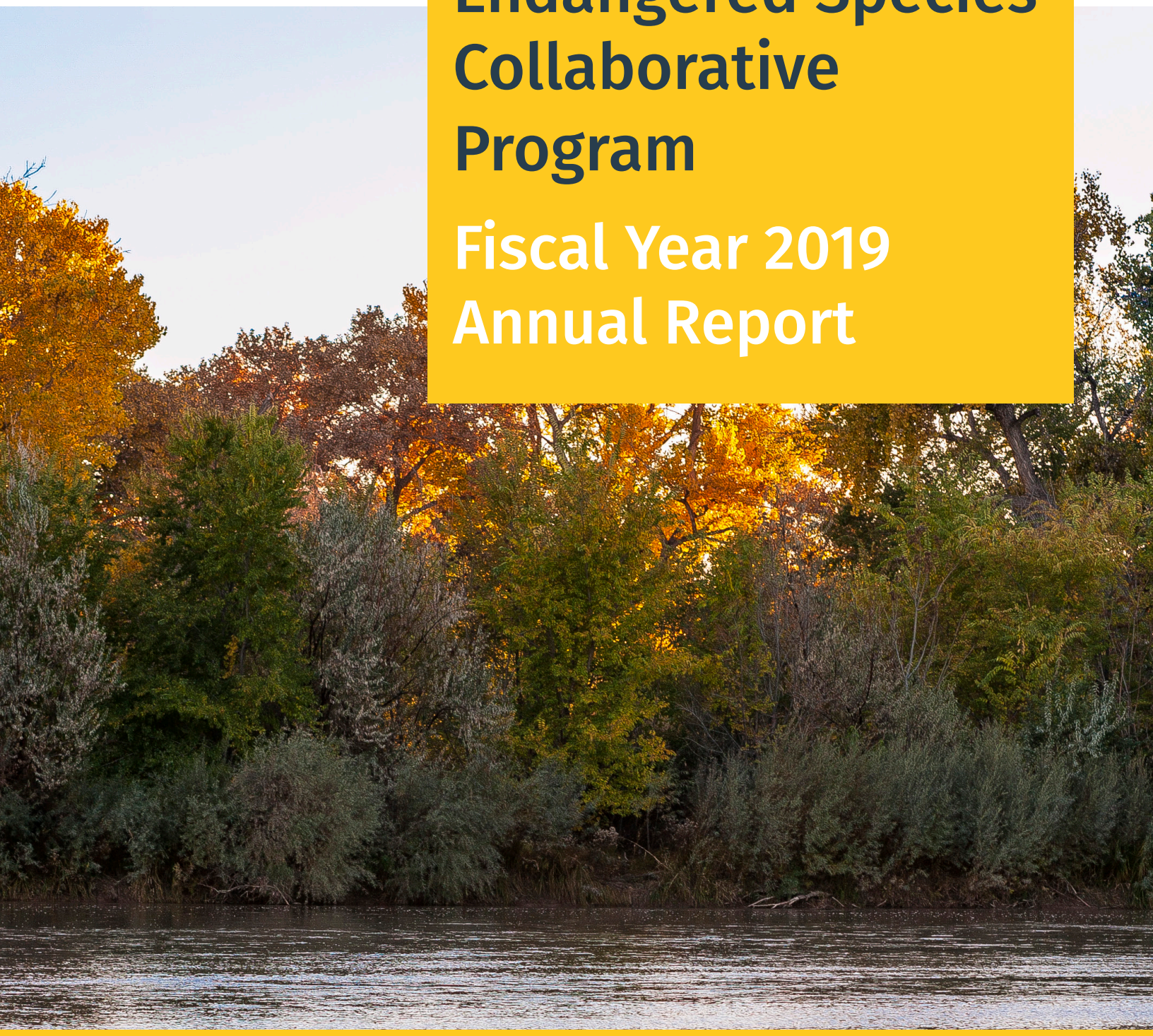
Middle Rio Grande Endangered Species Collaborative Program

Fiscal Year 2019 Annual Report



Program Website: https://webapps.usgs.gov/MRGESCP/

Photo: Scenic view at Bosque del Apache
Credit: Mike Marcus, APA

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On Behalf of:

The Middle Rio Grande Endangered Species Collaborative Program

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Acronyms & Abbreviations

Acronym/Abbreviation	Definition
2016 MRG BO	Final Biological and Conference Opinion for Bureau of Reclamation, Bureau of Indian Affairs, and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico
ACF	Aquatic Conservation Facility
ABCWUA	Albuquerque Bernalillo County Water Utility Authority
APA	Assessment Payers Association of the Middle Rio Grande Conservancy District
ARRC	Southwestern Native Aquatic Resource and Recovery Center
BEMP	Bosque Ecosystem Monitoring Program
BO	biological opinion
CoA	City of Albuquerque
CPUE	catch per unit effort
EC	Executive Committee
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
FPC	Fiscal Planning Committee
FY	fiscal year
HEC	Hydrologic Engineering Center
IDD	Isleta Diversion Dam
LLSMR	Los Lunas Silvery Minnow Refugium
MRG	Middle Rio Grande
MRGCD	Middle Rio Grande Conservancy District
MRGESCP/Program	Middle Rio Grande Endangered Species Collaborative Program
NMISC	New Mexico Interstate Stream Commission
PESU	Pecos sunflower
Reclamation	U.S. Bureau of Reclamation
RGSM	Rio Grande silvery minnow
SADD	San Acacia Diversion Dam
SWFL	Southwestern willow flycatcher
UNM	University of New Mexico
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YBCU	yellow-billed cuckoo

Executive Summary

The Middle Rio Grande Endangered Species Collaborative Program (MRGESCP or Program) is made up of federal, state, tribal, and local signatory organizations that work together to support actions in the Middle Rio Grande (MRG) that benefit endangered and threatened species. The Program aids in the recovery of five federally listed species inhabiting the MRG: the endangered Rio Grande silvery minnow (RGSM), the endangered Southwestern willow flycatcher (SWFL), the endangered New Mexico meadow jumping mouse (NMMJM), the threatened yellow-billed cuckoo (YBCU), and the threatened Pecos sunflower (PESU). As the MRGESCP works towards its species-specific goals, it is committed to protecting the MRG's existing and future water uses.

Program signatories support the Program's mission by performing scientific, technical, and administrative activities. The signatories fund and staff scientific studies, population management efforts, water operations, and habitat restoration to the benefit of the MRG's listed species, while also participating in Program planning, administration, and technical support. In fiscal year 2019 (FY19), the Program updated its mission to focus on conducting science that benefits listed species recovery through an adaptive management process. Signatories worked throughout FY19 to support this updated mission by contributing to numerous scientific endeavors and engaging in the development of an adaptive management framework for the Program. This report summarizes the Program's FY19 activities.

Photo: Jetty jacks in the Alameda Bosque
Credit: Mike Marcus, APA

Middle Rio Grande Endangered Species Collaborative Program

Background

The Middle Rio Grande Endangered Species Collaborative Program (MRGESCP or Program) is a collaborative partnership of federal, state, tribal, and local signatory organizations that aims to protect and recover federally listed species in the Middle Rio Grande (MRG), while also preserving the area's existing and future water uses. The Program has changed gradually over the years but was first formed in response to several events: the federal listing of the endangered Rio Grande silvery minnow (*Hybognathus amarus*; RGSM) under the Endangered Species Act (ESA) in 1994, the listing of the endangered Southwestern willow flycatcher (*Empidonax traillii extimus*; SWFL) in 1995, drought in 1996, and litigation related to these events in 1999.

In 2000, stakeholder organizations that were interested in species recovery and protection of water uses in the MRG formed the Endangered Species Act Work Group. This group led to the development of the MRGESCP, which was officially established in 2002 with the signing of the Memorandum of Understanding. In 2008, Program signatories reaffirmed their commitment by signing the Memorandum of Agreement (MOA).

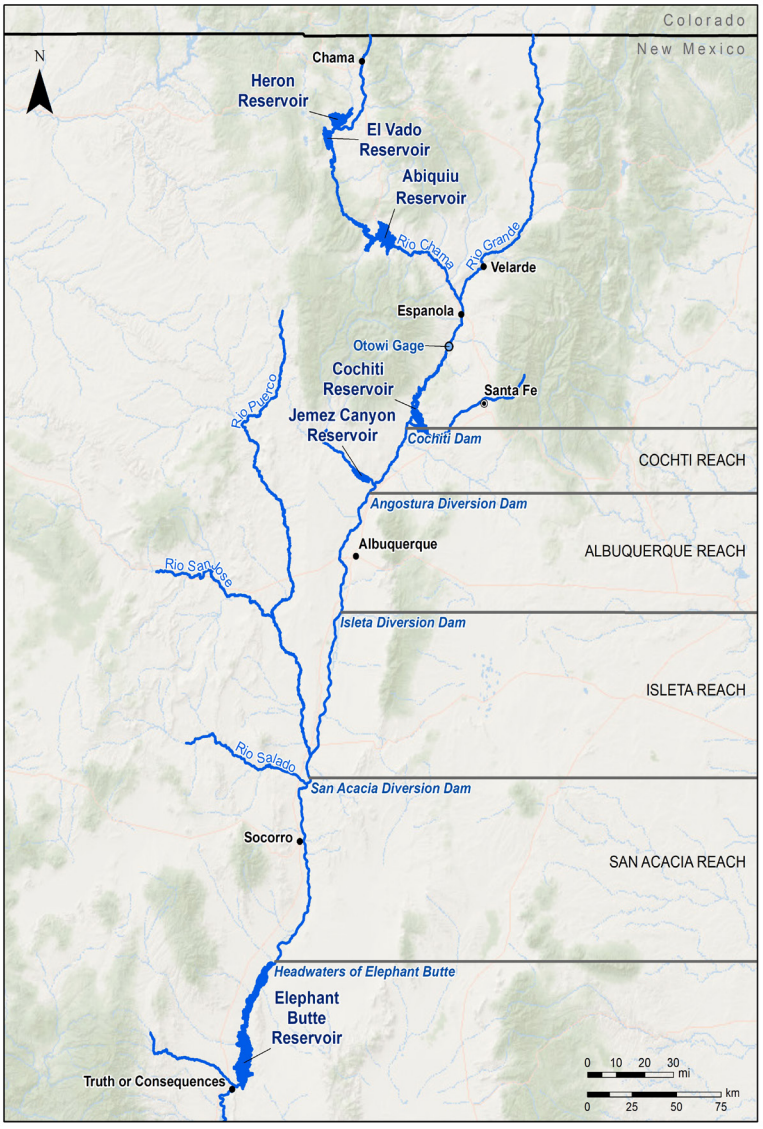

Figure 1. Map of the Program Area

The area of the Program stretches from the headwaters of the Rio Chama watershed and Rio Grande, including tributaries, downstream to the elevation of the spillway crest of Elephant Butte Reservoir at 4,450 feet above mean sea level, excluding the land area reserved for the full pool of the Elephant Butte Reservoir (Figure 1). Four reaches are delineated within the MRG and, from north to south, these are the Cochiti Reach, the Angostura (Albuquerque) Reach, the Isleta Reach, and the San Acacia Reach. Depending on their jurisdiction and authority, signatories may support activities within one or all four reaches.

FY19 Overview

Throughout FY19, the Program continued development of an adaptive management framework, which led to the adoption of an updated mission: to provide a collaborative forum to support scientific analysis and implementation of adaptive management to the benefit and recovery of the listed species pursuant to the ESA within the Program area, and to protect existing and future water uses while complying with applicable state, federal, and tribal laws, rules and regulations. Program signatories supported this mission by conducting numerous activities that benefited the MRG's listed species and contributing to the development of the MRGESCP's science and adaptive management program. Signatory activities in FY19 included scientific studies, habitat restoration, monitoring efforts, population management and augmentation, and water operations, as well as participation in Program planning, administration, and technical support.

In addition to its updated mission, the Program expanded its species of interest to include the following listed species in the MRG: the yellow-billed cuckoo (*Coccyzus americanus*; YBCU), listed as threatened in 2014; the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*; NMMJM), listed as endangered in 2014; and the Pecos sunflower (*Helianthus paradoxus;* PESU), listed as threatened in 1999. This was done to acknowledge the importance of ecosystem health in an effective science and adaptive management plan.

Photos (from left to right): Yellow-billed cuckoo | New Mexico meadow jumping mouse | Pecos sunflower
Credit: Andy Reago and Chrissy McClarren | Jennifer K. Frey, New Mexico State University | USFWS staff

Governance

Adopted in 2008, the Program's by-laws describe the governance structure, decision-making processes, and roles and responsibilities of its signatories. The by-laws have been amended over the years to accommodate Program development. Documents relating to governance, including by-laws, authorities, and charters, are maintained on the Program Portal, which can be accessed at **https://webapps.usgs.gov/MRGESCP/.**

Organizational Structure

Signatories

The following sixteen organizations were signatories of the Program's 2008 MOA in FY19:

- Albuquerque Bernalillo County Water Utility Authority (ABCWUA)
- Assessment Payers Association of the Middle Rio Grande Conservancy District (APA)
- Audubon New Mexico
- Bosque Ecosystem Monitoring Program (BEMP)
- City of Albuquerque (CoA) Open Space Division
- Middle Rio Grande Conservancy District (MRGCD)
- New Mexico Attorney General's Office
- New Mexico Department of Game and Fish
- New Mexico Interstate Stream Commission (NMISC)
- Pueblo of Isleta
- Pueblo of Sandia
- Pueblo of Santa Ana
- U.S. Army Corps of Engineers (USACE)
- U.S. Bureau of Reclamation (Reclamation)
- U.S. Fish and Wildlife Service (USFWS)
- University of New Mexico (UNM)

Representatives from these signatories, as well as other interested parties, worked collaboratively to complete the Program's FY19 activities. Program participants conduct activities through four main organizational structures: the Executive Committee (EC), the Fiscal Planning Committee (FPC), work groups, and ad hoc groups. The structures and functions of these committees and groups are outlined below.

Executive Committee

Federal Co-chair: Brent Esplin, Reclamation
Non-federal Co-chair: Janet Jarratt, APA (October 2018 - July 2019)
John Stomp, ABCWUA (July 2019 - present)

The MRGESCP is governed by the EC, which consists of one representative from each signatory. The EC oversees all Program groups and committees and makes decisions on their actions. The EC also informs, approves, and directs the implementation of Program initiatives and acts as the face of the Program in any communication with signatory and non-signatory organizations.

Fiscal Planning Committee

The EC selects a group of signatory representatives to serve on the Fiscal Planning Committee (FPC). This committee is tasked with coordinating and seeking funding streams for Program activities and coordinating related timelines and deadlines. The FPC reports signatory funding capabilities, potential funding resources, and gaps in funding to the EC.

