Introduction

From its headwaters in Colorado to its terminus at the Gulf of Mexico (fig. 1), the Rio Grande provides vital habitat to a variety of species adapted to its natural flood regime (Schmidt and others, 2003). The Rio Grande is the second longest river in North America. The principal natural flood regime from the headwaters downstream to Presidio, Texas, is the result of snowmelt runoff between April and July in Colorado and New Mexico; downstream from Presidio, the natural flood regime is the result of summer thunderstorms (U.S. Army Corps of Engineers and others, 2007; Schmidt and others, 2003). Native species in the Rio Grande, including *Hybognathus amarus* (Rio Grande silvery minnow) (fig. 2) and other small-bodied fish, are adapted to the natural flood regime of the Rio Grande (Sublette and others, 1990; Crawford and others, 1993). Background on this species and associated issues as well as a complete description of the study area can be found in the companion report to this one (Braun and others, 2015).

Federally listed as an endangered species in 1994 (U.S. Fish and Wildlife Service, 1994), the Rio Grande silvery minnow historically occupied about 4,000 kilometers (km) in the main stems of the Rio Grande and the Pecos River (fig. 1) (U.S. Fish and Wildlife Service, 2010). The decline of the Rio Grande silvery minnow throughout its historical range has been attributed to modifications of the natural streamflow regime, channel drying, construction of reservoirs and low-head diversion dams, stream channelization, declining water quality, and interactions with nonnative fish (Cook and others, 1992; Edwards, 2005; U.S. Fish and Wildlife Service, 2010). Natural populations of the Rio Grande silvery minnow currently (2015) are found only in the reach of the Rio Grande in N. Mex. that extends about 280 km between Cochiti Dam and Elephant Butte Reservoir (fig. 1) (U.S. Fish and Wildlife Service 2010; Gonzales and others, 2014), referred to as the "Middle Rio Grande" for the purpose of this report.

