fish included backpack electrofishers (Smith Root model LR24), Gee metal minnow traps (25 centimeter (cm) diameter, 47 cm long, double throat, 0.3 or 0.6 cm mesh), Promar® collapsible minnow traps (0.3 m diameter, 0.9 m long, double throat, 0.9 cm mesh and 0.46 m long x 0.3 m wide, with 0.6 cm mesh), seines (10 feet (ft) x 6ft, 1/8inch mesh), and dip-nets. Multiple gear types were used because the complex habitat, which included deep pools, could not be effectively sampled with just one gear type. The stream habitat can change annually, so gear types used at a site change accordingly to ensure sampling efficacy. Backpack electrofishers used in conjunction with dip-nets, or seines ("block and shock") were used in shallow pools (<3 ft deep), run, and riffle habitats. Deep pools (>3 ft deep) were sampled with Gee metal minnow traps and collapsible Promar minnow traps. All traps were baited with Purina Dog Chow and were set overnight.

All monitoring sites were delineated into mesohabitat types (*i.e.*, run, riffle, pool, etc.) and surveyed separately. Captured fish were held in buckets with aeration until processed. If fish numbers were high or if multiple adult chubs and suckers were captured, fishes were processed; otherwise processing occurred after the mesohabitat unit was sampled. Captured fish were identified to species and enumerated. All native fish species captured, with the exception of Gila topminnow were measured and total length recorded. After one hundred of each species had been measured, species were no longer measured, but were categorized into two size classes, which were meant to represent juveniles and adults (Table 2). Fish too small to identify were classified as larvae. Once processed, native fish were released alive just downstream of the reach where they were captured. All green sunfish and yellow bullhead collected were measured and sexed if gametes expressed. Following data collection, all nonnative species were euthanized using tricane methanesulfonate (MS-222).

Data recorded at each monitoring site included: stream name, site name, GPS location, date, time, participants, effort, species of fish captured, length of fish, general comments on the fish, gear type, gear settings and seconds shocked (if backpack electrofisher), and for traps, gear dimensions, date and time set, and date and time pulled. Water quality data collected included: water temperature in Celsius (ºC), pH, conductivity in microsiemens (µS), dissolved oxygen in milligrams per liter (mg/L), and turbidity in Nephelometric Turbidity Units (NTU).

The American Fisheries Society (AFS) macrohabitat classification (Arend, 1999) was used to identify primary mesohabitats (*i.e.*, pools, riffles, and glides) for quantification. Pebble counts following Wolman (1954) were used to characterize streambed materials at all permanent monitoring sites. The Wolman technique requires the observer to measure sizes of random particles using a gravelometer. A gravelometer is used as it is more accurate than a ruler, avoids bias for irregular particles, and meets USGS standards. A minimum of 100 measurements are taken in order to accurately quantify pebble distributions by walking upstream in a zig-zag pattern. Pebble sizes were delimited into 16 size classes (mm) and included: 2, 2.8, 4, 5.6, 8, 11, 16, 22.6, 32, 45, 64, 90, 128, 180, >180, and >256. The first 14 size classes, 2-180mm, are common sieve sizes. Two additional size classes (>180 and >256) were added to adequately capture larger particles encountered. Particle sizes were then grouped into substrate types (Table 3).

RESULTS FOR ANNUAL MONITORING 2016

Backpack Electrofisher Data: A total of 668 individuals representing seven native and four nonnative fish species were collected by electrofishing (Table 4). Natives comprised 92.2% (n=616) and nonnatives 7.8% (n=52) of total catch. Speckled dace was the most abundant native fish species captured and comprised 47.9% (n=320) of total catch, followed by Gila chub 12.1% (n=81), Sonora sucker 11.1% (n=74), desert sucker 9.7% (n=65), longfin dace 8.5% (n=57), Gila topminnow 2.5% (n=17), and loach minnow 0.3% (n=2) (Table 4). Of the four nonnative species collected, two, green sunfish (*Lepomis cyanellus*) and common carp (*Cyprinus carpio*) were only collected below the fish barrier and comprised 1.0% (n=7) and 0.1% (n=1) of nonnative total catch, respectively. Western mosquitofish 6.3% (n=42) and fathead minnow 0.3% (N=2) were both collected above the fish barrier and collectively comprised 6.6% of the catch. Tables 5-10 summarize backpack electrofisher data by site.

If Serna Cabin, the below barrier monitoring site, is excluded, a total of 660 individuals representing seven native and two nonnative fish species were collected. Natives comprised 93.3% (n=616) and nonnatives comprised 6.7% (n=44) of the total catch.

