Low Intensity Monitoring
2010 Water Year

Report prepared by the

MRGESCP Monitoring Plan Team

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MRGESCP Monitoring Plan Team

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Executive Summary

The Middle Rio Grande Endangered Species Collaborative Program (Program) funds habitat restoration projects as a management action designed specifically to achieve RPA Element S of the 2003 Biological Opinion and more broadly to improve habitat conditions for the benefit of the federally listed Rio Grande silvery minnow and Southwest Willow Flycatcher. Determining the effectiveness of the restoration projects over a range of elements and scales can provide crucial information to resource managers with which to make future management decisions. The Program initialized an Effectiveness Monitoring Plan that focused on collecting, analyzing and presenting physical information collected on a set of representative habitat restoration sites as a two year pilot program beginning in the 2010 water year. This report provides the preliminary data from the first year of this two year program.

Four major elements were included in the Program's Effectiveness Monitoring Plan: species (minnow and flycatcher), hydrology, vegetation and geomorphology. The species element addresses the questions of whether the target species are present on the restoration sites and potentially can provide insight into the species' life histories and habitat preferences. The hydrology element looks at both the larger scale inundation metric and site specific habitat characteristics of restoration sites. The vegetation and geomorphology monitoring both investigate structure, function, and maturity of restoration sites with a particular focus on potentially determining a range of expected site longevity and, as a result, future restoration maintenance schedules.

The 2010 Effectiveness Monitoring Plan implemented during the spring and summer of 2010 produced results that point to the potentially significant benefits associated with habitat restoration management activities. These results from the representative restoration sites include:

- 1643 Rio Grande silvery minnow sampled on inundated restoration sites.
- All restoration sites were inundated in 2010 with a Program-wide increase in the availability of floodplain habitat of 5903 acre/days.
- Hydrological conditions on all restoration sites fell within the suitable habitat range for velocity and all but one site for depth, while temperatures on restoration sites were consistently elevated compared to the adjacent river channel.
- Vegetation across all restoration sites was dominated by native species.
- Minor amounts of erosion and deposition occurred on restoration sites resulting in increased habitat diversity with no appreciable change in designed inundation levels.

While the exact definition of "effectiveness" as it pertains to habitat restoration activities will certainly continue to evolve based on an improving understanding of the life history and habitat preferences of the target species, there is little question based on the results presented here that the specific techniques and larger suite of projects create functional floodplain habitat, characterized by diverse and suitable physical conditions, that persist over a minimum of 1-2 years and a current maximum of 8-9 years. The issue resource managers now need to address is not identifying the benefits of this management action but understanding where additional restoration need to be implemented, how much and over what range of flows.

Open Letter to the Executive Committee

July 22, 2010

The co-chairs of the Monitoring Plan Team (MPT) would like to take a moment to recognize and bring to you attention the efforts of some of our colleagues for their contribution to habitat restoration (HR) effectiveness monitoring activities during the 2010 spring snowmelt runoff. As you know the MPT, a joint Science and HR ad hoc workgroup, has been in the process of developing and contracting out an Effectiveness Monitoring Plan in order to streamline the post-construction effectiveness monitoring of Collaborative Program funded HR projects.

This monitoring is required under both project specific environmental compliance agreements and the 2003 Biological Opinion RPA Element "S". Additionally this type of monitoring provides important information as to the utilization of the restoration sites by the species of concern, assists in the continuous effort of adaptively managing HR activities into the future, and is essential for showing lawmakers and other funding sources that HR activities are providing a return on their investment.

Due to unforeseen and unavoidable obstacles in the contracting process a contract award was not able to be made in sufficient time to allow for fisheries and hydrologic monitoring of the 2010 spring runoff season. The MPT as well as volunteers from both the Science and HR workgroups, after approval from the Coordination Committee, took it upon themselves to perform these monitoring activities. Substantial effort went into planning and coordinating the monitoring while the physical exertion of field activities on the Rio Grande cannot be overstated. All parties involved made significant contributions to the effort.

Provisional results indicate over 1600 silvery minnow were samples at the selected HR sites and all sites displayed hydrologic conditions conducive to silvery minnow utilization and occupancy.

The MPT is also planning on performing the low intensity vegetation, hydrology, and geomorphology measurements during the month of October. Performing the monitoring ourselves has helped us learn more about the sites and we, therefore, plan to continue to perform the low intensity monitoring next year. Elements of the high intensity and/or system-wide monitoring may be put out for RFP for FY '11. The MPT is working on this scope of work right now.

The MPT looks forward to presenting the monitoring results to you in a more formal presentation once the data has been reviewed and analyzed, which we believe will be in the next few months.

Contributors to monitoring on the ground include:

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Introduction

The Middle Rio Grande Endangered Species Collaborative Program (Program) is a partnership involving 16 current signatories organized to protect and improve the status of endangered species along the Middle Rio Grande (MRG) of New Mexico while simultaneously protecting existing and future regional water uses. The two species of concern are the Rio Grande silvery minnow (*Hybognathus amarus*, silvery minnow) and the Southwestern Willow Flycatcher (*Empidonax traillii extimus* , flycatcher). The Program's stated goals are to 1) alleviate jeopardy to listed species in the Program area; 2) conserve and contribute to the recovery of the listed species; 3) protect existing and future water uses; and 4) report to the community at large about the work of the Program (http://www.middleriogrande.com/) The Program funds activities that are anticipated to contribute to these goals including funding a broad category of habitat restoration (HR) projects. Given the expenditure of significant funds towards this end, the Program recognizes the need to understand the effectiveness of these projects in achieving their stated goals as well as the more general goals of the Program.

One of the objectives of the Program is to create or restore habitats necessary for the silvery minnow and flycatcher. The MRG was once a braided river meandering across a broad floodplain composed of a patchy mosaic of riparian habitats (Scurlock 1998) but has been reduced to a single channel constrained between levees. Water impoundments and diversions, channelization, and bank-stabilization have all contributed to dramatic changes in riverine function and processes in the MRG. These actions have largely isolated the contemporary MRG from its floodplain and have led to endangered status of the silvery minnow and flycatcher under the Endangered Species Act. Many of the current habitat restoration projects have been designed, in part, to reconnect a portion of the MRG with its adjacent floodplain in order to provide silvery minnow and flycatcher habitat and restore ecosystem function at these sites.

The specific objective of restoration projects for the silvery minnow is to increase habitat complexity to provide a diversity of habitats to accommodate the differing needs of each life stage. Knowledge of how the silvery minnow uses inundated floodplain and other habitats immediately lateral to the river channel could be used to improve future restoration designs. Connecting the floodplain to the river channel represents an effective restoration strategy to create essential low velocity silvery minnow habitat during high flows, potentially improving the survival of eggs and larvae in those areas. In addition, these projects have the potential to create conditions that benefit the flycatcher by removing invasive plants and replacing them with native vegetation and restoring hydrologic processes that could enhance flycatcher habitat. Before restoration activities began in the MRG, few if any of project sites experienced overbank inundation at allowable spring runoff discharges (USACE 2006, SWCA 2007.)

Until this point in time, Program-funded HR projects were monitored for effectiveness by the implementing agencies, typically using original project grant funding and project-specific methodologies. This report represents the first attempt of the Program to implement a single, comprehensive habitat restoration Effectiveness Monitoring Plan (EMP) for all HR projects funded by the Program for the benefit of the silvery minnow and flycatcher. The 2010 monitoring effort data and subsequent analytical results presented here are the culmination of this effort in its first calendar year.