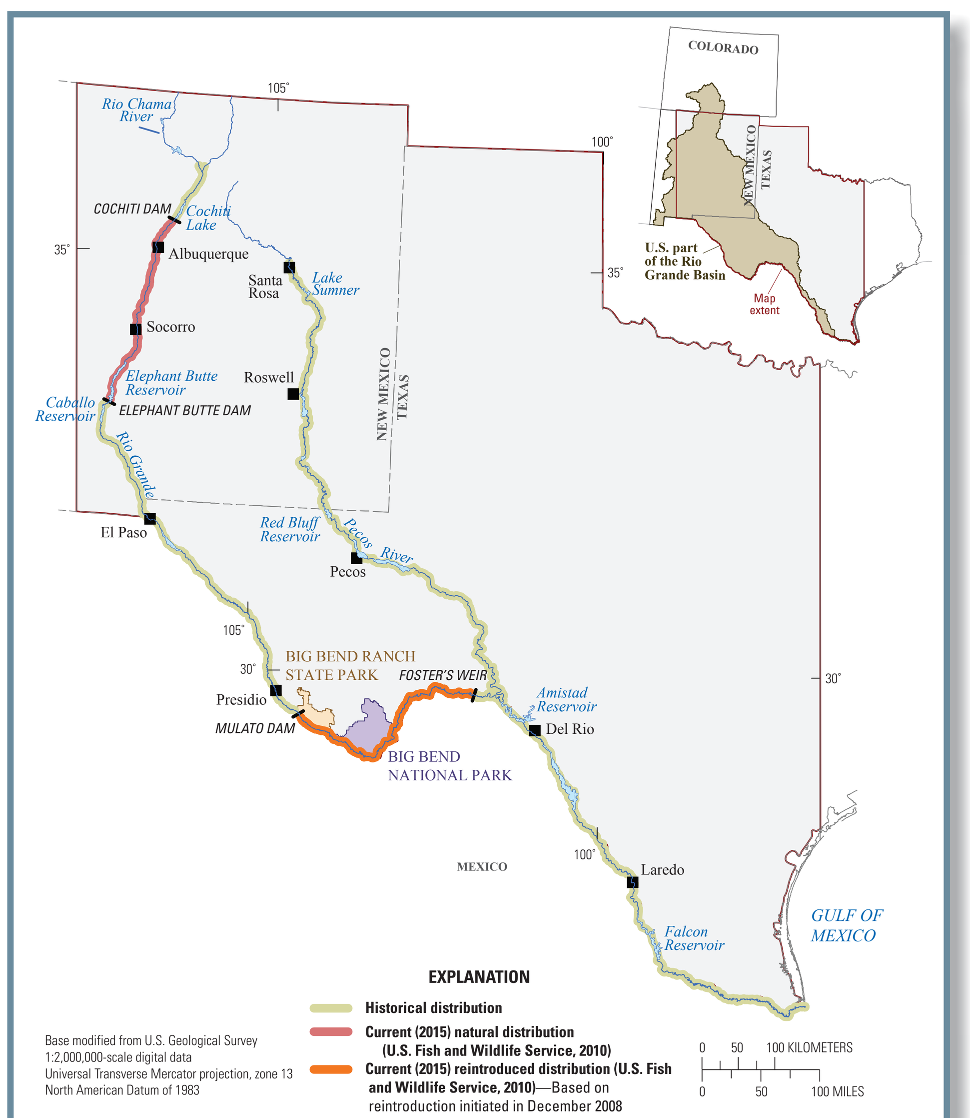

Figure 1. Historical and current distribution of *Hypognathus amarus* (Rio Grande silvery minnow) in the Rio Grande and Pecos River, New Mexico and Texas.

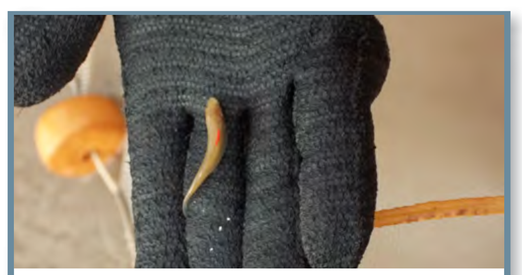

Figure 2. Nursery raised *Hybognathus amarus* (Rio Grande silvery minnow) with tagged dorsal fin; colored dorsal fin tag was attached for identification purposes and corresponds to the reach of the Middle Rio Grande in which it was released.

A mesohabitat scale assessment of available in-channel habitat in relation to streamflows is considered by many ecologists and fluvial geomorphologists to be critical for the development of practical tools in river management (Harper and Everard, 1998; Newson and Newson, 2000), and the availability of functional habitat is essential for maintaining viable fish populations (Lapointe and others, 2013). Mesohabitats are visually distinct units of habitat within a stream with apparent uniformity (Pardo and Armitage, 1997; Parasiewicz, 2001) and with similar depth, velocity, slope, substrate, and cover. Mesohabitat-scale assessments provide information on habitat area as a function of alterations in river flow, channel planform, and other activities (Parasiewicz, 2001).

Mesohabitat use by Rio Grande silvery minnows, along with the physical properties of depth, velocity, and substrate, have been the subject of previous studies (Dudley and Platania, 1997; Dudley and others, 2012, 2013; Moring and others, 2014); however, information on the spatial extent of available mesohabitats over a range of streamflows throughout the Middle Rio Grande remains sparse (Remshardt and Tashjian, 2003). To better understand the spatial extent of available mesohabitats over a range of streamflows, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army Corps of Engineers, Albuquerque District, and the U.S. Fish and Wildlife Service New Mexico Fish and Wildlife Conservation Office in Albuquerque, N. Mex., evaluated physical characteristics and mapped mesohabitats associated with small-bodied fish assemblages during 2011–12 during moderate and low streamflow at 15 sites on the Middle Rio Grande in New Mexico, in the reach between Cochiti Dam and Elephant Butte Reservoir.