Work Groups

Work groups are established by the EC to address specific Program directives and activities. They do so by providing focused assistance and expertise, scientific and technical review, and coordination of Program actions. Work groups meet regularly and are made up of signatory staff and additional parties with appropriate expertise. The following work groups met during FY19:

- Adaptive Management Work Group
- Population Monitoring Work Group
- Science and Habitat Restoration Work Group

Ad Hoc Groups

As necessary, Program committees and work groups create temporary subgroups that work on specific projects or tasks. These ad hoc groups consist of signatory staff and non-signatory parties with expertise or interest in the specialized topic assignment. Ad hoc groups report to their primary committee or work group and disband once their predetermined objectives have been met.

Photo: Scenic view at the Rio Grande Nature Center
Credit: Mike Marcus, APA

Program Activities

The MRGESCP signatories continued to support the recovery of the MRG's endangered and threatened species in FY19. These organizations worked collaboratively to conduct a wide range of activities, including scientific studies, surveys and monitoring, propagation and augmentation, habitat restoration, coordination of water operations, and Program support. The results of these activities helped signatories and other resource managers in the MRG determine the impacts of different actions on listed species and adjust management actions to benefit them. The signatories were also involved in Program management throughout the fiscal year.

The following sections describe the Program's FY19 activities, which are split into six categories: Avian Species, Rio Grande Silvery Minnow, Habitat Restoration, Science Support, Water Monitoring and Studies, and Program Support.

Avian Species

Program signatories contributed to long-term efforts aimed at monitoring SWFL and YBCU populations to discover trends and distribution in the MRG. Additionally, signatories collaborated to conduct noise disturbance and telemetry studies to better understand the listed avian species. Table 1 lists the avian species-related activities that were associated with the Program in FY19.

Activity Name	Begin	End	Sponsor/Contributor Signatories
Avian Monitoring	FY03	FY19	USACE
Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Noise Disturbance Study	FY17	FY20	Reclamation; USACE
Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Surveys and Nest Monitoring at U.S. Army Corps of Engineers Restoration Sites	FY04	FY20	USACE
Southwestern Willow Flycatcher Surveys	FY95	Ongoing	Reclamation; USACE
Yellow-Billed Cuckoo Surveys	FY06	Ongoing	Reclamation
Yellow-Billed Cuckoo Telemetry Study	FY17	FY20	Reclamation; USACE

Table 1. FY19 Avian Species Activities List

Avian Monitoring

As a result of inadequate habitat, avian populations have been decreasing in the MRG. This trend has been noted in surveys sampling avian abundance and species richness relative to vegetation community and structure types within the MRG Bosque. Avian monitoring surveys have occurred in 81 transects, from Rio Rancho to La Joya Wildlife Management Area, since December 2003. 21 of these transects included areas that USACE restored starting in 2010. Surveys were conducted not only during pre-construction of the restoration sites as part of the documentation of existing conditions, but also during and after construction. Established transects within the MRG are surveyed during both the breeding and wintering seasons. Locations within each reach are surveyed and compared to previous survey data. Nest search and monitoring are also conducted. Various nest parameters, including nest success, brood parasitism, predation, abandonment, and productivity are determined for the SWFL and YBCU, as well as for raptors and songbirds.

An additional objective of the avian monitoring surveys was established in 2017 and focuses on changes in the bosque since the 1984 MRG Biological Survey. This objective includes: (a) providing a 20-plus year comparison of change in avian abundance and species richness, (b) providing a 20-plus year comparison of change in community and structure types, (c) providing a 20-plus year comparison of change in types present, given the construction of MRG restoration sites. This report will be completed in spring 2020.

Photo: Southwestern willow flycatcher perching on a branch
Credit: Scarlett Howell, USGS

Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Noise Disturbance Study

Nesting avian species can be sensitive to noise disturbance. In spite of this, SWFL and YBCU are known to nest in riparian habitat in the Rio Grande floodplain that is adjacent to active construction zones. Current protocol within the MRG is to maintain a 400 meter (1/4 mile) buffer between active nests and construction activities. However, little data exist on the distance between the nest and construction activities at which breeding birds are disturbed.

Conducted in the spring and summer of 2019, the noise disturbance study sought to determine the sensitivity of SWFL and YBCU to noise disturbance by quantifying the impact of noise on the nesting activities of a group of surrogate, non-threatened riparian obligates. The study involved the recording of actual construction noise and the broadcasting of those recordings at a series of decreasing distances from a known nest to measure any effects on the nesting birds. Non-sensitive species were used during the pilot study trials to assess any potential detrimental effects of the study on nesting birds prior to the inclusion of SWFL or YBCU. The final report for this study will be available in FY20.

Photos (from top to bottom): Nest of newly hatched Southwestern willow flycatcher chicks | 12-day-old Southwestern willow flycatcher fledglings
Credit: Darrel Ahlers, Reclamation | Dave Moore, Reclamation

Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Surveys and Nest Monitoring at U.S. Army Corps of Engineers Restoration Sites

In accordance with established survey protocols, presence and absence surveys were conducted during the 2019 breeding season at several USACE restoration sites within the Albuquerque Reach. These surveys were conducted to assess the effectiveness of restoration activities. Restoration construction began as early as 2004 at several of the locations evaluated in this study. The species use and habitat suitability of each location were evaluated in regards to both the SWFL and YBCU. Restoration sites are presently in various stages of riparian succession, each with different vegetative species compositions and structures that are associated with different habitat potential for SWFL and YBCU. Trends and results were analyzed, and recommendations for future survey work based on habitat conditions were developed.

Southwestern Willow Flycatcher Surveys

Biologists have conducted SWFL surveys and studies at sites from Bandelier National Monument to Elephant Butte Reservoir since 1995. These studies were originally designed to identify potential threats to SWFL populations and their habitats, but they currently focus on presence and absence surveys, nest monitoring, and supporting compliance with the 2016 MRG Biological Opinion (BO).

In 2019, Reclamation conducted surveys and nest monitoring at select project sites within the MRG basin. Survey results were used to determine the distribution, abundance, and productivity of SWFL breeding within the defined study area. These surveys are required in order to achieve compliance with the ESA and meet project obligations.

In accordance with established survey protocols, presence and absence surveys were conducted during the 2019 breeding season. Surveys and nest monitoring were conducted within eight sub-reaches of the MRG's four reaches (Table 2), along approximately 205 miles of the Rio Grande. Results of the 2017, 2018, and 2019 surveys are shown in Table 2.

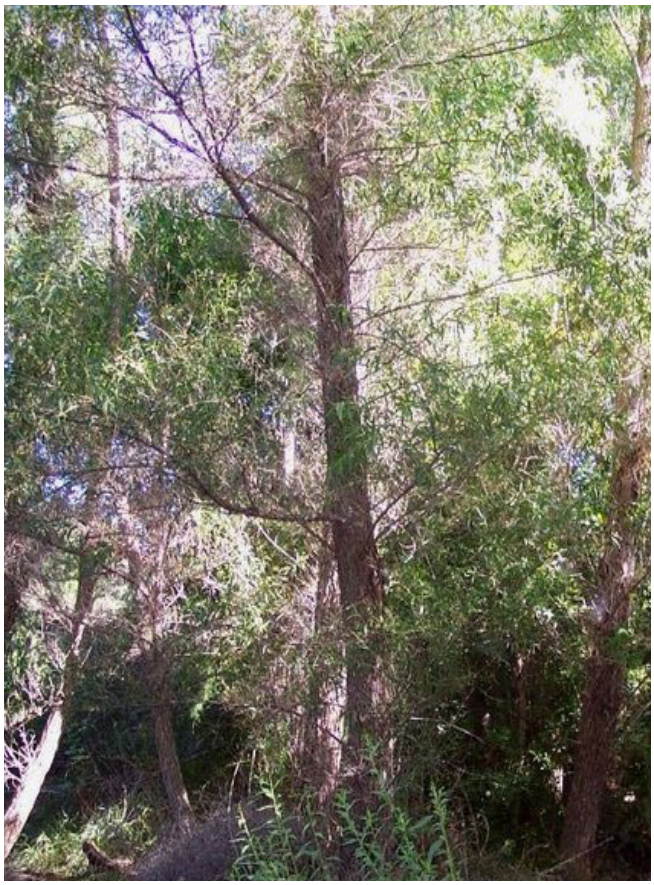

Photo: Southwestern willow flycatcher habitat
Credit: USGS staff

Sub-reach	2017 Territories	2018 Territories	2019 Territories	2017 Pairs	2018 Pairs	2019 Pairs	2017 Nests	2018 Nests	2019 Nests
Frijoles	0	0	NS	0	0	NS	0	0	0
Belen	17	20	NS	16	17	NS	27	17	NS
Sevilleta	4	12	NS	3	7	NS	1	3	NS
San Acacia	0	0	0	0	0	0	0	0	0
Escondida	8	4	9	6	4	5	9	4	4
Bosque del Apache	16	24	24	11	21	16	16	22	7
Tiffany	0	0	0	0	0	0	0	0	0
San Marcial	257	277	293	223	240	243	298	315	280
Totals	**302**	**337**	**326**	**259**	**289**	**864**	**351**	**361**	**291**

Table 2. Summary of Southwestern willow flycatcher territories, pairs, and nests recorded between 2017 and 2019 by Middle Rio Grande sub-reach. "NS" denotes that no surveys were conducted.

Yellow-Billed Cuckoo Surveys

Biologists have conducted YBCU protocol surveys within the MRG basin since 2006. These studies are designed to track YBCU population trends and provide insight into habitat use through presence and absence surveys. Survey results are used to determine the distribution and abundance of breeding YBCU within a defined study area. Additionally, the current studies achieve ESA compliance and support requirements detailed in the 2016 MRG BO. Surveys are conducted within seven sub-reaches of three MRG reaches, along approximately 130 miles of the Rio Grande. A breakdown of YBCU detections and territories from 2016 to 2019 is presented in Table 3.

Sub-reach	2017 Detections / Territories	2018 Detections / Territories	2019 Detections / Territories
Belen	34 / 4	41 / 10	NS
Sevilleta/La Joya	12 / 4	41 / 10	NS
San Acacia	50 / 13	47 / 14	29 / 8
Escondida	44 / 11	55 / 10	50 / 11
Bosque del Apache	43 / 10	46 / 13	59 / 14
Tiffany	2 / 0	0 / 0	0
San Marcial	227 / 56	193 / 49	190 / 42
Totals	**412 / 98**	**423 / 106**	**328 / 75**

Table 3. Summary of yellow-billed cuckoo detections and territores recorded between 2017 and 2019 by Middle Rio Grande sub-reach. “NS” denotes that no surveys were conducted.

Photos (from left to right): Yellow-billed cuckoo held by hand | Yellow-billed cuckoo nestlings
Credit: Mark Dettling, USFWS | Frontenac Bird Studies

Yellow-Billed Cuckoo Telemetry Study

Along the MRG, the YBCU typically nest in large, dense patches of riparian vegetation, particularly with a cottonwood/Goodding's willow overstory. A dense understory comprised of native vegetation or, alternatively, of exotic salt cedar or Russian olive also appears to be an important requirement for territory establishment. Although salt cedar may be a component of cuckoo habitat, as the proportion of salt cedar increases, the overall habitat suitability for YBCU is believed to decrease. There is uncertainty regarding what exactly constitutes suitable YBCU breeding habitat. Reclamation personnel have been conducting surveys within the MRG since 2006. Each year, YBCU detections and territories are recorded in both suitable and unsuitable habitat. Additionally, breeding YBCU are very mobile, cover large areas, and are not vocal near nests, which makes it difficult to find nests.

This study seeks to refine the habitat preferences of breeding YBCU within the MRG by continuing a radio telemetry study initiated in 2017. The pilot study conducted in 2017 refined transmitter attachment techniques and provided preliminary habitat use data. In 2018, the study focused on the delta of Elephant Butte Reservoir and included nine YBCU that provided useful movement and habitat data. In 2019, the study focused on areas upstream of Elephant Butte Reservoir in an effort to characterize YBCU habitat in a narrower, more managed active floodplain, where habitat is potentially of lesser quality. These data will be incorporated into the next MRG YBCU habitat model, which will better inform management efforts in regards to habitat preservation and restoration. Additionally, as few nests have been monitored due to the difficulty of finding them, increased nest discovery by radio tracking could expand sample size and allow for further insight into nesting variables and limiting factors of population growth.

Photo: Scenic view of the Middle Rio Grande Bosque
Credit: Mike Marcus, APA

Rio Grande Silvery Minnow

Program signatories implemented activities that supported long-term RGSM recovery efforts. These activities included population monitoring and modeling, captive breeding programs, population augmentation, genetics monitoring, fish rescue and salvage, and several RGSM-related studies. Table 4 lists the RGSM-related activities that were associated with the Program in FY19.

Activity Name	Begin	End	Sponsor/Contributor
Age Determination of Wild-Captured Larval Rio Grande Silvery Minnow Using Lapilli Otoliths Study	FY18	FY20	ABCWUA; NMISC
Assessment and Monitoring of Rio Grande Silvery Minnow Genetics	FY03	Ongoing	Reclamation
City of Albuquerque Aquatic Conservation Facility Rio Grande Silvery Minnow Program Operations and Maintenance	FY19 FY07	FY23 Ongoing	Reclamation ABCWUA
Drain Outfall Sampling	FY15	Ongoing	MRGCD
Engineering Modeling Applications for Quantifying Habitat for the Rio Grande Silvery Minnow	FY17	FY20	Reclamation; USACE
Environmental Flow Analysis for Rio Grande Silvery Minnow	FY10	FY20	USACE
Evaluation of Using eDNA for Detecting Larval Rio Grande Silvery Minnow on the Floodplain	FY19	FY20	USACE
Integrated Rio Grande Silvery Minnow Assessment Model Development	FY18	FY20	ABCWUA; NMISC
Larval Rio Grande Silvery Minnow Otolith Validation Study	FY18	FY20	ABCWUA; NMISC
Los Lunas Silvery Minnow Refugium Operations and Maintenance	FY07	Ongoing	NMISC; Reclamation
Pueblo of Santa Ana Fish Community Surveys	FY05	Ongoing	Pueblo of Santa Ana; Reclamation; USFWS
Rio Grande Silvery Minnow High-Throughput Markers	FY18	FY20	Reclamation
Rio Grande Silvery Minnow Population Management	FY18 FY01	FY18 FY22	MRGCD; Reclamation; USFWS
Rio Grande Silvery Minnow Population Monitoring	FY93	Ongoing	Reclamation
Rio Grande Silvery Minnow Reproductive Monitoring	FY18	Ongoing	Reclamation
Rio Grande Silvery Minnow Spawning Habitat Study	FY16	FY21	ABCWUA; NMISC
San Acacia Diversion Dam Fish Passage Pilot Study	FY16	FY21	MRGCD; NMISC; Reclamation
Spawning and Larval Fish Study in the San Acacia Reach	FY19	FY19	NMISC

Table 4. FY19 Rio Grande Silvery Minnow Activities List

Age Determination of Wild-Captured Larval Rio Grande Silvery Minnow Using Lapilli Otoliths Study

A total of 63 different specimens were used to compare the growth trajectories of wild-captured larval RGSM in three reaches of the Rio Grande. Larval RGSM were collected from habitat restoration sites in the Angostura, Isleta, and San Acacia Reaches in 2017, as part of the RGSM Spawning Habitat Study. In 2019, larvae were collected from the Angostura and San Acacia Reaches. These larval fish were aged using their otoliths to determine when they hatched and how long they were on the floodplain. The aged larval RGSM could then be used to determine the environmental factors, such as flow and temperature, that impact RGSM spawning, hatching, and larval development in each MRG reach.