The EMP, which is currently conducted under a broad scope of work, was developed and subsequently partially implemented by the Monitoring Plan Team (MPT), an ad hoc technical workgroup within the Program's operational structure. The MPT developed the plan during the second half of 2009 in collaboration with personnel from the three main Program technical workgroups (Science, Habitat Restoration and Species Water Management) as well as with other non-affiliated Program participants. Additionally an outside contractor, Dr. Paul Hook with Intermountain Aquatics, assisted the MPT with development of the plan.

In order to systematically examine the effectiveness of restoration projects in the Middle Rio Grande, the MPT created a pilot EMP. This protocol details fish presence/absence, and hydrologic data to be collected during the spring peak runoff. Vegetation and geomorphic data are to be collected during the late summer. These data allow the MPT to assess the success of habitat restoration efforts at recreating desirable habitat for the silvery minnow and flycatcher. This document reports the first year of monitoring under this new protocol. Monitoring was completed by members of the MPT and knowledge gained from the first year of monitoring will be used to improve future monitoring efforts.

Methods

Site Selection

A total of 63 Program-funded restoration sites throughout the MRG were considered for this monitoring effort. Each site was numbered sequentially from north to south and a random number generator was used to select a subset for monitoring. The MPT reviewed the list and eliminated any sites that were logistically not feasible to sample (e.g., area was too small, the site would not be accessible during high flows, etc.). After the list had been examined, the first 20 randomly-selected sites were identified for monitoring (Table 1, Appendices A and B). Sites were assigned to fish monitoring lead personnel based upon coverage under the U.S. Fish and Wildlife Service Endangered Species Act (ESA) permits and staff availability.

The original scope of work for the EMP was to have two levels of monitoring intensity: high and low. Low-intensity monitoring was designed to determine the presence or absence of minnows at selected sites while high-intensity monitoring was designed to answer more specific questions regarding habitat use (e.g., temporal patterns or spatial distribution). Because of limited staff availability, the MPT only implemented low-intensity minnow protocols during spring 2010. Most sites were visited twice during the high-flow period; however some sites were visited up to four times.

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Table 1. Effectiveness Monitoring Plan (EMP) sites and parameters measured.

EMP Site Number[+]	Alternative Site Name	Project Affiliation[§]	Feature Type	Inundation Target (cfs)	Construction Date	Feature Size (acres)	Rio Grande Silvery Minnow	Hydrology	Vegetation	Geomorphology
1	NDC 1CH	a	High-flow channel	1000-1500	2006	0.25	X	X	X	X
2	PDN 7i	b	Island terrace	3500	2007	0.34	X		X	X
3	PDN 9i	b	Island terrace		2007	0.10	X	X	X	X
4	PDN 11i	b	Island terrace	2500	2007	0.72	X	X	X	X
5	PDN 13i	b	Island terrace	3500	2007	1.21			X	X
6	Rio Grande Nature Center	c	High-flow channel	1000-2000	2009	3.04	X	X	X	X
7	I-40 2i	a	Island terrace	1500-3500	2007	1.00	X			
8	I-40 1CH (Central WW)	b	High-flow channel	1400	2007	1.04	X	X		
9	I-40 2b (Central NE)	b	High-flow channel	3500	2007	1.10	X	X		
10	I-40 4b (Tingley Bar)	b	Bankline terrace	3500	2007	5.88	X	X	X	X
11	COA – 1 Harrison M.S.	d	High-flow channel, bankline bench	n/a	2007	2.0	X		X	X
12	COA – 2 SDC	d	High-flow channel	n/a	2007	1.20			X	X
13	SDC 1i	b	Island terrace	1400-3500	2007	0.32			X	X
14	SDC 5b Price's Dairy	b	Bankline terrace	3500	2007	1.20		X	X	X

EMP Site Number[+]	Alternative Site Name	Project Affiliation[§]	Feature Type	Inundation Target (cfs)	Construction Date	Feature Size (acres)	Rio Grande Silvery Minnow	Hydrology	Vegetation	Geomorphology
15	Los Lunas	e	High-flow channel	1500-2500	2002	40.0	X		X	X
16	PER – 19	f	Bankline terrace	2500	2009	1.60	X	X	X	X
17	PER – 16	f	Bankline terrace	2500	2009	1.56	X	X	X	X
18	LP1 – 1	f	Bankline terrace	2500-3000	2009	1.01	X	X	X	X
19	LP1 – 3	f	Bankline terrace	1500-2500	2009	1.62	X	X	X	X
20	Willie Chavez	f	Embayment	2500-3500	2009	5.70	X	X	X	X

[+] *Refer to Appendix A for site locations and Appendix B for site descriptions.*

[§] *Project affiliations: a = Interstate Stream Commission-Albuquerque Reach-Phase I; b = Interstate Stream Commission-Albuquerque Reach-Phase II; c= U.S. Army Corps of Engineers; d = City of Albuquerque; e = Los Lunas Habitat Restoration Project; f = Interstate Stream Commission-Isleta Reach-Phase 1*

Rio Grande Silvery Minnow Use

Each of the selected habitat restoration sites was monitored during the spring runoff from 10-27 May, 2010, for use by silvery minnows. Sampling was scheduled for times when sites were anticipated to be inundated; but because of the variable nature of the flows, some sites were visited below target discharges. In these cases, sampling was conducted on a wetted shoreline area adjacent to the site. Silvery minnow presence/absence was determined at each monitored site using fyke nets and seines. Personnel from the U.S. Army Corps of Engineers and Bureau of Reclamation used rectangular nets (0.5 x 0.5 m, 6.4 mm mesh size) with 5.0 meter wings (5.0 x 0.5 m, 6.4 mm mesh size). US Fish and Wildlife Service personnel used hoop nets (0.6 m hoops, 6.4 mm mesh size) with 3 meter wings. Seining was conducted using a bag seine (4.5 meters x 1.8 meters with 3mm mesh).

Fyke nets were placed at each monitored site in areas that allowed for proper net function (i.e. approximately 0.3 – 0.5 meters deep, low or no current velocity) for two to four hours. Two of the net sets did not collect any fish during the set time, and were subsequently seined with the fyke net to collect fish. At two of the sites, the restoration feature was not inundated, so seining was conducted adjacent to the site and categorized by mesohabitat present at the time of minnow sampling (run, pool, embayment etc.). All captured fish were identified, counted, measured for standard length, and released on site. Water depth, velocity, temperature, and dissolved oxygen were measured at the mouth of each net. General mesohabitat type (e.g. run, side channel, backwater) was determined for each fyke net set or seine haul. Catch per unit effort (CPUE) and standard error were calculated per net as number of fish collected per hour set time. Because so few seine samples were taken, CPUE was not calculated for this gear type. Analysis for ANOVA and t-tests were conducted using data analysis tools in Microsoft Excel and SigmaPlot software. Photos of this sampling effort are presented in Appendix C.

Hydrology

The hydrological monitoring of HR sites consisted of two components: inundation evaluation and hydrologic characterization.