Purpose and Scope

This report documents differences in the mapped spatial extents and physical characteristics of in-channel fish habitat evaluated at the mesohabitat scale during winter 2011–12 (moderate streamflow) and summer 2012 (low streamflow) at 15 sites on the Middle Rio Grande in New Mexico starting about 3 km downstream from Cochiti Dam and ending about 40 km upstream from Elephant Butte Reservoir (fig. 3). The results of mesohabitat mapping, physical characterization, and fish assemblage surveys are summarized from the data that were collected. The report also presents general comparisons of physical mesohabitat data, such as wetted area and substrate type, and biological mesohabitat data, which included fish assemblage composition, species richness, Rio Grande silvery minnow relative abundance, and Rio Grande silvery minnow catch per unit effort. Selected water-quality properties (water temperature, specific conductance, dissolved oxygen, and pH) that were collected during low-flow conditions were published and analyzed in Braun and others (2015) and are not discussed in this report.

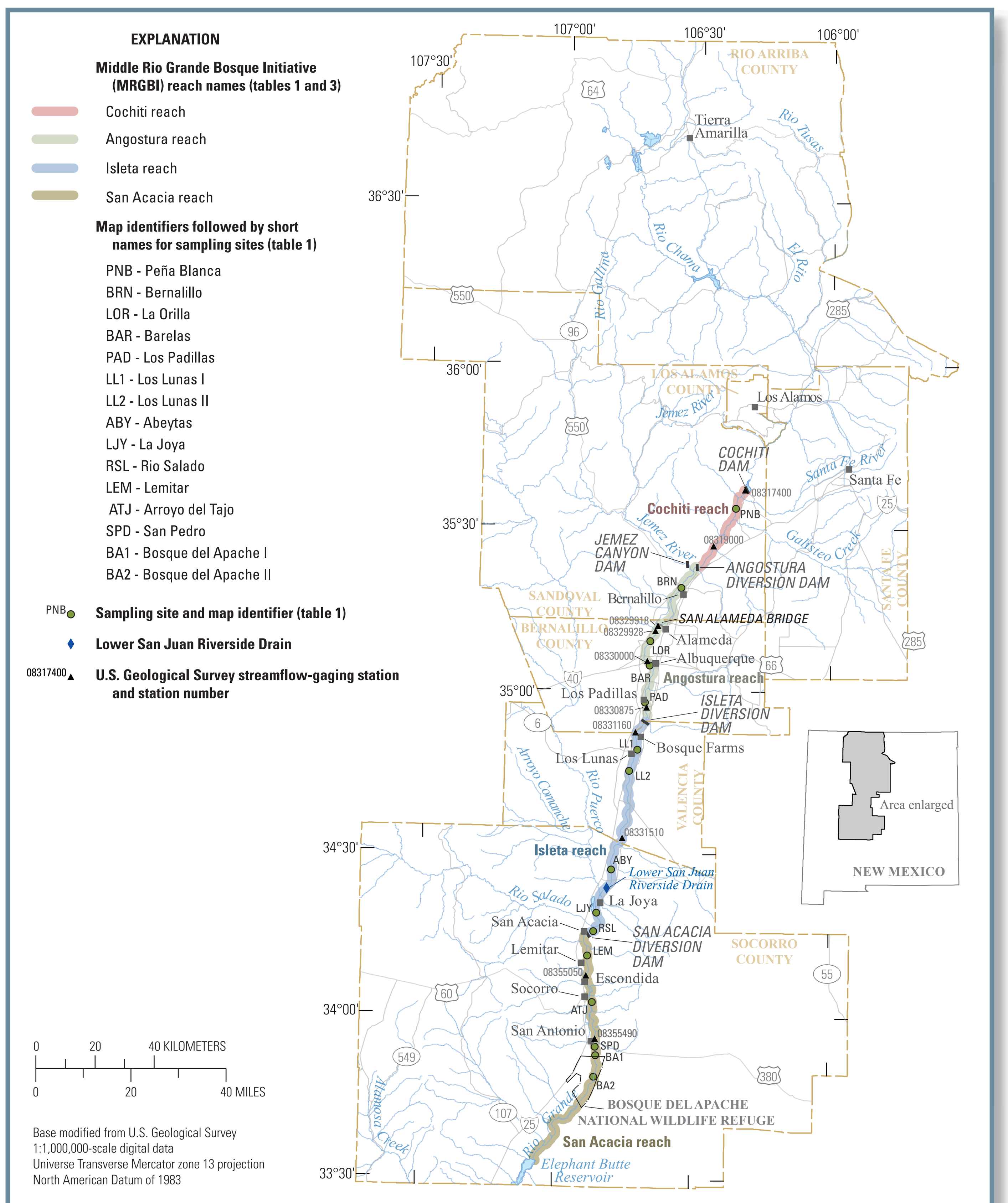

Figure 3. Sites where mesohabitats were assessed and Middle Rio Grande Bosque Initiative reaches on the Middle Rio Grande in New Mexico, 2011–12.

Description of Study Area

Braun and others (2015) provided a detailed description of the Middle Rio Grande; a brief description is provided herein. The Middle Rio Grande is an arid part of the Rio Grande Basin dependent on inflows from upstream. Historically, discharge in the Middle Rio Grande fluctuated between seasonal peaks from snowmelt runoff and from localized thunderstorms in the spring and early summer (U.S. Army Corps of Engineers and others, 2007) to periods of river fragmentation during late summer when some river segments would go dry (Tetra Tech, Inc., 