Otoliths from wild-captured larvae were more difficult to read than those from larvae reared for the Larval RGSM Otolith Validation Study and thus, required more time to read. Using the information learned from the Larval RGSM Otolith Validation Study, SWCA Environmental Consultants (SWCA) was able to age (in days) wild-captured larvae. Growth trajectories (i.e., standard length versus otolith age) were compared by reach. Although there were no significant reach differences, results from the study indicate that aging wild larvae is feasible. The study is expected to be published as an article in 2020.

Photo: Spawning flows for Rio Grande silvery minnows
Credit: Mike Marcus, APA

Assessment and Monitoring of Rio Grande Silvery Minnow Genetics

Reclamation contracted UNM to perform genetic monitoring of the RGSM population annually from 1999-2012, and again from 2014-2019. Since the augmentation program began in 2002, this work included the monitoring of RGSM stocks that are bred or reared in captivity, then released into the MRG. Genetic monitoring enables tracking of the genetic effects of population fluctuations due to inter-annual variability in flows and various management activities.

As part of this genetic work, changes in levels of genetic variability within the wild RGSM population were examined to determine how they potentially impacted population viability. UNM also examined the impacts of captive propagation and augmentation on RGSM wild stocks. The RGSM genetics database generated by the project was used to develop, parameterize, and verify models directed at predicting the genetic effects of captive propagation on RGSM wild stocks. These models informed captive propagation and augmentation strategies aimed at species recovery.

Genetic monitoring in 2019 included the genotyping of 134 wild and 127 wild-caught hatchery-reared RGSM collected in three occupied reaches of the MRG: the Angostura Reach, the Isleta Reach, and the San Acacia Reach. The progeny of captive stocks from the Southwestern Native Aquatic Resources and Recovery Center (ARRC) [n=197] and the CoA Aquatic Conservation Facility (ACF) [n=99] were also genotyped. Combined, these fish comprised the 2019 potential breeding population. In 2019, 553 broodstock were also genotyped and used to produce fish for release in fall 2019 from the Southwestern Native ARRC, ACF, and Los Lunas Silvery Minnow Refugium (LLSMR).

Data from genetic monitoring in 2019 indicate that genetic change in the wild RGSM population was largely determined by supplementation with captive-reared stocks. This supplementation buffers the population against potential losses of diversity due to drastic changes in population size. Over the duration of the monitoring effort, indications of genetic diversity, including heterozygosity and average number of alleles, have so far been maintained.

Photo: Rio Grande silvery minnow
Credit: Michael Porter, USACE

City of Albuquerque Aquatic Conservation Facility Rio Grande Silvery Minnow Program Operations and Maintenance

The ACF promotes the recovery of RGSM in the wild through captive propagation and augmentation. Each year, ACF staff collect naturally-spawned RGSM eggs and/or young-of-year fish from the MRG for use in the captive breeding program. In November 2018, the ACF captured 1,000 juvenile RGSM and transferred them to the LLSMR to serve as broodstock for captive spawning operations. Captive spawning produced approximately 54,054 viable RGSM eggs in 2019.

During the potential spawning season for wild RGSM (April through June 2019), the flow rate in the MRG was consistently over 3,000 cubic feet per second (cfs). This high flow rate created dangerous conditions for ACF staff and made egg monitoring and/or collection virtually impossible. This resulted in no naturally-spawned RGSM eggs being collected during the 2019 spawning season.

As it was not possible to collect RGSM eggs from the MRG, several trips were made to collect post-larval and/or juvenile fish. ACF staff, accompanied by staff from USFWS's New Mexico Fish and Wildlife Conservation Office, collected fish from the four MRG reaches. The captive fish were monitored over time for growth and development, which ensured that only RGSM were kept for the captive breeding program. After one month of observation, all remaining fish were transferred to an outdoor tank. In total, approximately 600 RGSM were collected. The dates, reaches, and approximate numbers of juvenile RGSM collected are given in Table 5.

Date	Reach	Approximate Number
June 4, 2019	Angostura	25
June 5, 2019	San Acacia	50
July 12, 2019	Isleta	200
July 17, 2019	Angostura	200
July 19, 2019	San Acacia	200
Total		**675**

Table 5. Summary of juvenile Rio Grande silvery minnow collections in 2019

In addition to collecting naturally-spawned eggs, ACF staff also conducted captive RGSM spawning. In 2019, adult RGSM (97 males and 97 females) were each injected with carp pituitary extract in order to initiate spawning. The fish were then separated into batches and placed in separate 100-gallon aquariums overnight. The next day, eggs were collected and counted volumetrically (assuming 30 eggs/milliliter [ml]). Percent viability was determined by visual examination of three samples of 100 eggs taken from each tank. A total of 117,510 eggs were produced and viability estimates ranged from 39 to 52 percent, with an overall average of 46 percent.

Captive-spawned (and occasionally naturally-spawned) young-of-year RGSM were released into the river in order to augment the wild population. During FY19, ACF staff released a total of 66,000 RGSM. The dates and locations of these releases are listed in Table 6.

Date	Reach	Approximate Number
November 15, 2018	San Acacia	18,000
November 16, 2018	Isleta	15,000
November 19, 2018	Angostura	15,000
February 14, 2019	San Acacia	6,000
February 14, 2019	Isleta	6,000
February 14, 2019	Angostura	6,000
Total		**66,000**

Table 6. Summary of Rio Grande silvery minnow releases in FY19

Photos (from left to right): Rio Grande silvery minnow at the Aquatic Research Facility | Release of Rio Grande silvery minnow into the river
Credit: ACF Staff

Drain Outfall Sampling

During the FY19 irrigation season, small volumes of water were consistently discharged from three MRGCD outfalls within the Isleta Reach of the MRG, where river channel drying is common in the summer and early fall. Much of the water discharged from the outfalls was supplied by agencies that have coordinated with MRGCD to convey this water through the MRGCD system.

The fish populations in MRGCD outfalls were sampled at monthly intervals in late summer and fall of 2018 to determine the degree to which RGSM utilize them as refugia during periods of adjacent river channel drying. These samplings will be used to inform future water management decisions, determine the most economical use of water when supplies are limited, and aid in the formation and refinement of future studies and monitoring projects.

Engineering Modeling Applications for Quantifying Habitat for the Rio Grande Silvery Minnow

Projects with the goal of creating habitat for the RGSM have been underway on the MRG since the 1990s. Though localized efforts to quantify habitat have been made, a standard method for quantifying the amount and quality of habitat that is constructed or preserved in the dynamic river system has yet to be developed.

This project used USACE's Hydraulic Engineering Center (HEC) modules to visualize, quantify, and track changes in RGSM habitat on the MRG. To utilize engineering models, a hypothesis of ideal habitat conditions for the RGSM was characterized into hydraulic parameters. Shallow depth, slower velocities, and sufficient duration of inundation are three habitat characteristics believed to be crucial for the survival of early-life stage RGSM reared on the floodplain. Version 5.0 of the HEC's River Analysis System (HEC-RAS) features the ability to perform two-dimensional hydrodynamic routing, which produces detailed channel and floodplain analysis and enables depth and velocity characteristics to be quantified. By coupling HEC-RAS 5.0 with version 4.0 of the HEC's Ecological Function Model (HEC-EFM), the duration of RGSM habitat under various flow regimes can be computed.

Environmental Flow Analysis for Rio Grande Silvery Minnow

Environmental flow criteria for floodplain inundation, which produces low-velocity habitats that support the feeding and growth of larval RGSM, provide guidance for how to manage spring runoff pulses to benefit recruitment. The objective of this study was to analyze annual RGSM recruitment in response to either routine water management or environmental flow manipulation at upstream reservoirs. Analysis of recruitment responses provides values for hydrograph parameters (e.g., magnitude, frequency, duration, timing, and rate-of-change) associated with increased RGSM recruitment rates and population indices. This information, in combination with the MRG inundation assessment and habitat restoration monitoring, will contribute to refinement of spring runoff flow parameters for more effective management of RGSM recruitment by MRG water management agencies.

Evaluation of Using eDNA for Detecting Larval Rio Grande Silvery Minnow on the Floodplain

Environmental DNA (eDNA) is a maturing technology for inventorying and monitoring aquatic species. Gut samples from predators can be used for diet analysis based on the presence of target eDNA markers. Filtered eDNA from large watershed areas may be used for detecting rare occurrences at a lower cost than traditional sampling methods (e.g., electrofishing or seining). Sampling for eDNA at downstream access points may be useful for monitoring upstream reaches that have limited access. Thus, development of reliable eDNA markers may potentially provide valuable information for RGSM studies.

The objective of this project is to develop and evaluate an eDNA tool for RGSM. The best approach is to develop two mitochondrial DNA quantitative real-time polymerase chain reaction (qPCR) markers that can be run as a multiplex qPCR on eDNA extracted from water samples. Multiplexing has been shown to be a useful countermeasure against false negatives arising from sampling errors when target DNA is rare and dilute or when water samples are carrying PCR inhibitors. This experimental design is similar to the current approach utilized by USFWS's Asian carp monitoring program.

Integrated Rio Grande Silvery Minnow Assessment Model Development

ABCWUA and NMISC contracted the Southwest Biological Science Center of the U.S. Geological Survey (USGS) to develop an integrated RGSM assessment model. The model integrates environmental and species-specific information and data to assess the status of the RGSM population in the MRG. The model will be useful in making predictions for how the RGSM population may respond to current and future management options. Species-specific information will include RGSM vital rate information, such as growth, survival, and reproductive capabilities at various ages. The model is being developed in collaboration with the MRGESCP's Population Monitoring Work Group. In 2019, background information about the RGSM and MRG was gathered to develop a draft framework for the model.

Photo: Rio Grande silvery minnow
Credit: Thomas Archdeacon, USFWS

Larval Rio Grande Silvery Minnow Otolith Validation Study

NMISC and ABCWUA contracted SWCA to conduct the Larval RGSM Otolith Validation Study. The LLSMR, the CoA BioPark, USFWS, and SWCA all took part in the design and implementation of the study. UNM also provided microscopy laboratory space for otolith readings. The purpose of this study was to validate that RGSM deposit a single daily increment on lapillar and sagittal otoliths, thereby facilitating a method for accurately estimating the age and hatch date of larval RGSM. RGSM were hatched and grown to 30 days post-hatch; then their otoliths were extracted for use in a double-blind aging method. The study indicated that larval RGSM deposited discernible daily increments on lapilli. Results from the study are important for showing that otoliths can be accurately and reliably used to age larval RGSM. This study is the first larval otolith validation for this species as well as the first study evaluating the efficacy of using otoliths to determine the daily age of wild larval RGSM. The study is expected to be published in 2020.

Los Lunas Silvery Minnow Refugium Operations and Maintenance

The LLSMR was built by NMISC with federal financial assistance and was designed for the propagation and culture of RGSM within a natural environment. The facility began operation in 2009 and is located on State of New Mexico property in the Village of Los Lunas, about 20 miles south of Albuquerque. The facility includes an outdoor refugium that has a stream, ponds, islands, and overbank areas to mimic the Rio Grande's habitats. The LLSMR also has an indoor hatchery, a quarantine building, outdoor tanks, and an office building. The facility has a permanent staff of two aquaculturists and one technician. NMISC also works with the Program's Science and Habitat Restoration Work Group and USFWS's Genetics and Captive Propagation Work Group to accomplish the goals and objectives of the LLSMR. In FY19, the facility was jointly funded by NMISC and Reclamation, and permitted by USFWS.

NMISC operates the LLSMR to propagate RGSM for augmentation into the MRG. The fish produced for augmentation support a reproducing population of RGSM in the MRG, especially in years with low population numbers. In FY19, the facility accommodated fish for a fish movement study being conducted by NMISC staff and a contractor. To support this study, four-year-old RGSM were injected with passive integrated transponder (PIT) tags and held on station for scheduled release.

Photo: Aerial view of Los Lunas Silvery Minnow Refugium
Credit: Douglas Tave, LLSMR

Pueblo of Santa Ana Fish Community Surveys

In 2019, the Pueblo of Santa Ana completed spring, summer, and fall fish community surveys with help from USFWS staff. These surveys provide management-relevant information on the RGSM, including trends in population responses to habitat restoration projects.

The Pueblo monitored eight sites in the Santa Ana stretch of the Rio Grande during all three seasons. The Rio Jemez was only accessible during the spring monitoring event, during which data was collected at six sites. There were 195 seine hauls during the spring event, 120 hauls during the summer event, and 120 hauls during the fall event. Figure 2 shows the percentage of RGSM caught in Santa Ana compared to all fish species caught in the area in 2019.