For each of the 20 study areas monitored in 2010, inundation evaluation used hydrograph data to estimate the area and duration of inundation at different flood stages. Inundation evaluation is a MRG-scale analysis of the extent and duration of inundation on HR sites designed as floodplain habitats. It is assumed that the first order definition of floodplain habitat as it pertains to these Program projects is the periodic inundation of land surfaces adjacent to the active river channel. As such, this analysis evaluates the proof of concept that lowering pre-existing land surface elevations results in the creation of floodplain habitat and since both extent and duration of inundation are theoretically important in the function of floodplain, this analysis provides a basic indication as to the potential function of the combination of all Program projects in area inundated (acres) per unit time (days). This concept is referred to as “acre/days” in this analysis and is the MPT’s current metric for evaluation first order project effectiveness. Figure 1 presents the total area of Program-funded HR projects that will be inundated at a given river discharge.

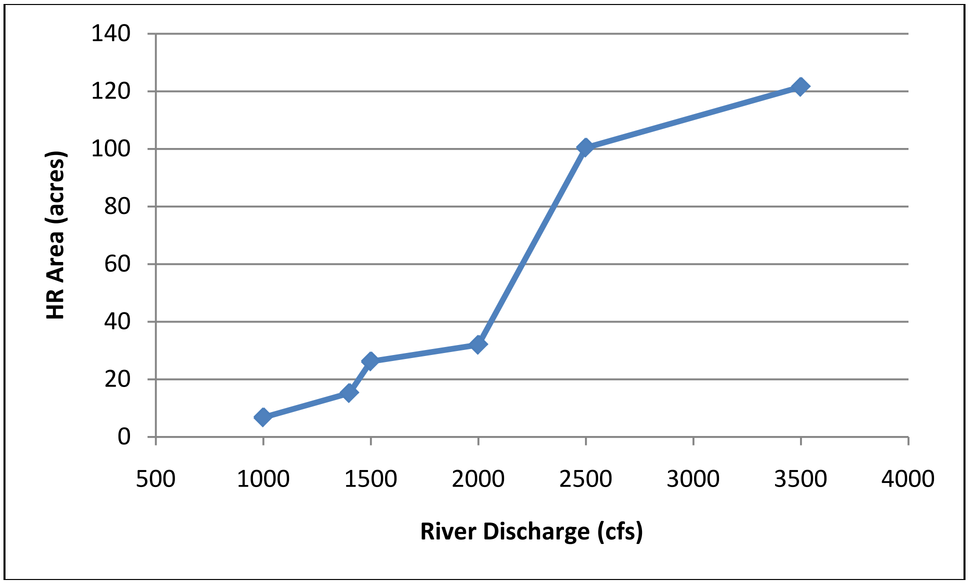


Figure 1. Projected cumulative inundation curve for Program habitat restoration (HR) sites within the MRG determined from project-specific target inundations and acreages.

The inundation evaluation was conducted using daily discharge data obtained from the U.S. Geological Survey National Water Information System web interface (http://waterdata.usgs.gov/nm/nwis) and processed through an Excel spreadsheet. Daily discharge data from the Central Avenue gage (USGS gage number 08330000) was utilized for analysis of all Albuquerque Reach restoration sites. Because there is not currently a high-flow rated gage in the Isleta Reach, the Central Avenue gage was also used to analyze HR inundation of sites in that reach. It is understood that irrigation diversions at Isleta Dam slightly reduce the magnitude of the discharges in that reach and thus inundation analysis of that reach is slightly overestimated. The spreadsheet was set up with the average daily discharge data, the series of HR inundation target flows and an "if, then" equation that produced a one or a zero depending on if the inundation target was exceeded or not respectively for that day. Exceedance days were then summed to produce inundation duration for the HR sites.

Hydrological characterization was intended to be a second level evaluation of the site-specific habitat conditions on the restoration sites and this analysis involved the measurement of depth, velocity, and water temperatures along cross-sectional transects established to characterize the variability of hydrological conditions present on the HR site and the adjacent river channel. Hydrological characterization monitoring was conducted on 13 of the 20 low intensity monitoring sites during the 2010 spring snow melt runoff between 21 April and 24 May 2010. A total of 29 individual site-specific monitoring events took place over a range of 2510-5180 cfs discharges and corresponding HR site inundation. Two sites were visited three times, eight sites were visited twice and three sites were visited once. A total of seven sites were not visited during the monitoring mainly because of safety concerns of accessing them during high flow conditions. The number of measurement points included in hydrological characterization cross-sections ranged between as few as four to as many as 40. Transect lengths and measurement point spacing was individually determined based on site geometries and inundation conditions in order to characterize the diversity of hydrologic conditions at the specific sites.

A Marsh-McBirney Flo-Mate 2000 velocity meter and an YSI-30 temperature meter were used to conduct the hydrologic characterization monitoring. During monitoring the Flo-Mate was affixed to a standard four-foot wading rod to allow for proper placement of the probe in the water column at 60%

of the depth as measured from the water surface elevation. Measurements were collected along a linear transect selected to capture the diversity of conditions at any particular location. Hydraulic conditions within the floodplain features were complex, with depths and velocities varying with localized conditions including but not limited to distance from the channel, vegetation, and ground surface elevation. Large quantities of debris were often present throughout the water column as well. It is important to note that split measurements were not performed for water depths over 2.5 ft as is standard practice in stream gaging (BOR 1997) because the presence of vegetation at many of the sites resulted in skewed velocity profiles on the habitat restoration floodplain sites.

Vegetation

Plant communities at the selected HR sites were mapped 15 October – 3 November 2010 using a modified version of the community-structure (C-S) classification scheme developed by Hink and Ohmart (1984). The intent of the vegetation monitoring was to capture the presence or absence (existing conditions) of woody vegetation at each HR site in a manner that would allow a vegetation component to be considered when analyzing the overall functionality of the site based on assumptions of desirable MRG habitat. The successive capture of vegetation conditions on HR sites over time will allow for a more advanced analysis of the functionality of HR in the context of the successional nature of riparian vegetation. Species codes similar to Hink and Ohmart were used and are shown in Table 2. Height classes were developed and are shown in Table 3. Density classes were also developed and are shown in Table 4. Patches containing similar vegetation type and structure were identified and delineated on recent aerial photographs. For each patch, relative abundance (% cover of each woody species and density on the site) and height of each woody species present were noted. Vegetation type patches were then digitized and quantified using ArcGIS for each HR site.

Table 2. Vegetation species/cover codes used in describing plant community types at HR monitoring sites.

Species Code	Species
C	Cottonwood (*Populus deltoides wislizenii*)
CW	Coyote Willow (*Salix exigua*)
NMO	New Mexico Olive (*Forestiera neomexicana*)
SC*	Salt Cedar (*Tamarix chinensis*)
TW	Tree willow (*Salix gooddingii*)
RO*	Russian Olive (*Elaeagnus angustifolia*)
SE*	Siberian Elm (*Ulmus pumilia*)
TH*	Tree of Heaven (*Ailanthus altissima*)

Those species marked with asterisk (*) are considered to be non-native.