Promar Collapsible and Gee Metal Minnow Traps Data: Promar collapsible nets and Gee metal minnow traps were set overnight (minimum 15 hours per net) in pool habitat at Upper Site 1, Lee Trail, and Red Knolls. At Midnight Canyon nets were set for approximately two hours. A total of 1,842 fish were collected, 92.7% (n=1,708) were native and 7.3% (n=134) were nonnative (Table 11). Gila chub was the most numerous native fish captured and comprised 78.1% (n=1,440) of the total catch. Sonora sucker was the second most numerous fish at 12.2% (n=225), followed by speckled dace at 1.3% (n=24), Gila topminnow at 0.8% (n=15), and desert sucker at 0.2% (n=4). Fathead minnow was the most abundant nonnative fish at 2.7% (n=50); followed by green sunfish at 2.4% (n=44), Western mosquitofish at 1.1% (n=20), yellow bullhead at 1.0% (n=19), and common carp at 0.1% (n=1). Number of native and nonnative individuals captured (#), mean catch-per-unit effort (#/h for traps), and standard error (SE) of the mean is presented in Table 12.

In both electrofishing and trapping efforts a total of 2,510 individuals were collected; 92.6% (n=2,325) were native and 7.4% (n=186) were nonnative.

HABITAT DATA

Mesohabitat data was collected at six of the seven monitoring sites (Serna Cabin, Upper Site 1, Lee Trail, Midnight Canyon, and Reservation Boundary). No habitat data was collected at the Gallery site as it was dewatered by City of Safford pumping in 2014. Primary habitats encountered included pools, glides, riffles, and runs. Pool comprised the majority (42.2%) of the mesohabitat across all monitoring sites, followed by glide (27.6%), run (21.3%), and riffle (4.0%) habitats (Table 13). Ancillary habitats such as backwaters and road crossings comprised the remaining 5.0% of mesohabitats. Pools were the primary mesohabitat encountered at Upper Site 1 (56.5%), Lee Trail (90.0%), and Red Knolls (84.8%). Midnight Canyon was dominated by run habitat (61.1%); whereas Serna Cabin and Reservation Boundary were predominantly glide habitats (40.7% and 84.5%), respectively.

When all gear types are combined, the majority of native fish collected (n=1,756) were captured in pool habitat, followed by run (n=228), glide (n=183), and riffle (n=143) habitats. Fifteen native fish were captured in a wetted road crossing. Nonnative fish were found primarily in pool (n=170) habitat, followed by glide (n=10), and run (n=6) habitats. If just backpack electrofisher data is analyzed the majority of native fish (n=228) were collected from run habitat, followed by glide habitat (n=183), riffle habitat (n=143), pool habitat (n=47), and ancillary habitat (n=15). Nonnative fish were collected from pool (n=36), glide (n=10), and run (n=6) habitats. Tables 14-19 show total number of native and nonnative fish species and their proportion collected by mesohabitat type using a backpack electrofisher at each monitoring site.

Sand, silt, and clay was the dominate substrate at Upper Site 1 (60.3%), Lee Trail (58.3%), Red Knolls (75.5%) and Reservation Boundary (52.3%). Gravel was the dominate substrate at Serna Cabin (59.5%) and Midnight Canyon (80.7%). If all sites are combined, sand, silt, and clay is the dominate substrate at 44.2%, followed by gravel at 41.4%, cobble at 12.9.%, and boulder at 1.4% (Table 20).

DISCUSSION START HERE

Native Fish Recovery Efforts

One of the key components of the Bonita Creek native fish restoration project was to establish self-sustaining populations of four endangered species (Gila topminnow, desert pupfish, loach minnow, and spikedace). In 2008, the four endangered species were stocked into lower Bonita Creek. In 2009-2011 and 2014-2015, upper Bonita Creek was stocked at four different locations (Lee Trail, Red Knolls, Midnight Canyon, and Reservation Boundary); however, not every species was stocked at each location due to habitat suitability and unavailability of stock. Annual monitoring documents and detects changes in the resident fish assemblage and determines if the stocked species have established populations. Of the four endangered fish species stocked between the City of Safford’s infiltration gallery and the constructed fish barrier, only Gila topminnow established a population. Gila topminnow dispersed both upstream and downstream of their stocking location and in certain reaches they numbered in the hundreds in 2009 (Boyarski *et al*., 2011) and 2010 (Blasius and Conn, 2010). However, since that time, their numbers decreased in the treatment reach and none were captured in 2011, only two were captured in 2012, and none were captured in 2013, 2014, 2015, or 2016. Although no Gila topminnow were captured during the annual monitoring, 78 were collected during nonnative removal efforts in 2016. Seventy-six were collected between road crossings 2-3, one was collected between road crossings 7-8, and one was collected between road crossings 11-12. Gila topminnow are persisting in the treatment reach, but their numbers have declined likely due to spread and establishment of Western mosquitofish, which can outcompete them for resources, and green sunfish and yellow bullhead, which prey on them.