2014). Today, the Middle Rio Grande is a highly regulated system influenced by numerous storage and flood control reservoirs, low-head diversion dams, and almost 1,500 km of irrigation canals and drainages between Cochiti Dam and Elephant Butte Reservoir. Dams, diversions, and canals have not altered the preregulation seasonal streamflow pattern (fig. 4) but have dampened the magnitude and duration of extreme streamflow events and have led to extended periods when the river is dry downstream from Albuquerque during the summer to the early fall irrigation period (U.S. Bureau of Reclamation, 2012).

The channel planform of the Middle Rio Grande has changed during the last 100 years from a braided aggrading channel to one that is mostly degrading, transitioning from a braided, sand-bed channel to a narrower, single-threaded channel that is dominated by a gravel bed through much of its length (Makar and AuBuchon, 2012). Between 1935 and 1989, the river channel area of the Middle Rio Grande decreased by about 50 percent (Crawford and others, 1993). Channel narrowing can be attributed to reductions in sediment supply, changes in peak spring flows caused by upstream flood control, channelization activities, and other river training actions used to manage flows for irrigation purposes (Makar and Aubuchon, 2012). The effects of changes in the Rio Grande planform on native fish species were summarized by Schmidt and others (2003, p. 25–26):

> Historically, the Rio Grande had a mobile bed and erodible banks, and the channel changed from year to year. Today's channel is smaller, more stable, changes less from year to year, and infrequently inundates its former floodplain.*** The Rio Grande silvery minnow is adapted to the former wide shallow braided channel and associated habitats, and its population has declined greatly in response to channelization and diminished flows.