Table 3. Vegetation height classes

Height Class	(ft)
1	0-3
2	3-6
3	6-9
4	9-12
5	>12

Table 4. Vegetation density classes

Density Class	Description
a	bare
b	sparse
c	dense

Geomorphology

Low intensity geomorphic monitoring was conducted simultaneously with vegetation monitoring and consisted of qualitative observations at each monitored site. Techniques included visual observations, completing notes/sketches, and taking photos where appropriate in order to ascertain trends in site function over time. In order to facilitate efficient data collection methods, the vegetation type patches described above were used as the starting point for geomorphology data collection. It is assumed that small amounts of suspended load (e.g., silt) deposition occurs across all inundated features and data collection methods do not necessarily capture this. Existing geomorphic conditions at the site during the visit were recorded for each patch as areas of degradation (e.g., erosion or scouring) and/or aggradation (e.g. deposition). In general, these conditions included bed material composition, any active and obvious bank erosion, bed form structure and any recent and obvious changes in river planform or deposition as these may pertain to overall functionality of the restoration sites. The type of bed material was recorded (Table 5) and any obvious areas of aggradation or degradation were drawn on the aerial photograph. A completed site map for each location delineates apparent topography, relationship to local vegetation, and any effects to site functionality that could be related to geomorphic events or processes at the individual site.

Table 5. Bed material classification

Bed Material	Size (mm)
Silt	<0.06
Sand	0.06-2.0
Gravel	2.0-64
Cobble	64-256

Results

Rio Grande Silvery Minnow Use

Results from spring 2010 monitoring yielded species, number of fish sampled, and catch per unit effort (CPUE) for each monitored site. Combined with hydrology, vegetation and basic geomorphic data, the fisheries data provide an indication of fish use (measured by presence/absence and relative abundance) of the locations monitored. Four broad types of habitats were encountered during monitoring (backwater, floodplain, inlet, and side channel) and the data provide a simple indication of fish preference under conditions of increased flows.

Sixteen sites were sampled in May 2010, four sites were not sampled because of permitting issues or timing of inundation. Twelve of the 16 sites were sampled on multiple occasions. A total of 1,724 fish and one bullfrog were collected in 58 samples (50 fyke net sets and eight seine hauls). All results are presented in Appendix D. Rio Grande silvery minnow was the most abundant species comprising 96% of fish collected (1,643 total, Table 6). CPUE for silvery minnow ranged from zero to 87 fish per hour in fyke net sampling, averaging 11 fish per hour (Figure 2). Eighty-five silvery minnows were captured in eight seine hauls comprising 73% of all fish collected with this gear type. Red shiner was the next most common species collected for both gear types.

Table 6. Species and numbers collected during May 2010 on habitat restoration sites on the Rio Grande, NM.

			Fyke Net Sets (53 Samples)			Seining (8 Samples)
Common Name	**Species**	**Species Code**	**Number**	**Mean Fish/Hour**	**Standard Error**	Number
Rio Grande Silvery Minnow	*Hybognathus amarus*	HYBAMA	1,558	11.0	2.84	85
Red Shiner	*Cyprinella lutrensis*	CYPLUT	38	0.88	0.20	19
Fathead Minnow	*Pimephales promelas*	PIMPRO	7	0.35	0.03	0
Western Mosquitofish	*Gambusia affinis*	GAMAFF	3	0.35	0.05	1
Common Carp	*Cyprinus carpio*	CYPCAR	2	0.34	0.06	0
Bullfrog	*Rana catesbeiana*	Bullfrog	1	0.4		0
Green Sunfish	*Lepomis cyanellus*	LEPCYA	1	0.33		0
Flathead Chub	*Platygobio gracillis*	PLAGRA	1	0.37		8
Longnose Dace	*Rhinichthys catarctae*	RHICAT	0	0.00	0.00	2

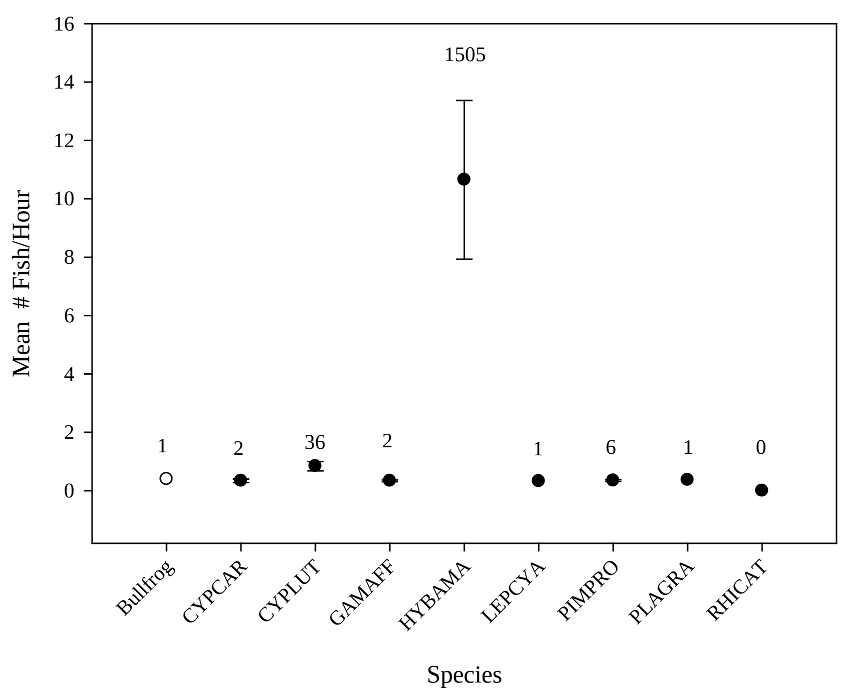


Figure 2. Catch per unit effort (number of fish per hour) of species collected in fyke nets May 2010, Rio Grande, New Mexico.
Error bars represent one standard error, numbers indicate total number of fish collected. See Table 1 for explanation of species codes. Note: effort was not noted on all fyke net samples.

Silvery minnows ranged from 28mm to 93 mm standard length. The mean size of silvery minnows collected in the fyke nets were larger (55.8 mm) than those collected by seining (53.6 mm, t=1.87 *p*=0.06) though the sample size was much larger with fyke nets (Figure 3). Approximately 10% of the silvery minnows collected were larger than 65 mm standard length.