It is likely that a combination of factors affected the establishment of the other three endangered fish species in the renovated reach. In 2010, one desert pupfish was captured at Upper Site 1. None were captured in 2011-2016, indicating that the species did not establish a population. Relatively few were stocked (147) and that in combination with predation by and competition with nonnative species likely made conditions unsuitable for their establishment. For spikedace and loach minnow, numbers stocked seemed adequate (448 and 687 respectively); however, lack of suitable habitat, mostly pools and glides, which are not typically occupied by these species, and green sunfish and yellow bullhead reinvasion likely negatively impacted these two endangered species. Pools and glides dominate the treatment reach and these habitats favor native species such as Sonora sucker and Gila chub and nonnative Western mosquitofish, yellow bullhead, green sunfish, and fathead minnow. Native fish will not be stocked into the renovated reach until the nonnative fishes can be controlled or eradicated. In addition, lower Bonita Creek is dewatered in sections from City of Safford groundwater pumping and water removal for municipal purposes. Beaver dam removal and pipeline access for monitoring and maintenance also result in significant alteration to both the aquatic and riparian habitats in lower Bonita Creek.

Above the City of Safford's infiltration gallery, native endangered fish were stocked into upper Bonita Creek in 2009, 2010, 2011, 2014, and 2015 (Table 1). Gila topminnow established a population at Lee Trail although none were collected in 2010 or 2011. In 2012, 168 were collected and in 2013, 96 were collected. In March 2013, hundreds of Gila topminnows were observed and 70 were collected during an outreach and education program. Forty-eight Gila topminnows were collected in 2014, 30 in 2015, and 14 in 2016. Pools have been the predominate mesohabitat at Lee Trail from 2012-2016 and provides preferred habitat for Gila topminnow, Gila chub, and Sonora sucker. Gila topminnow were observed, but not collected in 2012 at Red Knolls where they were stocked in 2011. In 2013 three were collected, in 2014 one was collected, and in 2015 10 were captured. No Gila topminnow were collected in 2016, although they were observed swimming in the Red Knolls road crossing. Although very few Gila topminnow have been collected during the annual monitoring, hundreds have been observed upstream of the Red Knolls monitoring site and have established a robust population. The habitat at Red Knolls from 2012-2016 was also predominately pool habitat and provides ideal habitat for Gila topminnow. Desert pupfish have not been captured during annual monitoring at Lee Trail since they were stocked in 2010, so do not appear to have established at this location. At Red Knolls, desert pupfish were stocked in 2011. Since that stocking one pupfish was collected in 2012 and one in 2013. None have been collected since, so it is unlikely they have established a population at this location. Neither spikedace nor loach minnow have been detected during the annual monitoring since being stocked near Red Knolls crossing likely due to unsuitable habitat. Potential segments of suitable habitat, although limited, may exist near the Midnight Canyon monitoring site for both loach minnow and spikedace. In November 2014, 288 loach minnow were stocked approximately 150 meters downstream of the Midnight Canyon monitoring site to attempt to establish a population. Seven of the stocked loach minnow were collected in 2015 and two in 2016. Additionally, 385 Gila topminnows were stocked in a beaver dam pool that is located in the upper portion of the Midnight Canyon monitoring site. Five Gila topminnow were collected in 2015 and 18 in 2016. Although not associated with a permanent monitoring site, both desert pupfish and Gila topminnow were stocked near the Reservation Boundary in 2014 and 2015. The fish stocked in 2014 were not detected during monitoring in 2015 so an additional stocking of both species into separate pool habitats was conducted on November 10, 2015 to try and establish populations. In 2016, The Arizona Game and Fish Department surveyed and collected 31 Gila topminnow in the pool they were stocked in; however, no desert pupfish were collected.

Collection of mesohabitat data began in 2011 to evaluate aquatic habitat, its relationship to species captured, and to better understand lack of establishment of stocked species. From 2011-2014, the number of fishes captured by electrofishing declined each year. In 2015, the number of fish collected increased by 196 and decreased in 2016 by 16. These differences between years, using catch per unit effort, as determined by one-way ANOVA (F (5, 34) = 0.68, p = 0.642) were not statistically significant.

The slight decrease in number of fish captured by electrofishing was likely not due to changes in habitat as the amount of shallow habitats that are monitored with electrofishing increased by 9.7% for riffles, 6.5% for glides, and 20.1 % for runs from 2015 to 2016. Conversely, the amount of habitat (*i.e.,* pools) sampled with nets decreased by 17% from 2015 to 2016. Note that Red Knolls habitat data was not collected in 2011 and no habitat data was collected in 2015 and 2016 from Gallery as the monitoring site was dry.