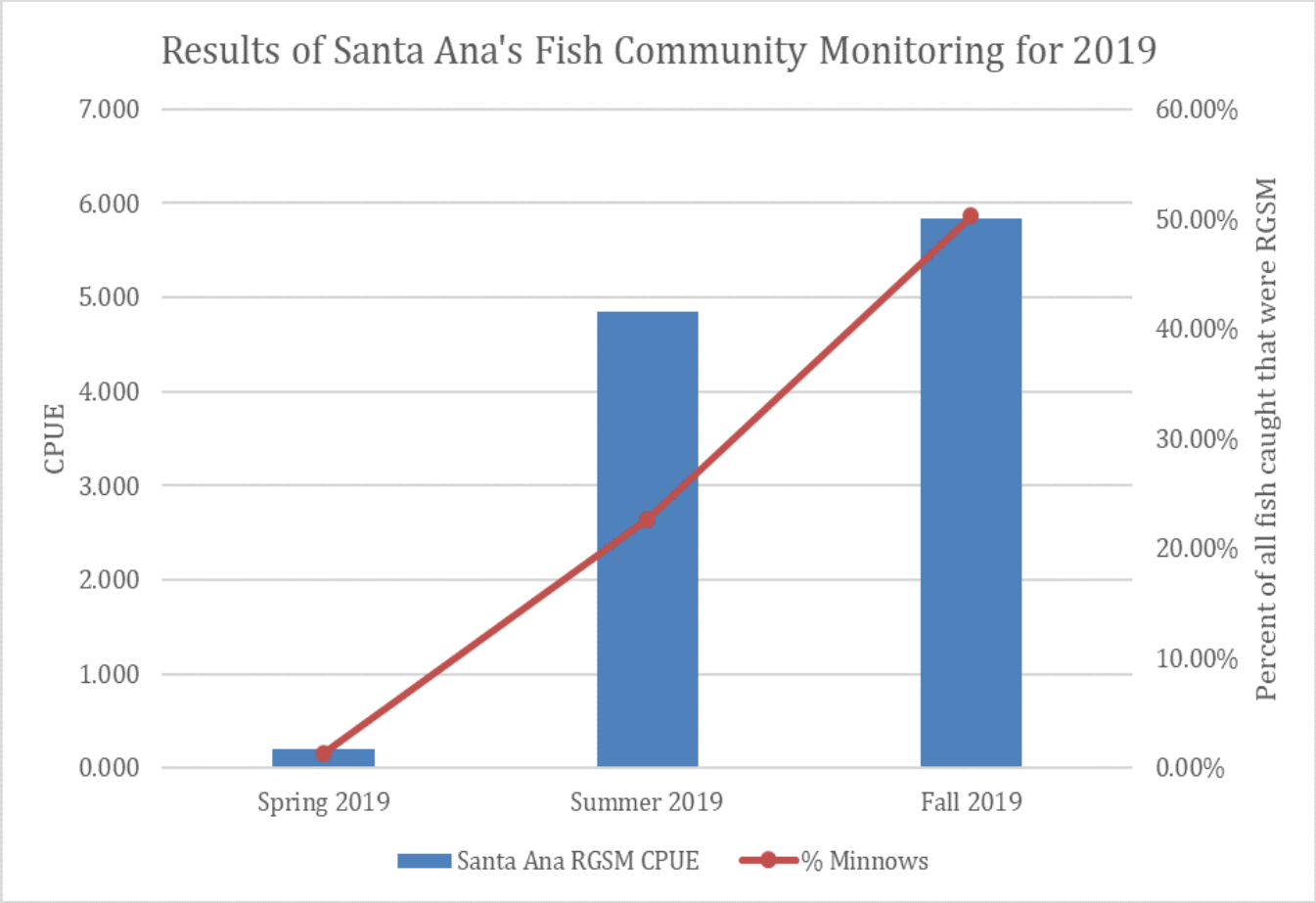

Figure 2. Catch per unit effort (CPUE) [fish/100 square meters (m^2)] of Rio Grande silvery minnow captured in Santa Ana in 2019 and the percentage of Santa Ana Rio Grande silvery minnow caught compared to all fish species caught in the area.

Rio Grande Silvery Minnow High-Throughput Markers

The purpose of this project is to develop a single nucleotide polymorphism (SNP) panel, which will allow for a thorough evaluation of various genetic metrics among RGSM. The project objectives are as follows:

1. Develop a SNP panel that provides sufficient loci to monitor genetic diversity, effective population size, population structure, and relatedness within or among captive and wild populations
2. Develop sex-specific markers that will allow for genetic determination of sex
3. Provide plans, updates, and reports for review and approval, including oral presentations, draft/final reports, and a draft study plan

To date, the project has resulted in an inventory of DNA subsampled from tissues at the Museum of Southwest Biology. This DNA inventory was isolated, purified, and assessed for quality, before being prepared for DNA sequencing and genotyping. Currently, the research team is working on the final steps of the filtering process to prepare the dataset for analysis.

Additional experiments have been conducted to develop sex-specific markers for the RGSM. These experiments included many of the project components listed previously. The final SNP panel is expected to be completed and reported by September 2020.

Rio Grande Silvery Minnow Population Management

The RGSM is restricted to a portion of the Rio Grande and ranges from approximately 150 river miles from the vicinity of Bernalillo downstream to the headwaters of Elephant Butte Reservoir. The objectives of the RGSM Population Management project include the continued propagation of RGSM, the monitoring and augmentation of wild RGSM with hatchery-raised RGSM, and the rescue and transport of stranded RGSM during intermittent flow periods in the MRG.

During FY19, both MRGCD and Reclamation provided resources for fish rescue and salvage activities conducted by USFWS. River channel drying in the MRG began late in 2019. Between September 3rd and September 29th, rescue activities were conducted on 5.6 unique miles of the main channel of the MRG that were dry or intermittent. All drying occurred within the San Acacia Reach. An additional 12 miles of drying occurred at the Bosque del Apache National Wildlife Refuge, but the area was inaccessible due to a sediment plug. As a result, no fish rescue operations were performed there.

In total, 989 RGSM were rescued. Of these, 966 were young-of-year, 22 were hatchery-reared, and one was a wild adult. 138 dead RGSM were also documented during river intermittency. Although spring runoff was high in 2019, the number of young-of-year RGSM was unexpectedly low; a pattern that was also observed in river-wide fish surveys. Late season low flows, drying, and a low number of RGSM that survived 2018 are all factors that may have contributed to the low RGSM count observed during fish rescue.

Rio Grande Silvery Minnow Population Monitoring

Systematic population monitoring of the RGSM and its associated MRG fish community began in 1993 at multiple sites from Algodones to Elephant Butte Reservoir. Monitoring was refined to standardized sites prior to MRGESCP involvement in FY02. This long-term monitoring program documents the number of fish captured per unit of effort, which is used to calculate the CPUE density metric. A comparison of CPUE over time is used to describe the long-term trends and overall status of the RGSM population. This monitoring is required to continue for regulatory compliance with the 2016 MRG BO.

Population monitoring occurs up to nine months of the year, at 20 locations in the MRG. The sampling design was modified in 2017 to include a total of 30 sites during the key months of April and October. Consistent monitoring protocol is expected to yield a long-term ecological dataset that accomplishes the following:

- Determines long-term (multi-year) and short-term (seasonal) trends in MRG fish populations using statistical approaches that discern spatiotemporal differences in the abundance of native and non-native fish, with a focus on the RGSM
- Evaluates the influence of water discharge timing, magnitude, and duration on population fluctuations of both native and non-native fish species in the MRG over time and space, with a focus on the RGSM,
- Compares changes in absolute and rank abundance between the RGSM and other native and non-native fish species
- Determines site-specific sampling variation
- Examines spatial correlation of RGSM population dynamics over time

Photo: Flooded site for population monitoring
Credit: American Southwest Ichthyological Researchers, L.L.C. staff

CPUE of the RGSM in October 2019 was higher than the October 2018 estimate (Figure 3). In October 2019, a total of 209 RGSM were collected from 19 of the 20 standard long-term monitoring sites. RGSM were collected in 92 of the 333 seine hauls that yielded fish. All RGSM collected in October 2019 were unmarked and presumably naturally spawned. In addition, the RGSM collected were in two age classes, with the majority being young-of-year fish. These monitoring results indicate that spring runoff flows in 2019 resulted in successful RGSM spawning and recruitment.

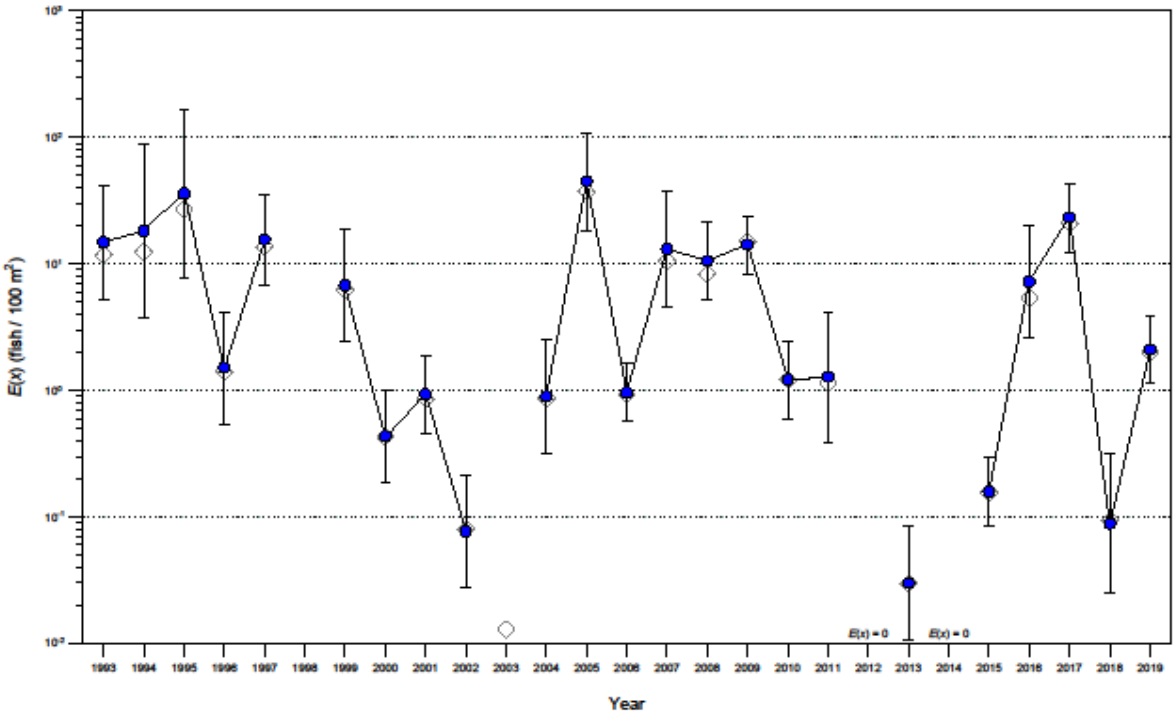

Figure 3. October Rio Grande silvery minnow density estimates (E(x)) [fish/100 square meters (m^2)] for 1993-2019. Solid circles indicate estimates, hollow circles represent simple estimates using methods of moments and bars mark 95 percent intervals.

Rio Grande Silvery Minnow Reproductive Monitoring

Systematic reproductive monitoring of the RGSM has been conducted annually since 2001, with the goal of providing insight into the key environmental factors that affect the spatiotemporal spawning patterns of the RGSM. Results assist managers in developing successful strategies for species recovery. The primary objectives of the RGSM Reproductive Monitoring Program are to characterize the timing, duration, and magnitude of RGSM spawning in the Angostura, Isleta, and San Acacia Reaches of the MRG. Additional objectives include characterization of reach-specific spawning patterns, assessment of linkages between egg passage rates and seasonal flows, and examination of the effects that flow and temperature have on spawning.

The 2019 study was a continuation of the long-term monitoring effort in the lower portion of the San Acacia Reach (San Marcial), just upstream of Elephant Butte Reservoir. Two additional sites in the Angostura and Isleta Reaches were also sampled from 2017 to 2019. RGSM eggs were collected from all three sampling sites in 2019.

Long-term spawning patterns and trends were based solely on eggs collected at San Marcial. Modeling of daily egg presence-absence data from 2003 to 2019 revealed that the daily probability of collecting eggs was highest when river flows increased substantially across consecutive days and declined as water temperature increased. Daily egg passage rates were highest in 2011 and lowest in 2004. There was a steady decline in passage rates from 2011 to 2013, followed by an increase in 2014. Passage rates declined again from 2015 to 2016 but increased slightly in 2017. The passage rate in 2019 was significantly lower than the 2017 rate.

Ecological models revealed that changes in the occurrence and passage rate of eggs were moderately predicted by differences in seasonal river flows over time. Out of 160 models considered, scientists found that three models, which represented high flows during spring, were most informative in explaining why some years had lower egg passage rates than others. In summary, egg occurrence probabilities were higher during years with reduced and truncated spring flows, and egg passage rates were lower during years with elevated and extended spring flows.

Each year, some portion of RGSM eggs remain upstream. This occurrence is likely related to prolonged and elevated spring flows, which result in overbank flooding in vegetated areas, formation of inundated habitats in the river channel, and creation of shoreline and island backwaters. As the successful growth and survival of RGSM, from the egg through the early larval phases, requires about one month, the long-term persistence of inundated habitats is essential. The future conservation status and recovery of the RGSM appears strongly dependent on consistent seasonal flow and habitat conditions.

Rio Grande Silvery Minnow Spawning Habitat Study

ABCWUA and NMISC collaborated on a study to investigate the occurrence of inundated floodplain habitat and use of this habitat by RGSM larvae and adults in both restored and unrestored sites in the Angostura, Isleta, and San Acacia Reaches. Monitoring began in FY16 and is ongoing. The objective of the study is to determine when and how long adult and larval RGSM use floodplain habitats in the spring, as well as to examine the utilization of floodplain habitat restoration sites. In 2019, larval fish were collected from two sites in the Angostura Reach and six sites in the San Acacia Reach. RGSM from these collections supported two supplemental studies: the Larval RGSM Otolith Validation Study and the Age Determination of Wild-Captured Larval RGSM Using Lapilli Otoliths Study

San Acacia Diversion Dam Fish Passage Pilot Study

NMISC, MRGCD, and Reclamation are evaluating a number of options to enhance river connectivity at the San Acacia Diversion Dam (SADD) for the purpose of allowing fish to navigate from downstream to upstream. NMISC continued to collect hydraulics information at the gates of the diversion structure and the downstream rock ramp. Fish are also being PIT tagged and tracked in the vicinity of the dam to determine if they have the ability to move through the dam at its current configuration. A long-term fish passage is being considered that may incorporate in-channel and off-channel structures to accommodate a greater range of river flows. Additionally, Reclamation began conducting environmental compliance of alternatives.

Spawning and Larval Fish Study in the San Acacia Reach

NMISC and its contractors have been conducting fisheries studies on constructed and natural floodplain habitats for over 10 years. In FY19, NMISC and ABCWUA contracted SWCA to conduct the 2019 RGSM Spawning and Nursery Habitat on Restored Floodplain Sites in the MRG Study. This study was conducted in the 4th year of a collaborative project that investigates MRG floodplain use by RGSM of all life stages. Floodplain habitat restoration is one of the critical components for avoiding jeopardy and improving the status of the RGSM, as directed in the 2016 MRG BO.

The purpose of this study was to identify key habitat features utilized by RGSM in floodplain sites within the San Acacia and Angostura Reaches. Life cycle monitoring for RGSM at these sites was conducted using fyke nets to capture adults and dip nets to capture larvae. A total of eight sites were sampled using both methods (Figure 4).