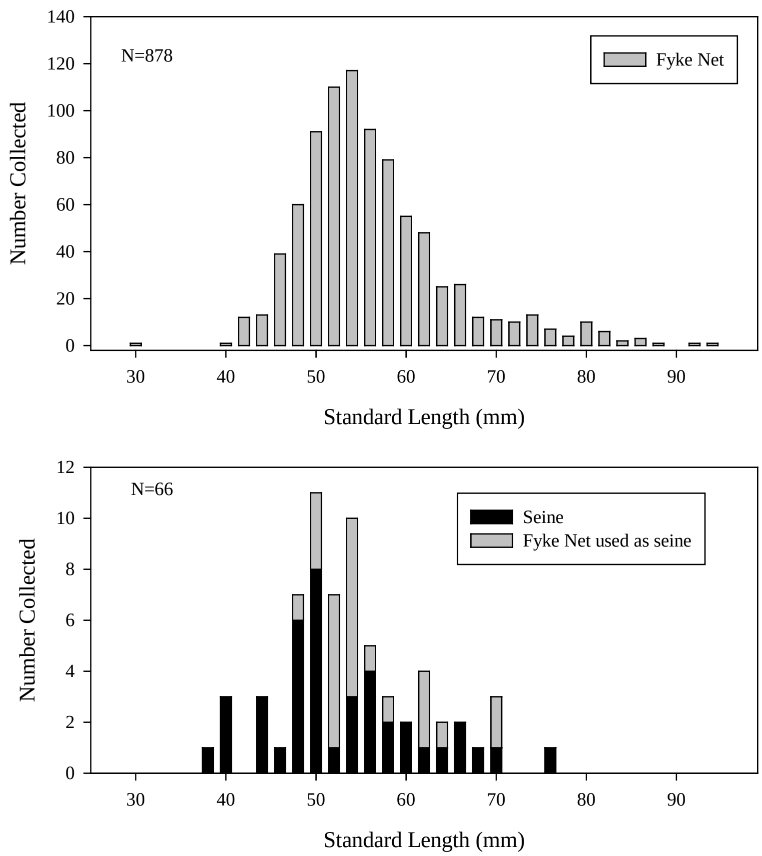
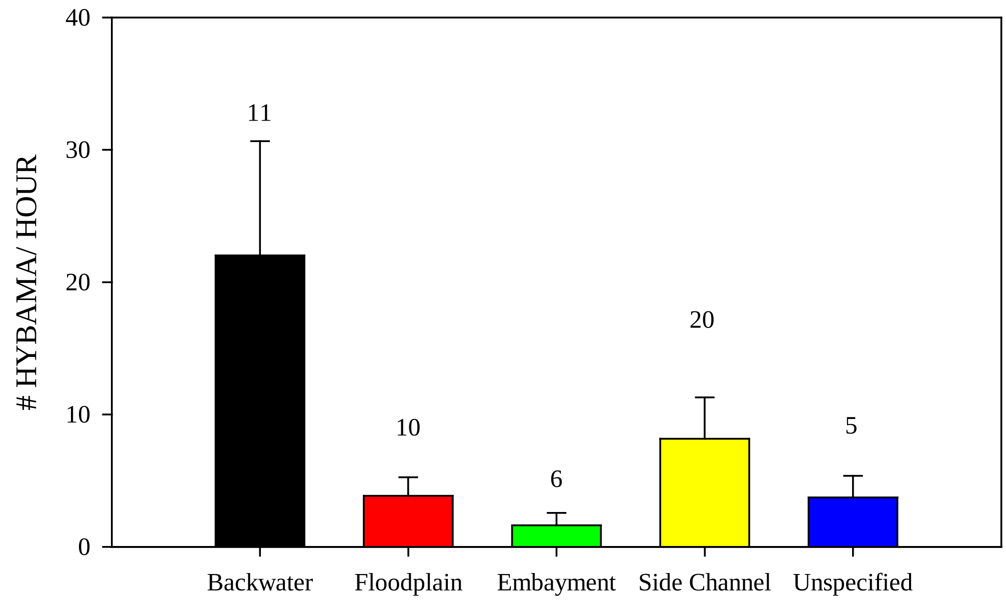


Figure 3. Length frequency histogram for Rio Grande silvery minnow measured (total number = 1558) during spring sampling on habitat restoration sites, May 2010, Rio Grande, New Mexico.

Habitats were grouped into general categories determined by site conditions at the time of sampling. Backwaters were generally low to no velocity areas at the tail of HR site features where there was no flow-through water. Floodplain was defined as the vegetated shoreline where high flow conditions cause inundation. Embayments refer to slackwater areas along high-flow channels. Side channels are generally runs that break away from the main portion of the river forming a smaller channel; these are also referred to as high-flow channels. There was no difference detectable between catch per unit effort for various habitat types (F=2.448, p=0.060 (Figure 4)). Backwaters and inlets (embayments) had the lowest velocities while side channels were the swiftest habitats sampled. There was no correlation between CPUE of silvery minnow with mean depth (R=0.14, p=0.32), mean velocity (R=0.20, p=0.18), or temperature (R=0.05, p=0.73).



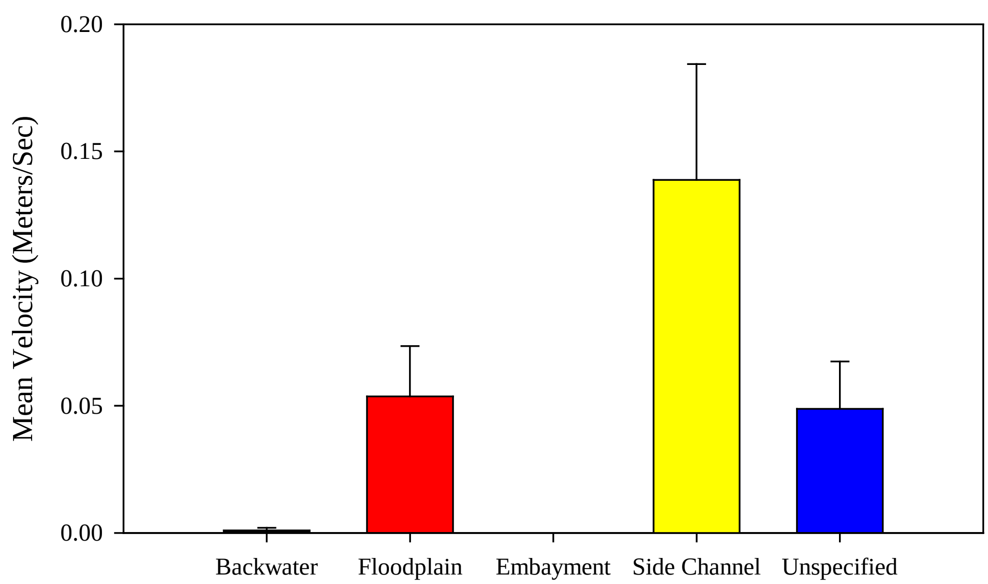


Figure 4. Catch per unit effort (fish per hour) for Rio Grande silvery minnow (top) and mean velocity (bottom) per habitat type for fyke net sampling on habitat restoration sites, Rio Grande, New Mexico, May 2010.
Error bars represent one standard error. Numbers indicate number of samples in each category.

Sampling was initiated approximately "mid-peak" and conducted into the tail off of the spring runoff hydrograph (Figure 5). Most sites were sampled while the discharge was above the target flow for the habitat site though a few samples were taken below target inundation levels in adjacent habitats.