Conversely to electrofishing, there was a 545.0% increase (1,547 more fish) in the number of fish collected in nets in 2012 than in 2011. An 8.14% increase (149 more fish) from 2012 to 2013; a 16.82% decrease (333 less fish) from 2013 to 2014; an increase of 5.89% (97 more fish) from 2014 to 2015; and an increase of 5.62% (n=98) from 2015-2016. The majority of pool and deeper glide habitats are sampled with traps. There was a 104.08% increase in pool habitat from 2011 to 2012, a 29.01% increase from 2012 to 2013, a 3.47% decrease from 2013 to 2014, a 18.06% decrease from 2014 to 2015, and a 16.90% decrease from 2015 to 2016. In 2011, 50 nets were set at three sites (Upper Site 1, Gallery, and Lee Trail), in 2012 230 nets were set at four sites (Upper Site 1, Gallery, Lee Trail, and Red Knolls), and in 2013-2014, 225 nets were set at five sites with pool and glide mesohabitats (Serna Cabin, Upper Site 1, Gallery, Lee Trail, and Red Knolls). The number of nets set across the monitoring sites decreased to 200 in 2015 as the Gallery monitoring site was dewatered and no nets were set. In 2016, the number of nets set increased by 10 to 210 as 10 Promar red nets were set at Midnight Canyon.

A one-way ANOVA was conducted to determine if Gee minnow trap and Promar minnow trap catch per unit effort differed between Upper Site 1, Gallery, Lee Trail, and Red Knolls. There was no statistical difference between Gee minnow trap catch per unit effort (F (5, 15) = 0.96, p = 0.474) or Promar minnow trap catch per unit effort (F (5, 15) = 0.43, p = 0.818) among the monitoring sites between the six years (2011-2016).

Nonnative Aquatic Species

Since 2008, four nonnative fish species have been collected above the barrier in the renovated reach. Fathead minnow likely washed downstream from a known source above the infiltration gallery. However, for the other three species, four possible scenarios for reinvasion have been put forth: 1) an intentional or accidental human-aided release, 2) the renovation was not 100% successful, 3) birds, or 4) barrier failure or compromise. The first two of these scenarios are the most plausible and have been discussed in previous reports (Blasius and Conn, 2010 and Blasius and Conn, 2011).

In December 2013, nonnative northern crayfish (*Orconectes virilis*), was detected above the barrier during nonnative fish removal. They are present below the barrier and in the Gila River, although they are not abundant in either location. It is not known at this time whether or not they will establish a population in Bonita Creek as they are removed when encountered. In 2015, nonnative American bullfrog (*Lithobates catesbeianus*) was detected at the Red Knolls monitoring site. Multiple size classes are present and they have established a population.

Anchor worm (*Lernaea sp.*), is a deleterious fish ecto-parasite, which has become widely distributed throughout the world presumably through the introduction of various aquatic organisms into new localities (McAllister, *et. al*., 2011). Lernaea was present on fish located below the City of Safford infiltration gallery, but was not detected on fish above the infiltration gallery until March of 2012 at Lee Trail (Blasius and Conn, 2011). Anchor worm is widespread in Arizona so infected fish in the Gila River may have moved into lower Bonita Creek, thus dispersing the parasite. It is also possible that anchor worm were inadvertently transported to upper Bonita Creek during a fish stocking. Low levels of Lernaea infestation are usually not life-threatening, however heavy infestations may severely stress the host fish, with the area of attachment usually the site of hemorrhages and muscle necrosis (Piasecki *et al*., 2004). These areas of inflammation are then susceptible to secondary bacterial and/or fungal infections. Parasitism by Lernaea is generally a problem in aquaculture facilities and in the aquarium trade

(Shariff and Roberts 1989), where infestation can be potentially lethal or pathogenic when secondary microbial infections occur at the sites of lesions. Parasitism by Lernaea can, however, also be a conservation concern because of its negative effects on native fish (Durham *et al.*, 2002; Bond, 2004; Hoffnagle *et al.*, 2006) and amphibians (Ming, 2001 and Kupferberg, 2009) when it becomes established in the wild.

The AGFD has fish health assessments done on all donor sites at least every two years to ensure that unwanted pathogens and parasites are not transported to stocking sites. Sites where parasites or pathogens of concern are detected are typically not used for stocking efforts unless the parasite is ubiquitous and not considered a threat or if the recipient location already has the identified parasite. Fish are also visually inspected for external parasites and if parasites of concern are detected, the fish are not transported. If Lernaea are detected, and it is still desirable to translocate the fish, then the fish would be treated with Dimlin for two-three weeks prior to being stocked. However, eradication of Lernaea from the donor site would be preferable.