Figure 4. Map of all San Acacia sites sampled during 2019

Fyke nets captured a total of 994 fish, representing 13 species. The two most abundant species were RGSM and Red Shiner (*Cyprinella lutrensis*). Of the 471 RGSM captured using fyke nets, 197 did not have a visible implant elastomer (VIE) tag and 274 had VIE tags. The majority of smaller RGSM (≤ 60 millimeters [mm] standard length) had a VIE tag. Conversely, the majority of RGSM that were greater than 60 mm standard length did not have a VIE tag. The majority of RGSM were adults and 23 percent were females.

Photo: Rio Grande silvery minnow with standard length of 59 millimeters and weight of 3.5 grams
Credit: SWCA staff

A total of 1,693 dip net samples were conducted throughout the study, capturing approximately 3,944 unknown larvae. In addition, 47 dip net samples were conducted under targeted non-random sampling, resulting in an additional 390 larvae for a total of 4,334 unknown larvae. The capture of RGSM gravid females and nuptial males over several years of monitoring provides evidence that RGSM are likely spawning on floodplain habitat when available.

Data collected under this study will help identify important factors that contribute to the presence of larval RGSM within floodplain habitat. This information will be used to evaluate and adjust sampling and analysis methods for floodplain monitoring, to demonstrate the life history of RGSM, to inform the water management of the MRG, to adaptively manage the species to meet the requirements set forth in the 2016 MRG BO, and to support the MRGESCP.

Photos (from left to right): Fyke net set-up for adult Rio Grande silvery minnow sampling at the Paseo del Norte southwest site | Inundation at the Paseo del Norte southwest site
Credit: Kate Mendoza, ABCWUA

Habitat Restoration

Program signatories supported habitat restoration activities in the MRG that provided sustainable habitat features for spawning and larval RGSM, SWFL, and YBCU. These activities included the identification of top locations for new habitat restoration sites and the evaluation of current sites. Table 7 lists the habitat restoration-related activities that were associated with the Program in FY19.

Activity Name	Begin	End	Sponsor/Contributor
Bosque and Riverine Restoration Project and Fish Passage at Isleta Diversion Dam	FY17	Ongoing	MRGCD; Pueblo of Isleta; Reclamation; USFWS
Evaluation of Sediment Dynamics in Habitat Restoration Features of the Albuquerque Reach	FY11	FY20	USACE
Development of a Habitat Restoration Geo-Database for the Middle Rio Grande	FY18	FY20	NMISC
Development of the Habitat Restoration Monitoring Plan for the Isleta and San Acacia Reaches	FY18	FY20	NMISC; Reclamation
Identifying Restoration Priorities for Threatened Tamarisk-Dominated Habitat to Benefit Future Habitat for the Southwestern Willow Flycatcher	FY18	FY20	USACE
Los Lunas Habitat Restoration Project Monitoring	FY00	FY20	Reclamation; USACE
Lower Reaches Habitat Restoration Project Monitoring	FY18	Ongoing	NMISC; Reclamation
New Mexico State Forestry Exotic Species Removal	FY19	Ongoing	ABCWUA; BEMP

Table 7. FY19 Habitat Restoration Activities List

Bosque and Riverine Restoration Project and Fish Passage at Isleta Diversion Dam

The Pueblo of Isleta continued to develop the Pueblo's Bosque and Riverine Implementation Report, which identifies specific treatments for the 2,000-acre Isleta Bosque. The project is intended to result in bosque and riverine improvements along Isleta's eight-mile stretch of the bosque. The project will include exotic species removal, fuels reduction, revegetation with native plants, wildlife habitat improvement, and jetty jack removal. Environmental assessments of the areas of interest are underway. In collaboration with Reclamation and MRGCD, the Pueblo of Isleta will also make modifications to the Isleta Diversion Dam (IDD), such as alteration of the dam's irrigation infrastructure for sediment management and production of a fish passage structure. Full implementation is scheduled for spring 2020.

The decline in RGSM populations has been attributed to several factors, including decreased and interrupted stream flow caused by impoundments and permanent water diversion structures. The IDD is one of three diversion dams dividing the remaining RGSM population, and building a fish passage structure at the dam will provide connectivity between the Isleta and Angostura Reaches of the MRG. The resulting bosque and riparian restoration due to the structure will enhance current habitat and provide new habitat for listed species.

In 2019, the Pueblo of Isleta matched grants funding fuels reduction and invasive plant species removal and control. Partners for these efforts include MRGCD, the Natural Resources Conservation Service, the New Mexico Environmental Quality Incentives Program, the New Mexico Water Trust Board, the New Mexico Environment Department's Isleta Island Removal Project, and the Bureau of Indian Affairs' Invasive Species Program.

Photos: Fuels reduction projects in the bosque
Credit: Mike Marcus, APA

Evaluation of Sediment Dynamics in Habitat Restoration Features of the Albuquerque Reach

Ecosystem restoration projects conducted by USACE on the MRG have focused on removing non-native vegetation, encouraging listed species habitat, and promoting main channel to floodplain connection. Surveying for these projects includes assessing morphological adjustments and sediment aggradation and erosion for a variety of hydrological features, such as high-flow channels and embayments, terraced or scalloped bank lines, and oxbows installed at various USACE project sites within the Albuquerque Reach. Surveys were conducted using current survey methods and practices, and utilizing local monuments to provide consistent controls for the sites. Reports were generated for surveys conducted from 2011-2018 to document changes observed at the sites.

The objective of this monitoring is to collect data on morphological changes of features at habitat restoration sites in order to assess how these features are functioning. Through repeated channel surveys and establishment of photo points, the changes over time of various habitat restoration features are tracked. The resultant information from this project helps biologists and design engineers understand how habitat restoration features function relative to their design intent and determine the hydrological conditions that initiate their inundation. Additionally, it helps project sponsors understand the types of operation and maintenance activities they may need to conduct to ensure the longevity of a feature. Finally, understanding hydrological inundation provides insight into potential conditions for RGSM spawning and recruitment, as well as for vegetation growth that is essential for establishment of SWFL habitat.

The morphological changes that occur due to sedimentation of the habitat restoration features were evaluated using repeated surveys conducted both parallel and perpendicular to the flow. The deposition of sediment, which can reduce the effective inundation, was then assessed. Initial results for all 17 sites indicated a general pattern of deposition in all overbanking feature types (e.g., high-flow channels, bank terraces, and interconnected swales). The greatest morphological change was observed at the entrances and exits of high-flow channels. Observation of the sites after the 2019 snowmelt runoff indicated that overbanking flows bring in sediment and also invigorate native riparian vegetation. Based on an initial assessment of the field surveys, a combination of feature types may best promote habitat for listed species. For example, large bank terracing promotes ample vegetation growth along the Rio Grande, while inland swales, connected via backflow channels, provide spawning habitat throughout the riparian zone.

Overall, evaluation of habitat restoration sites on the MRG revealed that habitat restoration projects have successfully encouraged more native riparian growth, created habitat development, and increased the river's connection with its floodplain. These projects benefit the local community in other ways as well, including as tools for recreation and teaching. Increased use and appreciation of the MRG Bosque benefits future generations of listed species and humans alike.

Photo: Los Lunas habitat restoration site
Credit: Mike Marcus, APA

Development of a Habitat Restoration Geo-Database for the Middle Rio Grande

NMISC is working with GeoSystems Analysis (GSA) to assemble and integrate a geo-database for the existing habitat restoration projects in the MRG. These projects include those constructed by Program signatories for ESA purposes, as well as those constructed by other agencies and stakeholders engaged in restoration of the bosque. The geo-database will be available on the MRGESCP Portal (**https://webapps.usgs.gov/MRGESCP/**).

Development of the Habitat Restoration Monitoring Plan for the Isleta and San Acacia Reaches

NMISC is working to improve habitat conditions for federally threatened and endangered species along the MRG. Since 2013, NMISC has focused its attention on segments of the Isleta and San Acacia Reaches, with an emphasis on expansion of off-channel nursery habitat for RGSM. In regulated river systems, like the MRG, most habitat restoration projects require focused and coordinated monitoring and adaptive management strategies to ensure that project objectives are achieved and sites function as intended.

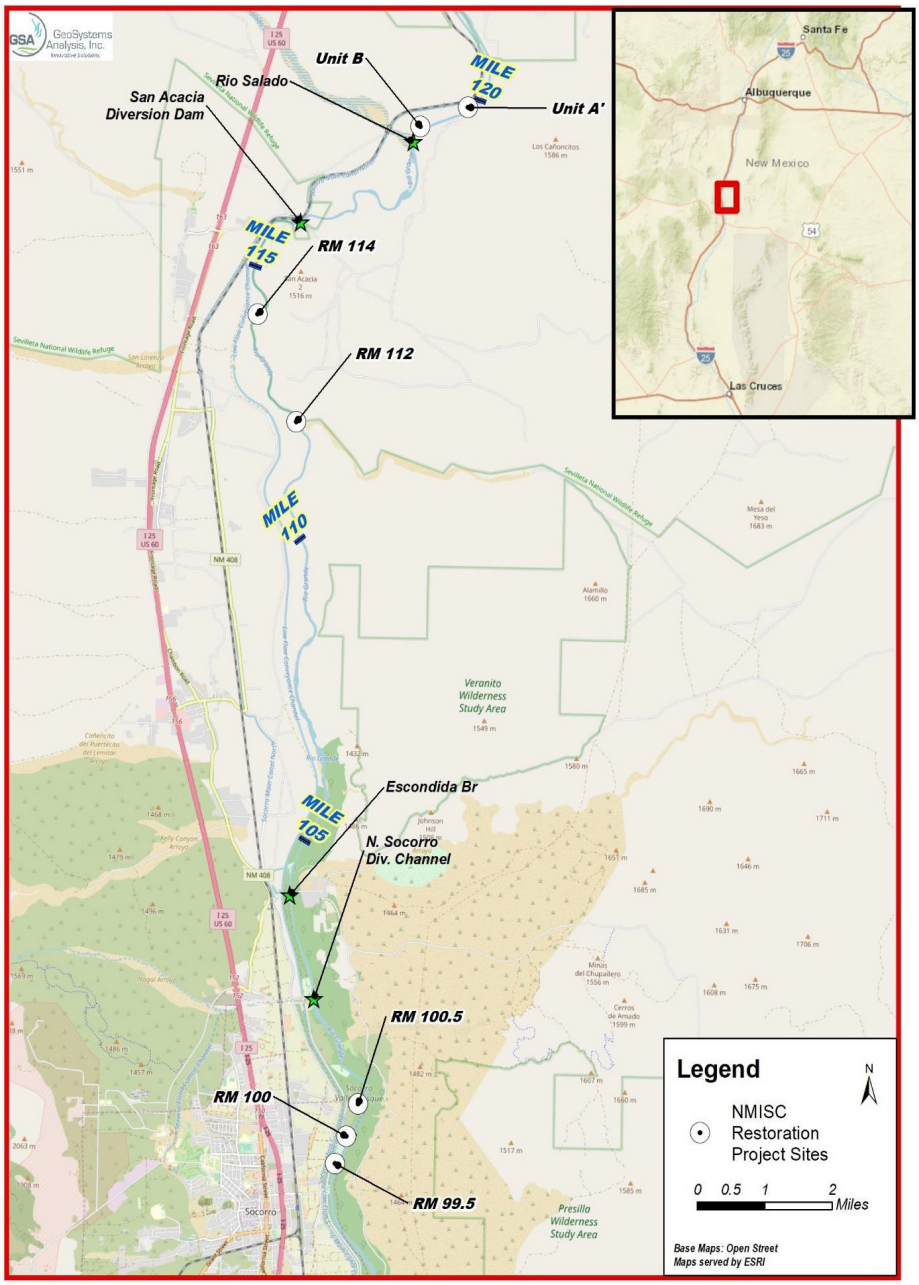

Figure 5. New Mexico Interstate Stream Commission restoration project sites

In FY19, GSA prepared an operational framework for implementing a project- scale monitoring and adaptive management program at five restoration project sites recently designed and constructed by NMISC and Reclamation. The monitoring framework and methodologies presented in the plan could be applied to additional project sites with similar objectives and used to support reach-scale habitat restoration and adaptive management efforts.

Given the RGSM's short life span (generally ≤ 2 years), water managers and restoration practitioners are suggested to implement projects that improve reproductive conditions to mitigate the impacts of multi-year droughts. Accordingly, NMISC restoration efforts focus on designing and constructing projects that improve the probability of annual floodplain inundation under relatively low to moderate discharge levels (i.e. 800-2000 cfs).

In FY19, GSA was contracted to identify and prioritize locations and design restoration projects to increase areal extent and spatial distribution of off-channel spawning and rearing habitat for the RGSM under low to moderate river discharges. Detailed restoration designs were developed for seven project sites, including two sites upstream and five sites downstream of the SADD (Figure 5).

Restoration design criteria were guided by existing studies addressing off-channel spawning and rearing habitat attributes associated with RGSM. As with any adaptive management program, the objective of the monitoring plan was to evaluate whether the restoration design concepts would yield the desired results and importantly, to use the monitoring results to improve future restoration design efforts.

Identifying Restoration Priorities for Threatened Tamarisk-Dominated Habitat to Benefit Future Habitat for the Southwestern Willow Flycatcher

The goal of this study is to provide site-specific verification and final priority rankings for the top 15 of the 103 tamarisk-dominated SWFL restoration sites previously identified by the Program in 2015. The project features the ground truthing of several sites in order to verify the continued appropriateness of restoration goals. Ground truthing incorporates examination of site access opportunities, validation of the vegetation community, and verification of continued nearness to SWFL nesting sites. The validation techniques also feature analysis of hydrology and stage-discharge relationships, floodplain connection, and groundwater dynamics. The final priority rankings of sites were presented to the Program's Science and Habitat Restoration Work Group. A report prioritizing the site rankings will be finalized in spring 2020.

Photo: Tamarisk with flowers
Credit: Eric Coombs, Oregon Department of Agriculture

Los Lunas Habitat Restoration Project Monitoring

Historically, the Los Lunas Habitat Restoration Project fulfilled requirements for one of eight sub-reaches in which habitat restoration was to be conducted in accordance with USFWS's June 2001 BO. Following a fire in April 2000, the Los Lunas restoration site was selected as the first 2003 MRG BO restoration area. Reclamation and USACE acted as joint lead federal agencies on the 40-acre project, and MRGCD was the primary non-federal cooperator. The project was the first habitat restoration project funded by the MRGESCP.

The primary objective of the project was to improve habitat conditions for the RGSM and SWFL. The design goals were to generate inundation of the project area at flows of ≥ 2,500 cfs. For flows below 2,500 cfs, a variety of substrate elevations were integrated into the project design to allow for the inundation of certain regions at lower river stages. This included features such as a network of variable depth side and transverse channels designed to aid in minnow egg retention and provide shallow water/low-velocity rearing habitat. In addition, the increased inundation frequency would begin the process of post-fire regeneration of high-value terrestrial habitats in portions within and adjacent to the restoration area to support the recovery of the SWFL. The project was completed in 2002 and monitoring of the site began in 2003.