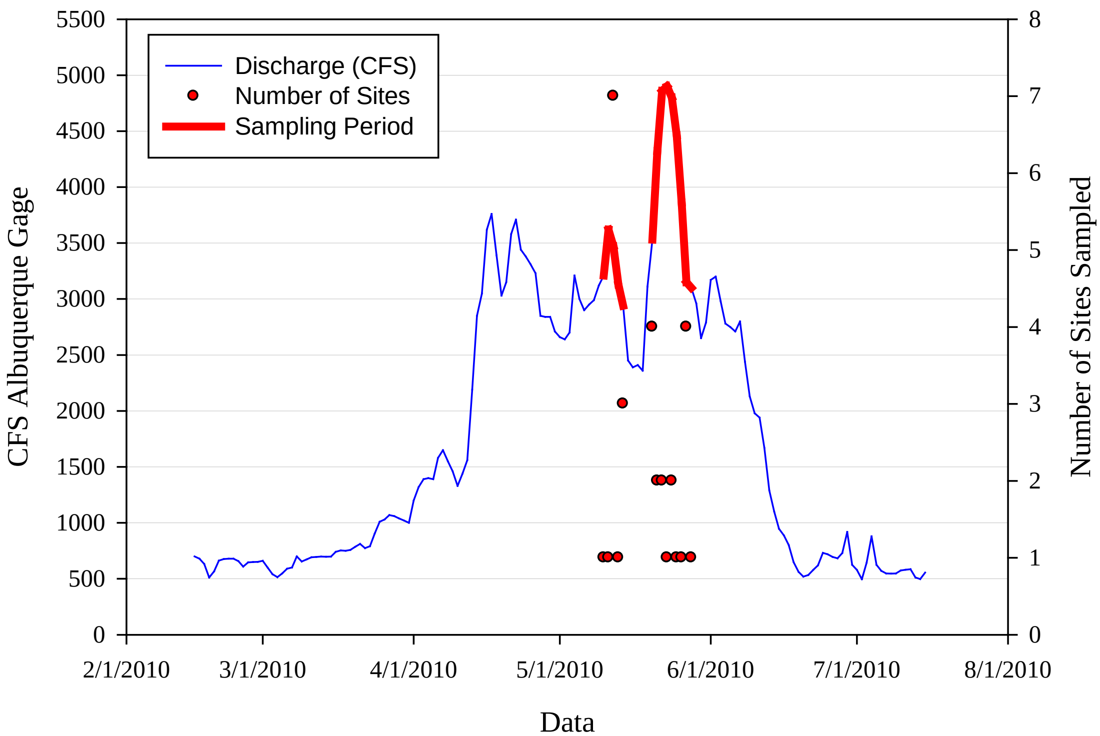


Figure 5. Spring hydrograph for Central Avenue Gage (USGS 08330000, Albuquerque, NM) and silvery minnow sampling dates for habitat restoration sites.

Hydrology

The results of the inundation evaluation are listed in Table 7. It is important to note that all Program-funded HR sites were included in the inundation evaluation (not just the 20 representative sites) and that it was assumed that all sites have maintained their originally constructed inundation targets defined in the first column. The relationship between inundation target and area of HR projects is strictly representative of how the HR projects were designed (e.g. how much floodplain habitat was constructed at each level). The “days of inundation” in the third column in Table 7 refer to the number of days that discharge at the Central Avenue gage exceeded the inundation targets presented in the first column. This information is also presented in Figure 6. It is the “acre/days” numbers that attempt to provide a measure of the combination of the extent and duration of inundation such that overall effectiveness of HR work can be quantified at this scale.

Table 7. Summary data for inundation analysis of effective floodplain habitat restoration features during the 2010 spring snowmelt runoff.

Inundation Target (cfs)	Area of HR (acres)	2010 Days of Inundation	acre/days
1000	6.7	81.0	543.5
1400	8.4	67.0	564.8
1500	11.0	65.0	715.7
2000	5.8	58.0	333.5
2500	68.5	51.0	3492.5
3500	21.1	12.0	253.0

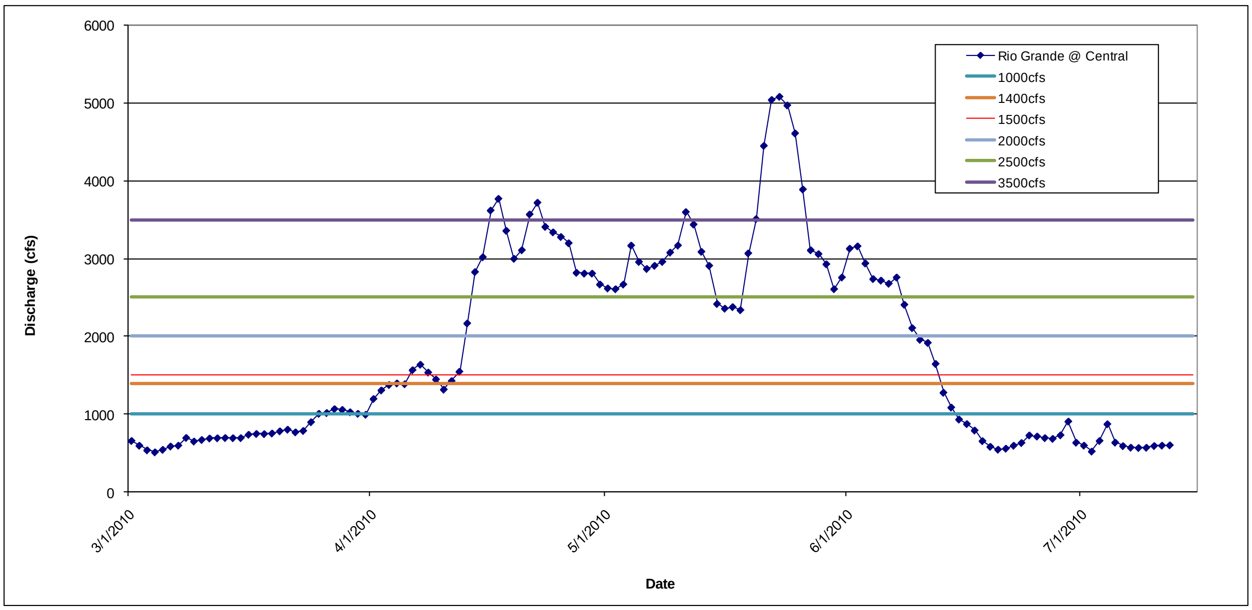


Figure 6. 2010 Spring snowmelt runoff hydrograph and habitat restoration target discharges

Hydrological characterization of habitat conditions on HR sites was conducted on 13 of the 20 representative sites and included 29 individual monitoring transects. Results for site specific average water depths and velocities on floodplain HR project sites ranged from 0.52-2.11 ft and 0.00-1.19 ft/sec respectively. Taken as a whole across all representative sites and monitored flow conditions, the average water depth of HR sites was 1.08 ft and the average water velocity was 0.53 ft/sec. For 23 of the 29 monitoring transects, adjacent active river channel conditions were also monitored resulting in the ability to compare these two distinct habitat types. HR and adjacent river channel averages plot relatively neatly in two distinct clusters as shown in Figure 7 with HR conditions consistently within the range of both variables of suitable habitat conditions and adjacent river channel conditions consistently falling outside these ranges. Comparing to the HR site averages above, the average conditions in the adjacent river channel across all monitored flow conditions were a depth of 2.95 ft and velocity of 1.87 ft/sec, an overall increase in average depth of 1.87 ft and an overall increase in average velocity of 1.35 ft/sec.