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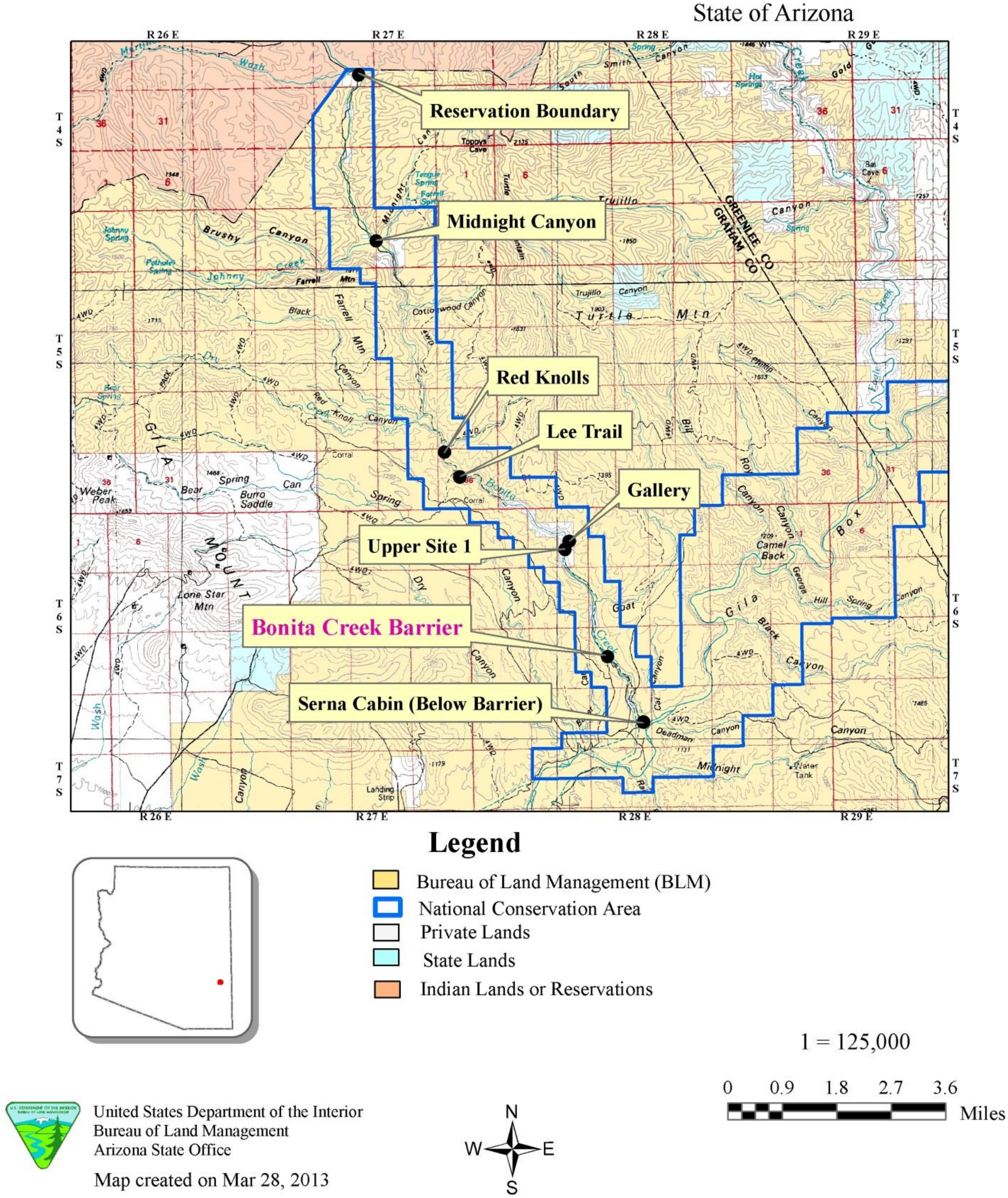

Figure 1. Map showing the locations of the seven monitoring sites and fish barrier.

Table 1. Native fish stockings into Bonita Creek, Graham County, Arizona from 2008 through 2015.