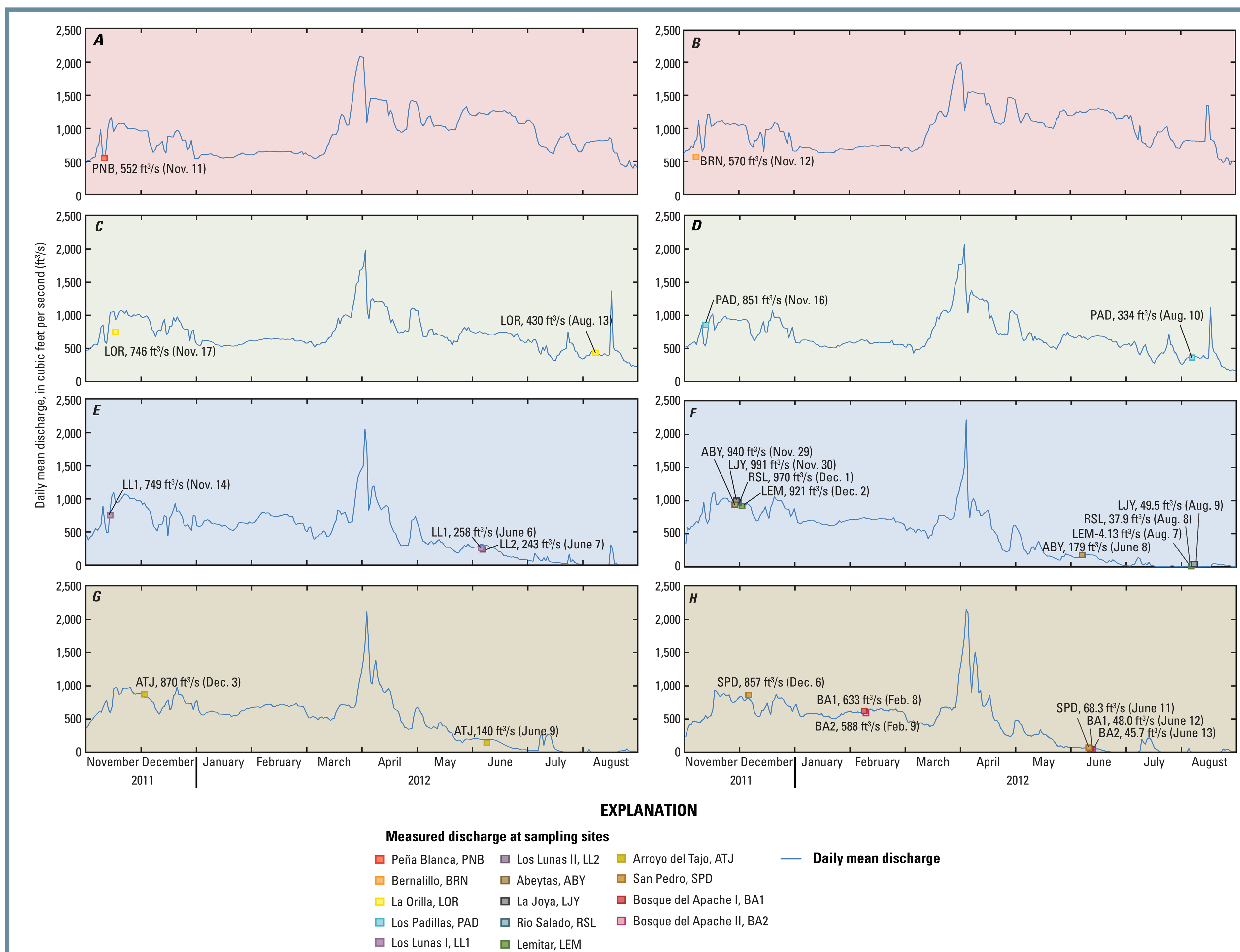

Figure 4. Measured discharge at sampling sites and daily mean discharge at U.S. Geological Survey streamflow-gaging stations on the Middle Rio Grande, New Mexico. *A*, 08317400 Rio Grande below Cochiti Dam, N. Mex.; *B*, 08319000 Rio Grande at San Felipe, N. Mex.; *C*, 08329928 Rio Grande at Alameda, N. Mex.; *D*, 08330000 Rio Grande at Albuquerque, N. Mex.; *E*, 08331160 Rio Grande near Bosque farms, N. Mex.; *F*, 08331510 Rio Grande at State Highway 346 near Bosque, N. Mex.; *G*, 08355050 Rio Grande at bridge near Escondida, N. Mex.; and *H*, 08355490 Rio Grande above U.S. Highway 380 near San Antonio, N. Mex.; November 1, 2011–August 31, 2012.