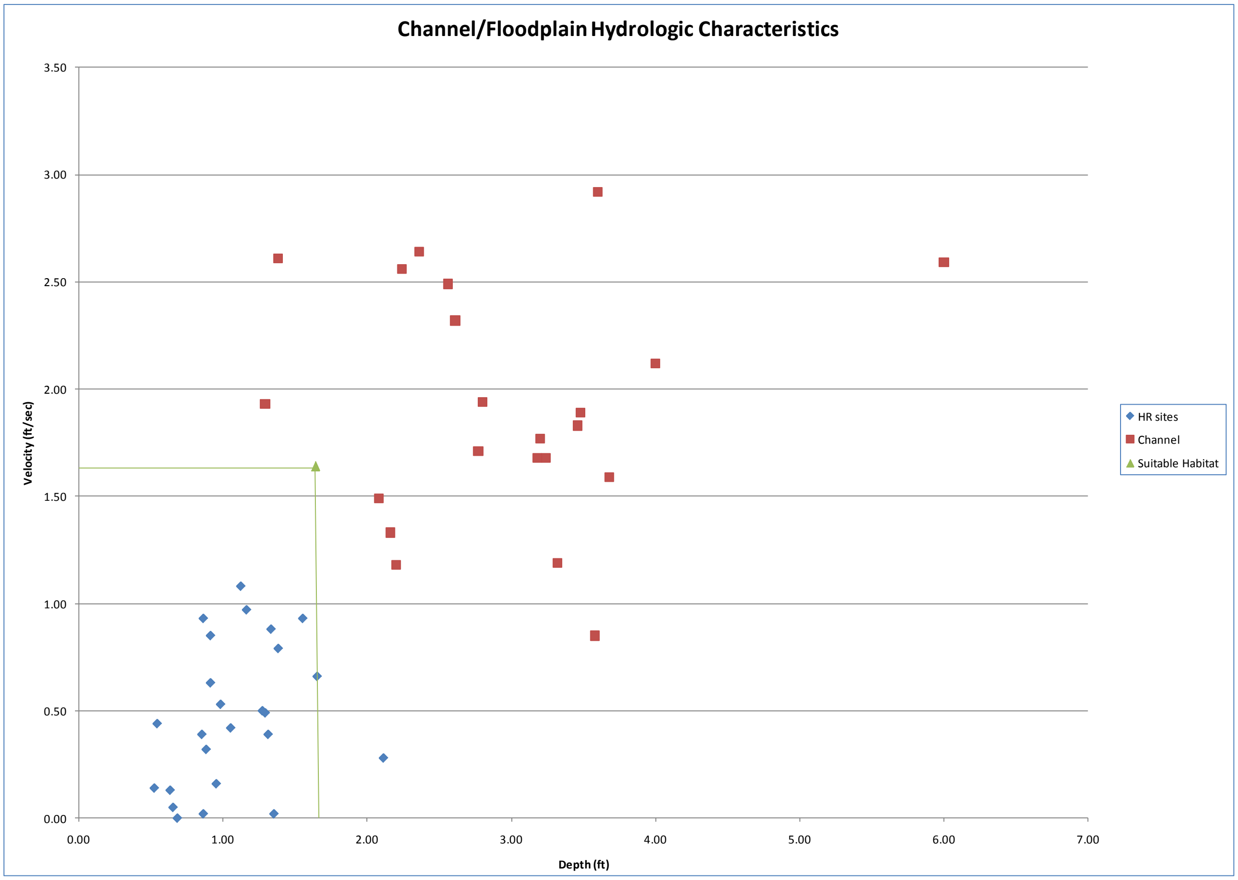


Figure 7. Scatter plot of site specific and adjacent channel average velocity and depth measurements with established suitable habitat boundaries included.

Additionally, these 23 transects also provide the opportunity to present relative differences in water temperatures between HR floodplain habitats and the adjacent river channel habitats (temperature data on HR sites alone lacks context). Of these 23 transects, only two resulted in HR site average temperatures lower than adjacent river channel temperatures (both monitoring events took place in early morning) and a single transect shown no difference in water temperatures between these two habitat types. On average HR sites were 0.79 C^{o} warmer then the adjacent river channel temperatures and two sites had water average water temperatures 3.70 C^{o} or more above the adjacent river channel conditions.

Vegetation

Seventeen of the 20 HR sites were surveyed for woody vegetation and digitized patch maps are presented in Appendix D. A total of 46 vegetation type patches were identified (totaling 289,000 m^2 or 71.4 acres) and only two lacked woody species. Each HR site contained between one and six different vegetation type patches that ranged from approximately 300 to 63,000 m^2 (0.07 to 15.5 acres) in size. All maps are presented in Appendix E. Native vegetation dominated sites sampled (Figure 8). Coyote willow was the dominant woody species (encountered in 41 of the 46 patches) and had a mean relative abundance of 64%. Because only the relative abundance of each woody species was noted, but not the absolute density of species, it is not possible to quantify in absolute terms the amount of each woody species present at HR sites.

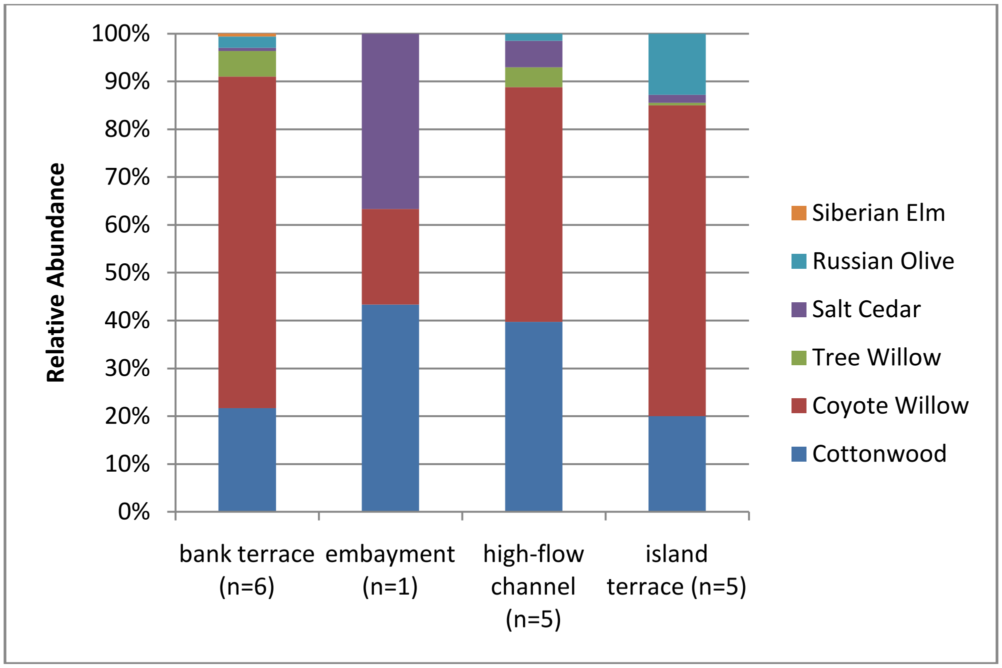


Figure 8. Relative abundance of woody species by habitat restoration feature type.

Although non-woody vegetation (forbs and grasses) were not explicitly included in the data collection, notes from field biologists indicate that HR sites contain a diversity of annual vegetation including cocklebur, bulrush, sedges, equisetum, and native and non-native grasses (e.g. Ravenna grass, salt grass, scratch grass, rice grass, foxtail barley). One site (Site 20, Willie Chavez) contained dense stands of invasive kochia. One site (Site 15, Los Lunas) contains suitable flycatcher habitat and three other sites (Sites 6, 10, and 14) have the potential to develop into suitable habitat over the next several years.

Geomorphology

Geomorphology was surveyed concurrently with vegetation at 17 of the 20 HR sites. Sand was the dominate substrate type (60.4% relative abundance) followed by silt (38.4%) and gravel (1.2%). Cobble was not present at any of the HR sites surveyed. All maps are presented in Appendix E.