Location	Year	Number and Species Stocked	Lineage	Origin of fish (donor site)
Treatment reach, between road crossings 13 and 14	2008	687 loach minnow	Blue River	ARCC
		448 spikedace	Upper Gila River	ARCC
Treatment reach, between road crossings 13 and 14	2008	147 desert pupfish	El Doctor Marsh	TNC-LSPRP
Treatment reach, between road crossings 2 and 3	2008	975 Gila topminnow	Bylas Spring	TNC-LSPRP
Red Knolls Crossing	2009	165 spikedace	Upper Gila River	ARCC
Lee Trail	2010	264 desert pupfish	El Doctor Marsh	TNC-LSPRP
		834 Gila topminnow	Bylas Spring	TNC-LSPRP
Red Knolls Crossing	2010	156 loach minnow	Blue River	ARCC
		567 spikedace	Upper Gila River	ARCC
Red Knolls Crossing	2011	1,972 Gila topminnow	Bylas Spring	TNC-LSPRP
		336 desert pupfish	El Doctor Marsh	TNC-LSPRP
Midnight Canyon	2014	288 loach minnow	Blue River	ARCC
		385 Gila topminnow	Bylas Spring	TNC-LSPRP
Reservation Boundary	2014	680 desert pupfish	El Doctor Marsh	TNC-LSPRP
		663 Gila topminnow	Bylas Spring	TNC-LSPRP
Reservation Boundary	2015	343 desert pupfish	El Doctor Marsh	TNC-LSPRP
		998 Gila topminnow	Bylas Spring	TNC-LSPRP

Table 2. Native fish size classes used during monitoring to differentiate putative juvenile fish (small) from putative adult fish (large). Fish measurements are total length (TL) in millimeters (mm).

Fish Species	**Size Class**	
	Small	**Large**
Longfin dace	<45	≥45
Gila chub	<90	≥90
Speckled dace	<45	≥45
Sonora sucker	<150	≥150
Desert sucker	<125	≥125
Loach minnow	<38	≥38
Spikedace	<45	≥45
Gila topminnow	<20	≥20
Desert pupfish	<20	≥20

Table 3. Wolman's classification of stream substrate by particle size.

Substrate Name	**Size Classes (mm)**
Sand, silt, clay	≤ 2
Very Fine Gravel	2-4
Fine Gravel	4-8
Medium Gravel	8-16
Coarse Gravel	16-32
Very Coarse Gravel	32-64
Small Cobble	64-90
Medium Cobble	90-128
Large Cobble	128-180
Very Large Cobble	180-256
Boulder	≥256

Table 4. Fishes captured from Bonita Creek, Arizona, March 19-23 and 29-30 by backpack electrofishing. Data represent number of individuals for each species at a site, total number across all sites and proportion for each species across sites, and total catch for each site. Native fish species are indicated with an asterisk (*).

Species	Serna Cabin (Below Barrier)	Upper Site 1	Lee Trail	Red Knolls	Midnight Canyon	Reservation Boundary	Total	Percent Total
*Gila chub		12	23		4	42	81	12.1
*Longfin dace					29	28	57	8.5
*Speckled dace			13	7	216	84	320	47.9
*Sonora sucker		8	25	1	29	11	74	11.1
*Desert sucker			1	7	46	11	65	9.7
*Gila topminnow			5		12		17	2.5
*Loach minnow					2		2	0.3
Western mosquitofish		42					42	6.3
Fathead minnow		2					2	0.3
Green sunfish	7						7	1.0
Common carp	1						1	0.1
# Native Species	0	20	67	15	338	176	616	92.2
# Nonnative Species	8	44	0	0	0	0	52	7.8
Total Fish	8	64	67	15	338	176	668	100.00

Table 5. Summary of fishes sampled by backpack electrofisher at Serna Cabin, 2016.

Species	Number	CPUE (fish/28.42min)	% of total
Common carp	1	0.04	12.50
Green sunfish	7	0.25	87.50
Total	8	0.28	100.00

Table 6. Summary of fishes sampled by backpack electrofisher at Upper Site 1, 2016.

Species	Number	CPUE (fish/13.28 min)	% of total
Gila chub	12	0.90	18.8
Sonora sucker	8	0.60	12.5
Fathead minnow	2	0.15	3.1
Western mosquitofish	42	3.16	65.6
Total	64	4.82	100.00

Table 7. Summary of fishes sampled by backpack electrofisher at Lee Trail, 2016.

Species	Number	CPUE (fish/17.53 min)	% of total
Gila chub	23	1.31	37.3
Sonora sucker	25	1.43	34.3
Desert sucker	1	0.06	1.5
Speckled dace	13	0.74	19.4
Gila topminnow	5	0.29	7.5
Total	67	3.82	100.00

Table 8. Summary of fishes sampled by backpack electrofisher at Red Knolls, 2016.

Species	Number	CPUE (fish/7.13 min)	% of total
Sonora sucker	1	0.14	6.7
Desert sucker	7	0.98	46.7
Speckled dace	7	0.98	46.7
Total	15	2.10	100.00

Table 9. Summary of fishes sampled by backpack electrofisher at Midnight Canyon, 2016.