Photo: Los Lunas habitat restoration site
Credit: Mike Marcus, APA

This ongoing monitoring activity observed the availability and effectiveness of restored habitat, including the physical elements related to habitat characteristics (e.g., hydrology, geomorphology, and vegetation) and the presence of RGSM and SWFL.

The objectives of the annual monitoring efforts were to:

- Determine the success of restoration at the Los Lunas restoration site in establishing a productive cottonwood/willow riparian community, as well to characterize factors that may have influenced the outcome
- Assess SWFL and YBCU habitat suitability/sustainability and identify those variables which contribute to the development of quality habitat
- Establish a potential timeframe in which a restored site develops into suitable SWFL and YBCU habitat under local environmental conditions
- Provide data for the adaptive management of future restoration efforts in the MRG

FY19 concluded with a summary of the past 20-plus years of monitoring and recommendations to the Program for where best to focus future monitoring efforts.

Lower Reaches Habitat Restoration Project Monitoring

Effectiveness monitoring of the Lower Reaches Habitat Restoration Project was completed in Spring 2019 at eight sites located along a 20-mile segment of the San Acacia Reach of the MRG, between the SADD (near river mile [RM] 116) and Brown Arroyo (RM 94). Five of the eight projects were designed by NMISC, while the other three were designed by Reclamation (Table 8). Reclamation's Socorro Field Division constructed all eight project sites, with final completion in winter 2019.

Project Name	Acres	Designed by	General Design Features
RM 114	1.7	NMISC	Two backwater channels, inundation initiated at approximately 800 cfs
RM 112	1.5	NMISC	One backwater channel, inundation initiated at approximately 800 cfs
RM 104.5 (Escondida East)	3.2	Reclamation	One backwater channel, inundation initiated at approximately 800 cfs
RM 103 (Escondida West)	10.5	Reclamation	Four backwater channels and one high-flow channel, inundation initiated at approximately 300 cfs
RM 100.5	8.2	NMISC	Two backwater channels, inundation initiated at approximately 800 cfs
RM 100	1.4	NMISC	One backwater channel, inundation initiated at approximately 800 cfs
RM 99.5	3.5	NMISC	Two backwater channels, inundation initiated at approximately 800 cfs
RM 94 (Rhodes)	17.2	Reclamation	Eleven embayments and one high-flow channel, inundation initiated at approximately 300 cfs

Table 8. Restoration Project Sites

The lower reaches monitoring effort represents a collaborative effort between NMISC and Reclamation to standardize monitoring procedures, so that similar physical and biological response variables across restoration project sites can be compared and evaluated. While some restoration design details differed between agency projects, the overarching project objectives for all eight projects were similar: to physically lower elevated floodplain terraces, so they could become inundated during low to moderate river discharges (≤ 800 cfs) and to provide physical conditions conducive to spawning and rearing for the RGSM.

Monitoring was implemented at all eight restoration project sites between March 14 and June 7, 2019. Activities included:

- Mapping inundation extent at approximately 800 cfs and 2,000 cfs
- Measuring inundation depth, velocity and water temperature
- Evaluating presence of isolated pools of water (i.e., not draining back to the river channel) and potential-to-strand RGSM
- Mapping the presence and distribution of New Mexico State listed noxious weeds

The monitoring was implemented primarily by the Save Our Bosque Task Force with technical support from GSA. The relationship between the monitoring actions implemented and restoration project objectives, as well as step-by-step descriptions of monitoring procedures, was included in NMISC's Monitoring and Adaptive Management Plan for NMISC Habitat Restoration Projects in the San Acacia Reach of the MRG. The results of the 2019 monitoring season can be found on the Program Portal (**https://webapps.usgs.gov/MRGESCP/**).

New Mexico State Forestry Exotic Species Removal

The CoA Open Space Division, in collaboration with New Mexico State Forestry (NMSF), conducted three separate exotic species removal projects. These projects were performed in part by NMSF's inmate work camp over the course of 40 days. The work included the operation and maintenance of previously constructed habitat restoration features with adherence to various agency jurisdictions and mandates.

The first of the three projects is located on the west bank of the Rio Grande, north of Central Avenue and within the Rio Grande Valley State Park Bosque. This project encompassed USACE's Ecosystem Revitalization Project at Route 66 and, in its second phase, entailed the treatment of 8.7 acres of exotic plant species and the removal of "dead and down" debris to include USACE's high-flow channel project area. The project was completed to maintain habitat and river-to-floodplain connectivity for the RGSM and SWFL.

The second of the three projects was the treatment and/or removal of exotic plant species for ABCWUA's San-Juan Chama Mitigation Project at the Paseo del Norte southeast habitat restoration site. This project is located on the east bank of the Rio Grande, approximately one mile south of Paseo del Norte, within the bosque. A total of six acres of exotic plant species were treated and/or removed, and the area was revegetated with native riparian vegetation, including Rio Grande cottonwood poles, Goodding's black willow poles, and coyote willows.

The third exotic species removal project was a collaborative project between CoA's Open Space Division, NMSF, Bosque School/BEMP, and Albuquerque Fire Rescue, which entailed the removal of "dead and down" vegetation. The goal of the project was to ultimately reduce the risk of catastrophic wildfire near a highly populated area and to treat and/or remove exotic plant species on approximately two acres. The project is located on the west bank of the Rio Grande, approximately half a mile south of Montano, within the bosque. A future phase of the project that features the construction of swales in order to benefit Bosque ecosystem health and SWFL habitat is currently being explored.

Photo: Rio Grande cottonwood
Credit: Mike Marcus, APA

Science Support

MRGESCP signatories funded and implemented various scientific studies and projects that benefited the RGSM, SWFL, YBCU, and other plant and animal species in the MRG. These FY19 activities included site and species monitoring, sediment studies, routine construction, an inundation assessment, and development of a mobile bed discharge gage. Table 8 lists the science support-related activities that were associated with the Program in FY19.

Activity Name	Begin	End	Sponsor/ Contributor
2012 Middle Rio Grande Inundation Assessment	FY19	FY20	USACE
Assessment and Quantification of Sediment and Discharge at Arroyo de los Piños	FY17	FY19	Reclamation; USACE
Bosque School Bosque Ecosystem Monitoring Program Site Monitoring	FY03	Ongoing	MRGCD; USACE
Changes in Terrestrial Soil Loss in the Middle Rio Grande Basin to 2100	FY19	FY19	USACE
Development and Application of a HEC-RAS, Mobile Bed, Sediment Transport Model of the Middle Rio Grande	FY17	FY19	USACE
Development of a Mobile Bed Discharge Gage	FY17	FY19	USACE
Effects of the Las Conchas Fire on Water Quality and Fish Assemblages in the Middle Rio Grande	FY16	FY19	USACE
Flume/Weir Construction Throughout the Middle Rio Grande Conservancy District		Ongoing	MRGCD
Monitoring Climate Change in the Middle Rio Grande	FY12	FY20	USACE
Middle Rio Grande Bedload Sediment Measurement	FY19	FY20	Reclamation; USACE
Middle Rio Grande Suspended Sediment Measurement at San Acacia	FY16	FY19	Reclamation; USACE
Middle Rio Grande Tributary Precipitation Induced Geomorphology	FY15	FY19	USACE
Rio Grande Sediment Gages: Rio Puerco, San Acacia, San Marcial	FY10	FY19	Reclamation; USACE
Tamarisk Leaf Beetle Distribution, Genetic Variation, Defoliation, and Mortality Impacts on Tamarisk Habitat in the Middle Rio Grande	FY12	FY19	USACE
Tamarisk Leaf Beetle Species and Habitat Analysis With Management Implications for the Middle Rio Grande	FY17	FY19	USACE

Table 8. FY19 Science Support Activities List

2012 Middle Rio Grande Inundation Assessment

Shallow depth, slower velocities, and sufficient duration of inundation are three habitat characteristics believed to be crucial for the survival of the early-life stage RGSM reared on the floodplain. Version 5.0 of the Hydraulic Engineering Center's River Analysis System (HEC-RAS) features the ability to conduct one-dimensional hydraulic modeling to generate water surfaces of rivers. This system was paired with a digital elevation model and aerial photography (for quality control) to estimate areas of inundation for the MRG. The purpose of this project is to update the 1992 and 2002 MRG analysis, which estimated areas of inundation at particular discharges throughout the MRG. The data was then used as a quantification of habitat for the RGSM in MRGESCP's population viability analysis model, which utilizes 2012 geometry to estimate areas of inundation per mile from Cochiti to San Marcial.

Assessment and Quantification of Sediment and Discharge at Arroyo de los Piños

USACE has partnered with Reclamation and others to better understand tributary sediment loading at Arroyo de los Piños, a tributary of the MRG. The MRG is a dynamic, complex river system, and its observed form is influenced by the flow and sediment transported from the Upper Rio Grande and MRG tributaries. Arroyo de los Piños is one of several ephemeral tributaries on the east side of the MRG, between San Acacia and San Antonio. Lateral input of sediment into the Rio Grande from ephemeral channels is poorly quantified. Measuring sediment discharge is difficult in a desert setting, as these channels flow only a few times a year and often for just a few hours at a time. Even so, ephemeral channels are the only source of sediment for much of the Rio Grande south of Albuquerque, where no perennial river feeds the Rio Grande until Texas.

The Arroyo de los Piños sediment monitoring station was built to address this knowledge gap. The station represents one of only a few locations worldwide where continuous sediment flux measurements are collected. The monitoring station's first year of data indicated that sediment was being transported at globally high rates, with bedload fluxes of up to 16 kilograms per second-meter (kg/s-m). More intriguing was the grain size distribution of the transported sediment. At low flows, sand-sized particles made up the majority of the sediment in transport. As water discharge increased, larger, gravel-sized particles became entrained and began making their way downstream.

The grain size distribution of sediment input is crucial for understanding the habitat availability for RGSM populations. Large floods along arroyos can produce low-velocity zones of debris and gravel within the Rio Grande that are ideal RGSM habitat. These areas persist until snow-driven spring runoff events are large enough to efficiently move the larger gravel and cobbles deposited by arroyos. Although 2018 rainfall runoff events in the Arroyo de los Piños caused the Rio Grande to shift its course to the west side, the snowmelt runoff in 2019 provided enough energy from the river to redistribute the sediment downstream. This created a diversity of low bar formations further downstream that dynamically changed with the 2019 spring snowmelt runoff. Through better understanding of sediment delivery from arroyos to the Rio Grande and of how that sediment is subsequently redistributed over time, there can be greater insight into how RGSM habitat forms and changes spatially and temporally.

Photos: Arroyo de los Piños sediment monitoring station
Credit: Kyle Stark, New Mexico Institute of Mining and Technology

Bosque Ecosystem Monitoring Program Site Monitoring

BEMP is a collaborative ecological monitoring and education program in partnership with UNM, the Bosque School, and the Sevilleta Long Term Ecological Research Program. In FY19, monitoring of the riparian corridor with New Mexico students, educational outreach, and other BEMP activities were funded, in part, by USACE, MRGCD, and the CoA Open Space Division.

BEMP conducts regular and systematic monitoring of habitats on the historic floodplain with the help of volunteers and K-12 and UNM students, while promoting education, awareness, and stewardship of the bosque. BEMP has collected long-term data for 20-plus years at a total of 33 research sites along 350 miles of the Rio Grande (Figure 6). Data include weather data, shallow groundwater table depth, monthly precipitation, surface arthropod activity, and forest production measurements (e.g., leaf litter biomass, tree diameter, growth rates, and plant distribution). BEMP shares its long-term data collection with Program signatories and other land and natural resource managers on an open access site (https://github.com/BEMPscience/bempdata), promotes public outreach, and furthers the preservation of habitat for listed species.

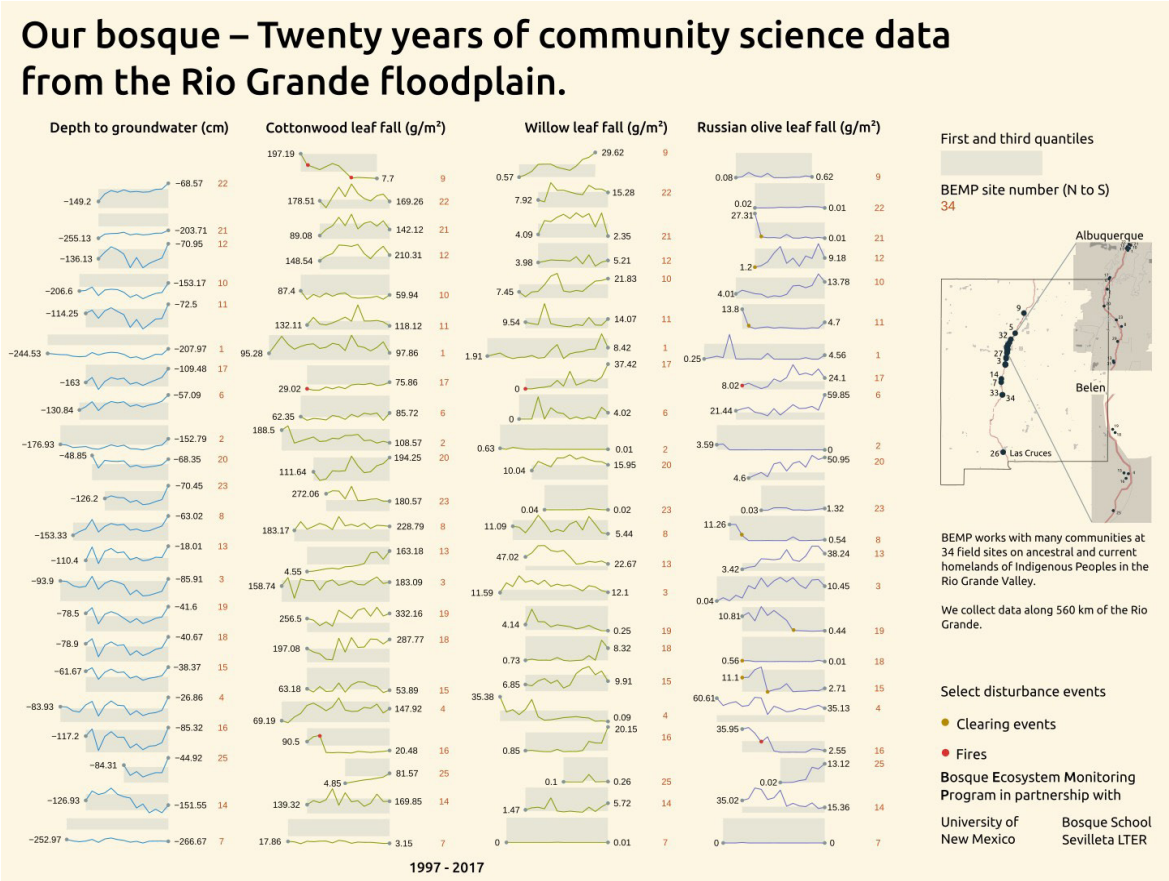

Figure 6. Data from 1997-2017 Bosque Ecosystem Monitoring Program sites on the Rio Grande floodplain. Site data is organized from top (most northern site) to bottom (most southern site).