Methods of Investigation

The physical characteristics and fish assemblage of stream mesohabitats were characterized within a 1-km length of stream channel at 15 sites distributed along the Middle Rio Grande and were selected starting about 3 km downstream from Cochiti Dam and ending about 40 km upstream from Elephant Butte Reservoir (table 1, fig. 3). Sites along the Middle Rio Grande were grouped into four river reaches separated by diversion dams. In downstream order, the names of the diversion dams followed by short names of the sites (in parentheses) were Cochiti (Peña Blanca), Angostura (Bernalillo, La Orilla, Barelas, Los Padillas), Isleta (Los Lunas I, Los Lunas II, Abeytas, La Joya, Rio Salado), and San Acacia (Lemitar, Arroyo del Tajo, San Pedro, Bosque del Apache I, and Bosque del Apache II). The Cochiti, Angostura, and Isleta reaches are bound by upstream and downstream diversion dams (fig. 3), whereas there is a diversion dam at the upstream boundary of the San Acacia reach, but the downstream boundary of the reach is the upstream extent of Elephant Butte Reservoir. Stream habitat was mapped in the field by using a geographic information system (GIS) in conjunction with a Global Positioning System (GPS). The four reaches delineated in this report are also being assessed as part of the Middle Rio Grande Bosque Initiative (MRGBI). The MRGBI "is an ongoing, congressionally supported, interagency ecosystem management effort to coordinate activities related to the ecological restoration and management of the Middle Rio Grande" (U.S. Fish and Wildlife Service, 2014, p. 1).

Table 1. Study sites and sampling dates in the Middle Rio Grande, New Mexico, 2010–11 (reach names are from U.S. Fish and Wildlife Service, 2014).

[MRGBI, Middle Rio Grande Bosque Initiative; nr, near; dws, downstream from; ups, upstream from; --, no data were collected during this time period]

U.S. Geological Survey site name	U.S. Geological Survey site number	Short name	Map identifier	MRGBI reach names[1]	Dates sampled: November–December 2011, Mapping	November–December 2011, Fish and aquatic habitat	February 2012, Mapping	February 2012, Fish and aquatic habitat	July–August 2012, Mapping	July–August 2012, Fish and aquatic habitat
Rio Grande nr Pena Blanca, N. Mex.	353330106213500	Peña Blanca	PNB	Cochiti	Nov. 10	Nov. 11	--	--	--	--
Rio Grande dws Hwy 550 at Bernalillo, N. Mex.	351848106333400	Bernalillo	BRN	Angostura	Nov. 11	Nov. 12	--	--	--	--
Rio Grande ups Montano Rd NW at Albuquerque, N. Mex.	350859106402600	La Orilla	LOR	Angostura	Nov. 16	Nov. 17	--	--	Aug. 11	Aug. 13
Rio Grande ups Hwy 314 at Albuquerque, N. Mex.	350432106400500	Barelas	BAR	Angostura	Nov. 9	Nov. 10	--	--	Aug. 10	Aug. 11
Rio Grande ups I-25 nr Los Padillas, N. Mex.	345732106410800	Los Padillas	PAD	Angostura	Nov. 15	Nov. 16	--	--	Aug. 9	Aug. 10
Rio Grande ups Hwy 6 at Los Lunas, N. Mex.	344852106424200	Los Lunas I	LL1	Isleta	Nov. 12	Nov. 14	--	--	June 5	June 6
Rio Grande nr Los Chavez, N. Mex.	344457106443300	Los Lunas II	LL2	Isleta	Nov. 14	Nov. 15	--	--	June 6	June 7
Rio Grande ups Hwy 60 nr Contreras, N. Mex.	342644106481300	Abeytas	ABY	Isleta	Nov. 28	Nov. 29	--	--	June 7	June 8
Rio Grande nr La Joya, N. Mex.	341842106511100	La Joya	LJY	Isleta	Nov. 29	Nov. 30	--	--	Aug. 8	Aug. 9
Rio Grande dws Arroyo Rosa de Castillo, San Acacia	341542106520700	Rio Salado	RSL	Isleta	Nov. 30	Dec. 1	--	--	Aug. 7	Aug. 8
Rio Grande nr Lemitar, N. Mex.	341044106530300	Lemitar	LEM	San Acacia	Dec. 1	Dec. 2	--	--	Aug. 6	Aug. 7
Rio Grande dws Arroyo del Tajo nr Socorro, N. Mex.	340215106515500	Arroyo del Tajo	ATJ	San Acacia	Dec. 1	Dec. 3	--	--	June 8	June 9
Rio Grande dws Hwy 380 nr San Antonio, N. Mex.	335403106505800	San Pedro	SPD	San Acacia	[2]Dec. 3	[2]Dec. 6	[2]Feb. 6	[2]Feb. 7	June 9	June 11
Rio Grande N of Bosque del Apache, San Antonio, N. Mex.	335229106505800	Bosque del Apache I	BA1	San Acacia	--	--	[2]Feb. 7	[2]Feb. 8	June 11	June 12
Rio Grande at Bosque del Apache nr San Antonio, N. Mex.	334833106512200	Bosque del Apache II	BA2	San Acacia	[2]Dec. 6	--	[2]Feb. 8	[2]Feb. 9	June 12	June 13