Species	Number	CPUE (fish/17.55 min)	% of total
Gila chub	4	0.23	1.2
Sonora sucker	29	1.65	8.6
Desert sucker	46	2.62	13.6
Longfin dace	29	1.65	8.6
Speckled dace	216	12.31	63.9
Loach minnow	2	0.11	0.6
Gila topminnow	12	0.68	3.6
Total	338	19.26	100.00

Table 10. Summary of fishes sampled by backpack electrofisher at Reservation Boundary, 2016.

Species	Number	CPUE (fish/22.58 min)	% of total
Gila chub	42	1.86	23.9
Longfin dace	28	1.24	15.9
Sonora sucker	11	0.49	6.3
Desert sucker	11	0.49	6.3
Speckled dace	84	3.72	47.7
Total	176	7.79	100.00

Table 11. Fishes captured from Bonita Creek, Arizona, March 19-23 and 29-30, 2017 in Promar collapsible traps and Gee metal minnow traps. Data represent number of individuals for each species, total number, and proportion for each species across sites. Native fish species are indicated with an asterisk (*).

Net Data	*Gila chub	*Sonora sucker	*Desert sucker	*Speckled dace	*Gila topminnow	Green sunfish	Yellow bullhead	Common carp	Fathead minnow	Western mosquitofish	Total
Serna Cabin Promar						20	8	1			29
Serna Cabin Metal						24					24
Upper Site 1 Promar	19	16					11				46
Upper Site 1 Metal	126	36							40	20	222
Lee Trail Promar	183	87	1						1		272
Lee Trail Metal	313	55			9				5		382
Red Knolls Promar	395	23	1						2		421
Red Knolls Red Promar	14										14
Red Knolls Metal	364	7	1						2		374
Midnight Canyon Red Promar	26	1	1	24	6						58
Total	1,440	225	4	24	15	44	19	1	50	20	1,842

Table 12. Fishes captured from Bonita Creek, Arizona, March 19-23 and 29-30, 2016, in Promar collapsible traps and Gee metal minnow traps. Data represent number of individuals for each species captured (#), mean catch-per-unit effort (#/hour) and standard error (SE). Sample size (N) is the number of collapsible or metals minnow traps set. Native fish species are indicated with an asterisk (*).

Species	**Statistics**	**Serna Cabin**		**Upper Site 1**		**Lee Trail**		**Red Knolls**			**Midnight Canyon**
		Promar (N=10)	**Metal (N=10)**	**Promar (N=40)**	**Metal (N=40)**	**Promar (N=25)**	**Metal (N=25)**	**Promar (N=20)**	**Promar Red (N=10)**	**Metal (N=20)**	**Promar Red (N=10)**
***Gila chub**	Number	—	—	19	126	183	313	395	14	364	26
	Mean #/Hour	—	—	0.02	0.15	0.40	0.67	1.02	0.07	0.94	0.71
	SE	—	—	0.01	0.03	0.10	0.10	0.31	0.03	0.12	0.33
***Sonora sucker**	Number	—	—	16	36	87	55	23	—	7	1
	Mean #/Hour	—	—	0.02	0.04	0.19	0.12	0.06	—	0.02	0.03
	SE	—	—	0.01	0.01	0.06	0.03	0.02	—	0.01	0.03
***Desert sucker**	Number	—	—	—	—	1	—	1	—	1	1
	Mean #/Hour	—	—	—	—	0.00	—	0.00	—	0.00	0.03
	SE	—	—	—	—	0.00	—	0.00	—	0.00	0.03
***Speckled dace**	Number	—	—	—	—	—	—	—	—	—	24
	Mean #/Hour	—	—	—	—	—	—	—	—	—	0.66
	SE	—	—	—	—	—	—	—	—	—	0.38
***Longfin dace**	Number	—	—	—	—	—	—	—	—	—	—
	Mean #/Hour	—	—	—	—	—	—	—	—	—	—
	SE	—	—	—	—	—	—	—	—	—	—
***Gila topminnow**	Number	—	—	—	—	—	9	—	—	—	6
	Mean #/Hour	—	—	—	—	—	0.02	—	—	—	0.16
	SE	—	—	—	—	—	0.01	—	—	—	0.17
Common carp	Number	1	—	—	—	—	—	—	—	—	—
	Mean #/Hour	0.01	—	—	—	—	—	—	—	—	—
	SE	0.01	—	—	—	—	—	—	—	—	—
Green sunfish	Number	20	24	—	—	—	—	—	—	—	—
	Mean #/Hour	0.11	0.13	—	—	—	—	—	—	—	—
	SE	0.05	0.05	—	—	—	—	—	—	—	—
Yellow bullhead	Number	8	—	11	—	—	—	—	—	—	—
	Mean #/Hour	0.04	—	0.01	—	—	—	—	—	—	—
	SE	0.02	—	0.00	—	—	—	—	—	—	—
Fathead minnow	Number	—	—	—	40	1	5	2	—	2	—
	Mean #/Hour	—	—	—	0.05	0.00	0.01	0.01	—	0.01	—
	SE	—	—	—	0.01	0.00	0.01	0.01	—	0.01	—
Western mosquitofish	Number	—	—	—	20	—	—	—	—	—	—
	Mean #/Hour	—	—	—	0.02	—	—	—	—	—	—
	SE	—	—	—	0.01	—	—	—	—	—	—
Sonora mud turtle	Number	—	—	1	—	—	—	1	—	—	—
	Mean #/Hour	—	—	0.00	—	—	—	0.00	—	—	—
	SE	—	—	0.00	—	—	—	0.00	—	—	—