Changes in Terrestrial Soil Loss in the Middle Rio Grande Basin to 2100

Riverine sediment in the MRG is essential for the creation of habitat for fish and native plant species, such as willows and cottonwoods. Sediment in riverine systems originates from both terrestrial (e.g., soil erosion and overland transport) and in-channel sources, and is responsive to changes in land use (e.g., infrastructure development), land cover, and climate. This project explored how projected changes in climate and land use may affect terrestrial sediment supply in the MRG, below Cochiti Reservoir, in the 21st century. Historic watershed soil loss rates were modeled using the revised universal soil loss equation (RUSLE) forced with observed precipitation rates and historic land use/land cover (LULC) data from the USGS LandCarbon study. The RUSLE model was then forced with localized constructed analogs (LOCA)-modeled precipitation data and LandCarbon LULC data for two 21st century epochs in order to assess changes in future terrestrial sediment supply rates within the basin.

Development and Application of a HEC-RAS, Mobile Bed, Sediment Transport Model of the Middle Rio Grande

Considering how sediment moves through the MRG is important for planning and engineering because it influences a range of concerns, including flood risk reduction and river rehabilitation. Additionally, a sediment imbalance may impair the riverine and riparian ecosystems that are vital to listed species. USACE recently completed the development and application of a one-dimensional sediment transport model (HEC-RAS) to evaluate potential future geomorphic and sedimentation trends in MRG reaches. The model was developed with continuity of parameters between Cochiti Dam and Elephant Butte Reservoir in order to provide consistency across diversion dams that have historically segregated modeling reaches and to reset modeling boundary conditions. The simulated results provide insight into the potential future magnitude and gradation of sediment transported in the MRG as well as spatial and temporal changes in channel bed elevation and stored sediment volumes. Some key interpretations of the results that may impact listed species habitat include:

- Bed lowering/channel widening occurs in response to expected decrease in sediment storage from Cochiti to Angostura, from Isleta to Bernardo, and in the downstream portion of the San Acacia Reach
- Bed raising/channel narrowing occurs in response to expected increase in sediment storage in other MRG reaches
- MRG morphology is influenced by tributary sediment loading; hydrologic sequences, such as extended drought; and anthropogenic influences, such as diversion dams or reservoir pool levels

The model is useful for evaluating reach and longer time-scale scenarios, and for supplying boundary conditions with more detailed temporal and spatial scale modeling of flood risk, sedimentation, and habitat improvement projects. For example, one current application of the model is providing boundary conditions around the IDD in order to investigate potential solutions for problems with sedimentation and the RGSM passage.

Development of a Mobile Bed Discharge Gage

The USGS tested the initial prototype Mobile Bed Discharge (MoBeD) gage designed by USACE. The goal of the MoBed platform is autonomous capture of physical system measurements to quantify channel evolution, geomorphology, and discharge estimations. Many ecosystems are difficult or cost prohibitive to monitor with traditional gaging. MoBed seeks to fill gaps in current data collection at static locations and via drone for post-flood automated high water mark delineation. Field operation of the device will also be explored, but was not conducted in FY19. Review of the device included technical comments on its design, programming, and operation, in context of operation at the Arroyo de los Piños study site.

Primary lessons learned from prototype development will be incorporated into version 2 of MoBeD. The first job is to simplify the device. Draft specifications for the revision are based on a new hardware foundation providing better modularity and durability, while increasing sensor and processing capacity. The primary photogrammetric camera array is new and has the potential for dramatically increasing image quality and response time. In version 1 of MoBeD, video cameras used for velocity measurement were 'borrowed' from the structure from motion (SfM) array due to a four-camera capacity when using one camera multiplexer. Version 2 has a dedicated SfM array with two additional cameras to record velocity or track a staff gage independently.

The MoBed gage project was presented at the Sedimentation and Hydrologic Modeling Conference. Possible deployment opportunities arose from the presentation, and initial discussions are underway for a flume test in cooperation with the Engineer Research and Development Center (ERDC) and the U.S. Department of Agriculture's Agricultural Research Service. The USGS also expressed interest in testing the MoBed gage on the Delaware River experimental watershed. As part of the prototype gage testing, specific attention is being given to evaluating how MoBed may effectively supplement the USGS instrumentation catalog. Deployment is planned on the Arroyo de los Piños upon completion of field hardening.

Photo: Middle Rio Grande drain levee
Credit: Mike Marcus, APA

Photo: Smoke cloud over Las Conchas
Credit: Mike Marcus, APA

Effects of the Las Conchas Fire on Water Quality and Fish Assemblages in the Middle Rio Grande

This study evaluated the effects of wildfire on downstream water quality and fish assemblages in large arid-land rivers. Through use of data from a high-frequency water quality monitoring network in the MRG, the dissolved oxygen (DO) was analyzed at five sites following the Las Conchas fire in 2011. DO is an important characteristic for determining the quality of a river or stream. DO measurements decrease, or sag, when a pollutant is present. As organic matter enters the river, it requires oxygen to decompose. This increased oxygen demand causes DO to sag and recover downstream of the pollutant. In the first three years after the 2011 fire, numerous DO sag events were documented at least 50 kilometers downstream. Periodic sags were also observed throughout 2018.

Long-term fish community surveys in the MRG were used to assess the response of fish assemblages at two sites closest to the wildfire. Despite poor water quality conditions, indicated by low DO, minnow species at both sites were resilient, with the exception of the longnose dace and fathead minnow at the upstream site. Following a major flood in September 2013, total fish density, richness, and diversity were negatively impacted at the upstream site. Native species, as well as the greater fish community, were unaffected by the flood at the downstream site. The variability in the fish community response was attributed to differences in spatial factors related to the burn scar, site-specific physical characteristics, and species-specific traits.

As wildfire timing, frequency, and severity have increased across Western United States over the last several decades, it is critical for water and resource managers to be aware of potential impacts to water quality and biota in arid-land catchments that are susceptible to wildfire.

Flume/Weir Construction Throughout the Middle Rio Grande Conservancy District

MRGCD installs new flow measurement and control structures at its facilities every year. In 2019, MRGCD installed three flumes for flow measurement, four weirs for water level control, and an automatic gate for water control and measurement. These structures aid MRGCD in providing more reliable water deliveries to irrigators and making informed water management decisions. Water measurement and flow control are tools that allow MRGCD to operate more efficiently. Increased efficiencies within the MRGCD system, including greater measurement precision, allow for more flexibility in water management, which could potentially benefit RGSM.

Monitoring Climate Change in the Middle Rio Grande

Most model projections of future climate in the Rio Grande basin are characterized by persistent drought. Recent drought has highlighted the vulnerability of regional water supplies to persistent drought and the potential impacts of drought on habitat and species conservation efforts. This project helps decision-makers understand and plan for climate change impacts to listed species and critical habitat by creating and maintaining an ongoing summary and analysis of the current trends in climate and the resulting hydrologic changes in the Rio Grande basin above Elephant Butte Reservoir. In addition, this project supports the following regional climate change planning efforts:

- Climate change projects, including the Rio Grande-New Mexico Basin Study and Drought Framework Planning Study, by Reclamation and MRGCD
- The Extreme Weather Events, Critical Thresholds, and Climate Preparedness Study by the City of Las Cruces and Southwest Climate Science Center
- Climate Research Symposium and Adaptation Round Tables by Los Alamos National Laboratory
- Rio Grande basin representation on the South Central Climate Science Center Rio Grande Coordinating Call and Southern Rockies Landscape Conservation Cooperative
- Information sharing with federal agencies through the Watershed Futures Initiative

Middle Rio Grande Bedload Sediment Measurement

The geomorphology of the Rio Grande is influenced by sediment transported in suspension, near the river bed. The quantity and type of sediment transported by the river changes with distance from the bed, with the assumption that higher fluxes occur near the bed. The majority of sediment data collected on the Rio Grande is used to measure the suspended sediment. There is a lack of physical sediment measurements of the MRG's bedload. This project makes use of sound technology (sonar and acoustic) to collect repeated sand dune movements and estimate bedload transportation in the MRG using the integrated section surface difference over time version 2 (ISSDOTv2) technique, developed by USACE's ERDC. The objective of this research is to collect data on bedload movement and compare the ISSDOTv2 technique with the semi-empirical bedload estimation technique currently used on the MRG. This information, coupled with suspended sediment information already collected on the MRG, provides information on how sediment moves through the system. As information on sediment transport is important for understanding how RGSM habitat develops and adjusts, this project helps provide insight into sediment transport mechanisms on the MRG.

Sediment data collection was conducted around the Albuquerque and San Acacia USGS gaging stations during the spring snowmelt runoff in June 2019. Data collection was a joint effort between USACE, USGS, and Reclamation. The effort involved typical sediment data collections on the MRG from established USGS gaging stations using physical samples of suspended sediment and bed material. The collected samples were processed to obtain sediment gradations and suspended sediment concentrations, then used with the semi-empirical modified Einstein procedure to estimate bedload. In addition, an acoustic Doppler current profiler (ADCP) and multi-beam sonar were both used to make multiple swaths of the bed. Both ADCP and sonar data are being processed to evaluate bedload movement, with the sonar data specifically being used to evaluate the ISSDOTv2 software.

Middle Rio Grande Suspended Sediment Measurement at San Acacia

The suspended sediment measurement at San Acacia is part of the larger MRG Bedload Sediment Measurement Study described previously. Sediment gages on the Rio Grande provide daily information with regard to changes in the quantity and gradation of suspended sediment. To better understand the temporal transport of suspended sediment in the MRG, active acoustics were installed at the San Acacia USGS gage. Acoustical research work on other rivers has revealed a more in-depth understanding of the timing, magnitude, and duration of sediment loads in those systems than was impossible with previously collected datasets. This data collection effort will aid in the understanding of sediment movement on the Rio Grande and how USACE project activities affect listed species' environments. The information on sediment flux also helps support operational and strategic decision making.

Three different acoustical instruments were installed at the San Acacia USGS gage in 2016/2017. This collaborative effort between Reclamation, USGS, USACE, and the University of Mississippi resulted in the collection of data between 2016 and 2019. An initial evaluation of this data shows that the suspended sediment load may be underrepresented when using a daily suspended sediment value. From the collected acoustic information, it was observed that more sand-sized particles are moved during the spring snowmelt runoff than at other time periods, with a continuous discharge threshold of around 1,500 cfs needed to mobilize the sand particles. Fine particles tend to dominate during the rest of the year and are also dominant on the rising and falling limb of the spring snowmelt runoff. Monsoon flows showed more variability, with data indicating higher suspended sediment concentrations in January than in February.

Middle Rio Grande Tributary Precipitation Induced Geomorphology

In 2019, there was a catchment-wide, high-resolution, precipitation-driven geomorphic change analysis of several MRG tributaries. Development of a sediment transport rating table was a key goal of this project. Catchment and sub-catchment volume changes can be correlated to rainfall distributions by depth, direction, and intensity. This project has three key requirements:

Requirement 1: High-resolution photogrammetric data, collected at high temporal frequency

Civil Air Patrol data collection flights are regularly scheduled for the full Arroyo de los Piños watershed and include catchment-wide geomorphic difference analysis. The FY19 flight data was compared with FY17 flight data at high spatial resolution.

Requirement 2: Regional radar at high spatial and temporal resolution, illustrating depth and intensity

Extraction of National Weather Service products was extensively investigated. Many MRG catchments have times of concentration that are less than one hour. When building a hydrology model that accurately represents the physical system, the time step of the primary input should be less than the entire model runtime. Several critical steps were made toward accomplishing this task. Semi-automated batch scripts were configured in order to retrieve raw data from National Oceanic and Atmospheric Administration servers, to process raw data into various analysis and reporting formats, and to convert raw data to the Data Storage System for use in the HEC's Hydrologic Modeling System (HEC-HMS).

Requirement 3: A calibrated gage network

Several storm events occurred in the drainage that were correlated to FY19-FY17 volume difference grids. At Arroyo de los Piños, New Mexico Tech (NMT) installed several rain gages in the watershed. The USGS was employed to review the precipitation instrumentation installation and data management plan. Guidance provided by the USGS increased confidence in rainfall depth measurements collected at Arroyo de los Piños for long-term rain gage and radar correlation analysis. Discussions are underway to conduct gage/radar correlation analysis with NMT, the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), and the Southern Sandoval County Flood Control Authority (SSCAFCA) to determine the impacts of the precipitation accounting method on HEC-HMS results

The volume and frequency of sediment entering the MRG drives channel geomorphology, sandbar bar formation, and vertical and lateral movement. Geomorphic changes drive the distribution and re-distribution of riverine species. Refining understanding of sediment response to specific precipitation frequencies will allow for better forecasting of restoration site operations and maintenance.

Photo: Middle Rio Grande
Credit: Mike Marcus, APA

Rio Grande Sediment Gages: Rio Puerco, San Acacia, San Marcial

The overall goal of this data collection effort was to provide information by which to assess the movement of sediment in the Rio Grande and to evaluate the secondary influences that sediment has on the geomorphology of the Rio Grande. The geomorphology of the Rio Grande within the Middle Valley has been affected by flood control and irrigation projects, which have influenced the amount and type of sediment supplied to the Rio Grande. Influences, such as dams, channel rectification measures, and sediment delivery from contributing drainage areas, have an effect on the geomorphology of the Rio Grande. Accurate sediment gage data are critical for understanding how much sediment moves through the Rio Grande, what type of sediment is moving, and when that sediment is moving. This project supported data collection at three essential gages: the Rio Puerco gage, the San Acacia gage, and the San Marcial gage.

Tamarisk Leaf Beetle Distribution, Genetic Variation, Defoliation, and Mortality Impacts on Tamarisk Habitat in the Middle Rio Grande

Tamarisk leaf beetle monitoring results revealed spread of the beetle, which has resulted in tamarisk defoliation in the Rio Grande watershed. The spread of the tamarisk leaf beetle from the north (*Diorhabda carinulata*) and the potential spread of another tamarisk leaf beetle species from Texas (*Diorhabda elongata*) will ultimately affect riparian forests in Central and Southern New Mexico. The *Diorhabda carinulata* has already spread further south, and the *Diorhabda elongata* is expected to continue expanding into New Mexico watersheds. These areas are critical habitat for the endangered SWFL and are important to many other riparian breeding birds and herpetofauna.