There was evidence that nearly all HR sites surveyed were inundated to some degree during the spring 2010 runoff. Areas of obvious aggradation and degradation were delineated on aerial photographs and later quantified using GIS. In gross terms, areas of aggradation totaled approximately 33,600 m^2 (8.3 acres) and degradation totaled approximately 7,600 m^2 (1.9 acres). All other areas are assumed to be geomorphically stable.

No obvious changes to river bed form structure or river planform were noted at any of the sites. The small scale of some of the sites will likely make this a difficult effect to observe in the future. Nor was any severe erosion noted at any of the sites. Aggradation was the predominant geomorphological process occurring at the sites, with notable amounts estimated at 10 sites, with the greatest amount (approximately 48 per cent of the aggradation observed at all sites) occurring at Site 20 (Willie Chavez). This is one of the larger sites monitored. Degradation was observed, but with only sizeable estimated amounts at Site 15 (Los Lunas), also a larger site (approximately 92 % of the total amount of degradation observed at all sites).

Only Site 6 (Rio Grande Nature Center) exhibited both aggradation and degradation, although in small amounts. Most of the aggradation at this location is occurring near the channel entrance and exit, which would be expected in the first few years of a channel project. In response to general geomorphological processes, the sites are not yet exhibiting substantive geomorphological events, excluding Site 15 (Los Lunas), which is the oldest restoration site. In time and in response to variation in river flows, along with vegetation succession or eruptions, physical changes in the appearance and performance of the sites are likely but current estimates of site longevity are minimally in the 5-10 year range and potentially longer.

Discussion

There has been much discussion within the Middle Rio Grande Endangered Species Collaborative Program as to what defines "effective" habitat restoration for endangered species. While the Program has not yet reached consensus, there are broad elements that have been agreed upon. Modifying isolated floodplain areas in order to significantly increase the acreage inundated by annual flooding is one measure of success. All of the HR sites monitored by the MPT during 2010 accomplished this and were inundated for a period ranging between 12 and 81 days (Figure 6). Restoring hydrologic connectivity between the river and its historic floodplain helps restore ecologic processes and creates habitat for key species such as the minnow and flycatcher.

Sampling for silvery minnows during spring runoff indicated that they were often present at inundated HR sites and often as the dominant species of the fish community via the EMP sampling methods. While the exact movements and numbers of fish using these habitats are unknown, the fact that they are present in these areas suggests that they are using them in one capacity or another. Site specific hydrologic characterization measured water depth and current velocity across the HR site. The U.S. Fish and Wildlife Service (USFWS) defines suitable habitat for the silvery minnow through ranges of preferred water depth and velocity. The Recovery Plan (USFWS 2007) indicates silvery minnow habitat suitability as depths of less than 1.64 ft (0.5m) and velocities between 0.0 and 1.64 ft/sec (0.0-0.5 m/sec). These conditions were observed at nearly all HR sites monitored in Spring 2010. Additionally the HR sites contributed to an overall greater heterogeneity of habitat conditions in the larger river system at the monitoring discharges.

The fact that HR sites are dominated by native woody vegetation is encouraging, especially as most of the sites were not manually revegetated following mechanical restoration. This indicates that by simply lowering land-surface elevations, existing root material and restored hydrologic connectivity are sufficient for immediate response in native vegetation communities. However, it is important to continue monitoring this over time. The successive capture of vegetation conditions on HR sites over time will allow for a more advanced analysis of the functionality of HR in the future. As discussed in the recommendations below, future mapping should include wetland and grass components of the HR site. Monitoring and analysis of these components over time will allow for further interpretation of the results in relation to functional habitat for both the flycatcher and minnow.

The findings of the vegetation monitoring component of the EMP may also lead to recommended adaptive management for HR projects. For example, if there is an influx of noxious weeds or other problematic non-native vegetation at one or more sites, the Program may want to add the maintenance of native vegetation (by clearance of non-native vegetation) to its management schedule. Recommended adaptive management would depend on the specific situation on site. Analysis of changing vegetation patterns should provide insight into the expected longevity of native vegetation restored to riparian habitats by HR projects both with and without active maintenance.

The data collection methods in the geomorphic monitoring effort were not sufficient to track large-scale geomorphologic processes in the MRG; however, they do provide some indication of how HR sites change over time and whether sites continue to function today as they were designed. These types of observations could be useful in better understanding the potential for site longevity and in the development of adaptive management tools to best maintain optimal HR site function. Because restoring pre-development flows on the MRG is not likely a feasible option, managing and redistributing sediment to ensure the most beneficial interaction of the annual hydrograph with the existing land surfaces becomes something that decision makers will continue to be responsible for (Schmidt and Wilcock 2008).

Recommendations from the Monitoring Plan Team

A significant expectation of the MPT in self-implementing this monitoring effort and in the idea that this is an interim plan was that the EMP could and would be refined through time. In this sense the MPT has established a set of categories that broadly define core components of the monitoring effort. The first major category revolves around the scope of monitoring effort and includes: the continued inclusion of new projects into the portfolio of monitored sites, the determination of the appropriate percentage of project sites to include in the monitoring sample, and the categorization of various design attributes of projects and sites. The second major category of refinement involves the specifics of the monitoring design and their efficient and effective implementation in the field. Specific recommendations from personnel involved in the 2010 effort follow. While the MPT can contribute to the discussion of this component, it is the Program managers who will eventually need to make these management-based decisions.

- Site Selection
  - It needs to be determined how future HR sites will be added to the subset of 20 examined here.
  - Sample timing should be further refined.
- Hydrology Parameters
  - A closer link between hydrology parameters measured in the field and silvery minnow sampling should be discussed. If this is determined appropriate then these two parameters should be measured simultaneously (see below for specific suggestions.)
- Rio Grande Silvery Minnow Parameters
  - Placement of sample locations within the site should be further refined.
  - Catch per unit effort (CPUE) should be calculated for all fish samples taken.
  - Metrics for standardizing sampling gear between groups should be developed.
  - Habitat measurements should be defined and standardized:
    - Recommend a standard cross section if fyke nets are used (at least 5 data points along net and wings)
    - Take at least 5 depth and velocity measurements per habitat sampled.
    - Choose a limited number of habitat categorizations and standardize among sampling agencies.
  - A clearer consensus is needed to define what exactly our fish sampling methods can tell us and how this relates to monitoring of habitat characteristics.
- Vegetation Parameters
  - Whether or not relative abundance of each woody species is an appropriate measure should be discussed and refined if necessary.
  - Need to expand vegetation to all classes, working out specific monitoring protocols needed for wetland habitat (404 requirements), grasses, and forbs.
- Geomorphology Parameters
  - Is measuring the depth of aggraded/dedgraded sediment a useful metric?
  - How to determine and define the current function of HR sites relative to constructed design.
- Overall Recommendations
  - There needs to be stricter adherence to and consistency with data collection methodology. It is suggested that one individual be designated crew lead for each parameter measured and be present at all sampling events.

- A quality control protocol should be developed and implemented.
- How are we going to compare 2011 data to 2010?
- We should consider age of the site especially with regards to vegetation type and height.

The final category of refinement of the EMP involves determining appropriate cycles for various monitoring elements including how long after a project is completed should monitoring begin and what monitoring return interval should be used for the various elements of the effort to insure an efficient temporal component based on what the element specific goal of the monitoring is. This is a fundamental question for the EMP as this gets to the cost/benefit analysis of implementing HR projects and HR effectiveness monitoring.

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