Table 13. Length (m) and percent length (in parentheses) of mesohabitat types at each permanent monitoring site within Bonita Creek, 2016.

Monitoring Site	Riffle	Pool	Glide	Run	Isolated Backwater	Backwater	Road Crossing	Total Length
Serna Cabin		56.15 (20.4)	111.7 (40.7)	83.3 (30.3)	23.5 (8.6)			274.7
Upper Site 1		99 (56.5)	40.4 (23.1)	35.7 (20.4)				175.1
Lee Trail		180 (90.0)	10 (5.0)	10 (5.0)				200.0
Red Knolls		173 (84.8)					31 (15.2)	204.0
Midnight Canyon	50 (24.0)	6 (2.9)	17 (8.2)	127 (61.1)		8 (3.8)		208.0
Reservation Boundary		18 (9.0)	169 (84.5)	13 (6.5)				200.0
Total Mesohabitat Composition	50	532.2	348.1	269	23.5	8	31	1261.8
Percent Habitat	4.0	42.2	27.6	21.3	1.9	0.6	2.5	100

Table 14. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Serna Cabin using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Serna Cabin					
Species	Glide	Pool	Riffle	Run	Road Crossing
Green sunfish	2	5			
Common carp		1			
Total	2	6			

Table 15. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Upper Site 1 using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Upper Site 1					
Species	Glide	Pool	Riffle	Run	Road Crossing
*Gila chub	1	6		5	
*Sonora sucker		7		1	
Fathead minnow		2			
Western Mosquitofish	8	28		6	
Total	9	43		12	

Table 16. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Lee Trail using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Lee Trail					
Species	Glide	Pool	Riffle	Run	Road Crossing
*Gila chub	4	10		9	
*Speckled dace				13	
*Sonora sucker	8	16		1	
*Desert sucker				1	
*Gila topminnow	3			2	
Total	15	26		26	

Table 17. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Red Knolls using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Red Knolls					
Species	Glide	Pool	Riffle	Run	Road Crossing
*Speckled dace					7
*Sonora sucker					1
*Desert sucker					7
Total					15

Table 18. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Midnight Canyon using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Midnight Canyon					
Species	Glide	Pool	Riffle	Run	Road Crossing
*Gila chub			4		
*Longfin dace			10	19	
*Speckled dace	8		74	134	
*Loach minnow				2	
*Sonora sucker	1		18	10	
*Desert sucker	1		37	8	
*Gila topminnow	1			11	
Total	11		143	184	

Table 19. Total number of native and nonnative fish species and their proportion collected by mesohabitat type at Reservation Boundary using a backpack electrofisher, 2016. Native fish species are indicated with an asterisk (*).

Reservation Boundary					
Species	Glide	Pool	Riffle	Run	Road Crossing
Gila chub	38	3		1	
Longfin dace	26			2	
Speckled dace	77			7	
Sonora sucker	5	5		1	
Desert sucker	10			1	
Total	156	8		12	

Table 20. Count and percent composition of substrate types by monitoring sites in 2015.

Monitoring Site	**Sand, silt, clay**	**Gravel**	**Cobble**	**Boulder**	**Total**
Serna Cabin	18 (14.3%)	75 (59.5%)	33 (26.2%)	0	126
Upper Site 1	73 (60.3%)	31 (25.6%)	14 (11.6%)	3 (2.5%)	121
Lee Trail	98 (58.3%)	52 (31.0%)	12 (7.1%)	6 (3.6%)	168
Red Knolls	80 (75.5%)	19 (17.9%)	7 (6.6%)	0	106
Midnight Canyon	17 (11.7%)	117 (80.7%)	10 (6.9%)	1 (0.7%)	145
Reservation Boundary	56 (52.3%)	26 (24.3%)	24 (22.4%)	1 (0.9%)	107
Total	342 (44.2%)	320 (41.4%)	100(12.9%)	11 (1.4%)	773