From 2012 through 2019, tamarisk leaf beetle surveys and tamarisk habitat evaluations have been conducted throughout the Rio Grande watershed. Over an eight-year period, tamarisk leaf beetle distribution and phenology (e.g., defoliation, mortality, and flowering) have been tracked. The survey methods for monitoring the tamarisk leaf beetle are based on those established by the Tamarisk Coalition, with some modifications. Field datasheets were compiled and entered into a database, the spatial data for beetle numbers present at each sampling location were used to create a geographic information system (GIS) map, and findings identifying what beetle species are present in New Mexico watersheds were used to coordinate and compile tamarisk leaf beetle monitoring datasets with the Tamarisk Coalition. Genetic analysis of tamarisk leaf beetle species within the watershed was also completed, and four species were identified: the Northern tamarisk leaf beetle (*Diorhabda carinulata*), the Subtropical tamarisk leaf beetle (*Diorhabda sublineata*), the Mediterranean tamarisk leaf beetle (*Diorhabda elongata*), and the larger tamarisk leaf beetle (*Diorhabda carinata*). Through genetic analysis, tamarisk leaf beetle hybridization among the identified species was also identified.

Tamarisk Leaf Beetle Species and Habitat Analysis With Management Implications for the Middle Rio Grande

The introduction and proliferation of the tamarisk leaf beetle for the biological control of tamarisk, starting in 2001, has initiated landscape-scale compositional shifts in riparian vegetation communities and altered habitat conditions. Tamarisk leaf beetle populations in the MRG have increased from 2015 through 2019, with overall effects on tamarisk-dominated habitat for riparian species. This increase is mainly due the presence of the Northern tamarisk leaf beetle (*Diorhabda carinulata*), which arrived in 2012, and the Subtropical tamarisk leaf beetle (*Diorhabda sublineata*), which ranged into New Mexico from Texas in 2015. The biocontrol of tamarisk may result in a reduction of habitat and the subsequent population decline of the SWFL and YBCU. Moreover, reductions in tamarisk vegetative cover may result in increased Russian olive abundance, which brings additional management problems.

In 2017, this study was initiated to analyze tamarisk leaf beetle-related changes to tamarisk-dominated habitat, to examine specific locations in the study area over time using remote sensing, and to field monitor vegetative and avian communities. In 2017, vegetation data was collected at 30 selected locations; in 2018, avian population data was collected; and in both 2017 and 2018, tamarisk leaf beetle data was collected. Data was collected in order to understand baseline conditions, study the ongoing effects of tamarisk leaf beetle use, and provide a reference for post-treatment patterns and dynamics in regards to vegetation composition and structure and associated habitat conditions. This study documented ecosystem responses to alterations in riparian habitat structure and plant communities due to tamarisk leaf beetle use over time, and also recorded any possible changes to avian species richness and density. The ongoing monitoring of riparian systems altered by the tamarisk leaf beetle is critical for understanding the possible management implications for plant and avian communities, especially the SWFL population.

Photo: Tamarisk leaf beetle
Credit: Daniel Bean, Colorado Department of Agriculture

Water Monitoring and Studies

Program signatories aided in several activities related to water monitoring and studies, including data collection, water releases, and hydrologic monitoring in the MRG. Table 9 lists the water monitoring and studies-related activities that were associated with the Program in FY19.

Activity Name	Begin	End	Sponsor/ Contributor
Collaborative Aerial Data Collection and Analysis	FY15	FY19	USACE
High-Frequency Water Temperature Data Collection Within the Inundated Floodplain of the Middle Rio Grande During the 2019 Snowmelt Pulse	FY19	FY20	USACE
Middle Rio Grande Groundwater Monitoring	FY07	FY20	USACE
Minnow Action Team	FY12	Ongoing	All MRGESCP signatories
Multi-Agency High Flow Collector Application Used for Monitoring the 2019 Rio Grande Runoff	FY17	FY19	Reclamation; USACE
Rio Grande Nature Center High Flow Channel Gage Monitoring	FY10	Ongoing	USACE
Socorro South Distribution Hub	FY16	FY19	MRGCD
Water Quality Monitoring of Aquatic Refugia in the Middle Rio Grande	FY16	FY19	MRGCD; USACE; USFWS

Table 9. FY19 Water Monitoring and Studies Activities List

Photo: Middle Rio Grande
Credit: Mike Marcus, APA

Collaborative Aerial Data Collection and Analysis

Movement of sediment in the American Southwest tends to be initiated by flash flood events due to monsoons. These events are short-term and occur under monsoonal weather conditions, which makes them difficult to accurately monitor using common terrain mapping technologies, such as aerial light detection and ranging (LiDAR). The major impediments to using these methods are the short notice to activate flight missions and the inability to rapidly develop maps. This project develops tools to facilitate the rapid production of sediment-related measurements.

USACE collaborated with UNM's GIScience for Environmental Management Lab, the U.S. Air Force Civil Air Patrol, and the U.S. Bureau of Land Management to implement the sensor array and conduct aerial data collection. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) and Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) also collaborated on arroyo data collection and ground control for aerial flights. In 2019, this project conducted several flights along the MRG. Information gathered during these flights will be used to extend in-flight computational capacity and reliability for ongoing geomorphic and vegetation analysis.

Collecting high-resolution orthoimagery and terrain data at the reach scale after precipitation events provides a critical geomorphic snapshot for the calibration of hydraulic, sediment, and vegetation models. The geomorphic snapshots are correlated to precipitation frequency and volume for event-based habitat monitoring. These models provide the foundation for Rio Grande tributary and main stem restoration efforts and efficient listed species protections measures.

High-Frequency Water Temperature Data Collection Within the Inundated Floodplain of the Middle Rio Grande During the 2019 Snowmelt Pulse

Inundated floodplains provide spawning and nursery habitat for the RGSM, which improve the reproductive success and recruitment of the species. However, the thermal regime within this habitat type has not been well studied, despite the observed effects of water temperature on growth, development, and survival of RGSM eggs and larvae. The May to July 2019 hydrologic forecast for the Rio Grande at the Otowi gage was 143 percent of the 30-year median. Given this unique hydrologic condition, USACE documented the thermal regime of the MRG floodplain using 12 randomly selected, spatially distributed, and high-frequency measurements at two sites that experienced widespread (>15 acres) and sustained (May-July) inundation. High-frequency measurements of air temperature at each site and water temperature from the nearby mainstem were also collected. In addition, water depth, velocity, specific conductance, dissolved oxygen, turbidity, pH, and estimated canopy cover were collected at each location during routine site visits. All temperature records were validated using previously developed methods. The data and associated report will be provided in FY20.

Middle Rio Grande Groundwater Monitoring

Data from MRG groundwater monitoring will provide invaluable information regarding how long designed groundwater depths are sustained following repeated flood inundation. Moist surface soils are not only important for establishment and growth of riparian-wetland plant species but also for organic soil development, nutrient cycling, invertebrate diversity, and other ecological processes. Long-term monitoring will help determine if depth thresholds are exceeded after restoration features become repeatedly inundated. In addition, monitoring of groundwater levels is needed to evaluate if and to what degree soil moisture retention improves with time as restoration features become repeatedly inundated. These data are invaluable for evaluating the effects of different soil moisture availabilities on vegetation growth attributes of constructed willow restoration features. This information is particularly important for guiding future designs for SWFL restoration projects. Additionally, the data collected can also be used to evaluate the differences in primary biological productivity between restoration features with and without direct river connections. The final report, to be completed in spring of 2020, will include a review of existing groundwater wells to determine if any of them can be retired from the monitoring network and excluded from the development of a groundwater database.

Minnow Action Team

The Minnow Action Team (MAT) began in 2012 as an ad hoc work group that aimed to bring adaptive management to MRG water and species activities. The MAT was formed after 2012 reports revealed low RGSM numbers due to prolonged drought. MAT meetings continue to take place each spring. During these meetings, resource managers and scientists coordinate information to make management decisions with the goal of benefitting listed species.

The MAT assists water and resource management entities with the annual coordination of, evaluation of, and recommendations for water operations and species management that aid in meeting the 2016 MRG BO and RGSM recovery goals. The MAT does this by assimilating hydrologic, biological, and ecological information on an annual basis, which informs the group's recommendations for reducing threats to listed species and enhancing the spawning, recruitment, and survival of RGSM.

Photo: Middle Rio Grande
Credit: Mike Marcus, APA

Multi-Agency High Flow Collector Application Used for Monitoring the 2019 Rio Grande Runoff

Like many areas in the arid Southwest, the MRG Valley, from Cochiti Lake through Albuquerque, downstream to Elephant Butte Lake, has seen drought for approximately a decade. This has impacted environmentally-sensitive species, agriculture, and water delivery to Rio Grande Compact partners downstream. Fortunately, the winter of 2018-2019 saw above average snowpacks in the Upper Rio Grande watershed, resulting in higher than average runoff levels.

In 2019, high-flow runoff provided an opportunity to carry out a multi-agency collaborative effort, led by USACE, with the objective of monitoring and documenting the effects of high-flow runoff on levee integrity, floodplain inundation, overbanking extents, and fish spawning habitat. To accomplish this, the Environmental Systems Research Institute's Collector for ArcGIS mobile application was implemented in the first coordinated multi-agency undertaking of its kind. USACE partnered with MRGCD and Reclamation to submit photographs and georeferenced observations. ArcGIS Online mapping enabled participants to share near real-time monitoring with all participating agencies. This effort was especially effective in identifying seepage points in the levees, thereby mitigating risks of levee failure, and in identifying whether habitat restoration sites were inundating at design flows.

Photo: Rio Grande backwater channel
Credit: Mike Marcus, APA

Rio Grande Nature Center High Flow Channel Gage Monitoring

The Rio Grande Nature Center Habitat Restoration Project was designed to restore an ephemeral side channel of the Rio Grande, thereby reconnecting the floodplain of the bosque to the river and reestablishing native habitat. The objective of this monitoring study is to collect data on stream flow through the channel during spring runoff. This information helps biologists understand if and how long flow conditions in the channel are suitable for RGSM spawning and recruitment. The amount and duration of flows also affect growth of native shrub species, which provide essential SWFL habitat.

Photo: Scenic view at the Rio Grande Nature Center
Credit: Mike Marcus, APA

Socorro South Distribution Hub

The Socorro Main South Distribution Hub uses two check structures in the Socorro Riverside Drain to supply water to a pump station. In turn, this pump station provides water for three separate discharge locations. Two of the three locations discharge into the MRGCD conveyance system; this enables MRGCD to access drain water for delivery to irrigators. The third discharge location is through the levee, which allows existing infrastructure to discharge the pumped water into the river channel and augment flows for listed species.

The Socorro Hub gives MRGCD access to the water from the Socorro Riverside Drain in order to effectively minimize the amount of water diverted directly from the Rio Grande. In addition, the pump station is used to augment flows in the river channel for the benefit of the RGSM below the SADD.

Water Quality Monitoring of Aquatic Refugia in the Middle Rio Grande

River intermittency, or the drying of stretches of the river so there is not continuous flow, will continue to become more common because of climate change, especially in the American Southwest. On the MRG, significant river intermittency is now considered normal and will likely become more frequent and widespread given water scarcity predictions.

Aquatic MRG wildlife experiences habitat loss as drying occurs along stretches of the river. Remaining habitat for aquatic wildlife, such as irrigation outfalls, areas below irrigation outfalls, and isolated pools, may provide temporary refuge during periods of river intermittency. These spaces are known as aquatic refugia, and may become increasingly important as drying trends continue in the Rio Grande basin. Water quality factors of aquatic refugia, including pH, nutrient content, temperature, and dissolved oxygen, have been identified as potential inhibitors of use of these critical spaces by listed species, such as the RGSM. Continuous and discrete measurements of water quality within aquatic refugia have provided insight into factors that may influence fish survival and, more specifically, survival of the endangered RGSM. Moreover, the evaluation of these aquatic refugia has led to a greater understanding of stream fish ecology and of future challenges facing the MRG. The results of this work may also be used to inform management decisions.

Photo: Middle Rio Grande edge habitat with algae growth
Credit: Mike Marcus, APA

Program Support

MRGESCP signatories provide support for the Program and its activities. This support is vital for accomplishing the Program's mission and goals, which benefit the MRG's listed species. The signatories provide administrative assistance and aid in the funding, planning, coordination, and staffing of Program activities. Table 10 lists the Program support-related activities that occurred in FY19.

Activity Name	Begin	End	Sponsor/ Contributor
MRGESCP Portal and Database Management System	FY07 FY18	FY18 FY20	ABCWUA USACE
MRGESCP Program and Science Support Contract	FY16	FY21	Reclamation
U.S. Fish and Wildlife Service Management and Support	FY02	FY22	Reclamation; USFWS

Table 10. FY19 Program Support Activities List

MRGESCP Portal and Database Management System

The Program Portal is a database management system that also functions as the Program's website and meeting calendar. It is regularly maintained and updated, and stores and facilitates access to scientific data, reports, and papers relating to species of interest and critical habitat in the MRG. The Portal also functions as the document repository for the Program's administrative record of meetings and activities. Stored information and data is available for use by Program members and the public. The Program Portal can be found at **https://webapps.usgs.gov/MRGESCP/**.

MRGESCP Program and Science Support Contract

In FY19, Reclamation continued to contract Western EcoSystems Technology, Inc. (WEST, Inc.) to provide third-party program and science support services for the MRGESCP. The Program Support Team (PST) includes a Program Manager, a Science Coordinator, and support staff. The PST is responsible for facilitating the achievement of Program goals and initiatives by providing meeting administration, technical and scientific support, signatory correspondence, activity planning and coordination, Program outreach, and dissemination of Program-related information to relevant parties. The PST's science coordination services include assistance with scientific activities, as well as coordination with Program scientists and technical experts to develop plans, processes, and other work products in support of the MRGESCP.

The support services of the PST aid in the implementation of Program activities that progress the Program's mission and goals. Improvement of coordination and communication around Program efforts by the PST enables the Program to make better informed recommendations for the MRG and its listed species.

U.S. Fish and Wildlife Service Management and Support

In FY19, Reclamation continued to provide funding to USFWS for the hiring of personnel tasked with supporting MRGESCP management activities and facilitating ESA compliance. Specific ESA compliance tasks of USFWS personnel include facilitating Section 7 consultations for the Program's federal partners and managing Section 10 permits for other Program signatories.

As a signatory, USFWS also independently provides Program management and on-the-ground support for activities that advanced the recovery of listed species. These efforts aim to minimize the adverse effects that actions in the MRG have on federally listed species, as well as on their proposed and designated critical habitat.

Photo: Rio Grande cottonwoods in the Middle Rio Grande
Credit: Mike Marcus, APA

Middle Rio Grande Endangered Species Collaborative Program

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