[1] MRGBI reach names are from U.S. Fish and Wildlife Service (2014); colors associated with reaches are used throughout the report.

[2] Inclement weather made accurate mapping and representative fish sampling impossible. As a result, the San Pedro, Bosque del Apache I, and Bosque del Apache II sites were revisited in February 2012, when weather conditions were more suitable.

Fish Assemblage Composition and Mapped Mesohabitat Features Over a Range of Streamflows in the Middle Rio Grande, New Mexico, Winter 2011–12, Summer 2012

By

Daniel K. Pearson, Christopher L. Braun, and J. Bruce Moring

2015

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Sampling Assessments and Streamflow

During this study, 13 of the 15 sites were assessed under two different seasonal streamflow regimes during winter 2011–12 and summer 2012 (table 1, fig. 4); the two remaining sites (Peña Blanca and Bernalillo) were only assessed in winter 2011–12. Mesohabitats were mapped and sampled during a period of moderate streamflow between November 2011 and February 2012 and during a period of low streamflow between June and August 2012 (table 1; fig. 4). In winter 2011–12, sites were sampled generally from upstream to downstream, whereas in summer 2012, sites were sampled in an order that would ensure the Middle Rio Grande was flowing at all sites at the time of sampling. The reordered sampling during low streamflow conditions facilitated the assessment of as many sites as possible, as well as the measurement of physical properties and sampling of fish. Those sites that were at the greatest risk of drying were visited in early June 2012, and those sites that were expected to have streamflow throughout the summer were visited in August 2012. The period of comparatively low streamflows in the summer of 2012 was an opportunity to determine available habitat during a time of the year when water temperatures in the Middle Rio Grande are seasonally high and the stream channel is more accessible for sampling, thus providing more ideal conditions for the evaluation of habitat use by and distribution of fishes at low flow.

Mesohabitat Assessments

The approach used to assess mesohabitats in the Middle Rio Grande was modified from Parasiewicz and Dunbar (2001) (fig. 5). Mesohabitat assessments generally consist of (1) geospatial measurements to document the sampling site, (2) physical measurements of the stream properties, and (3) biological sampling at the site. Geospatial measurements (data associated with a particular location) are made as a first step to generate maps over a range of streamflows (that is, how the various mesohabitat types change under different streamflow conditions) (Bovee and others, 1998, 2008). Geospatial and physical measurements provide a description of the eco-hydraulic habitat conditions for the streamflow at the time the measurements are made. Physical measurements and biological measurements are used to determine habitat use by selected fish species.

For this study, the following mesohabitats were mapped at each study site when present: riffles, runs, pools (channel and eddy), isolated pools, forewaters, backwaters, embayments, and flats (table 2, fig. 6). Point bars and channel bars were also mapped to provide a more complete assessment of the active channel at each site. Data from two types of pools—channel and eddy—were combined into a "pools" category for analysis.

Digital mapping techniques were used for all geospatial measurements. The hardware, software, and field methods that were used to accomplish the study mapping goals were selected specifically to overcome the challenges of working in a remote, arid riverine environment. A geographic information system (GIS) (Esri, 2013) and Global Positioning System (GPS) were used to create the map in the field. Location data were collected by using a Trimble DSM 232 modular receiving unit (Trimble, 2015a) with an OmniSTAR subscription (Trimble, 2015b) for real-time, subfoot accuracy observations needed for mapping. The GPS observations were directly read into a field laptop computer for onsite visualization within the GIS, and polygons were created by using location information, aerial photography, and editing tools.

Field mapping was accomplished by using a variety of approaches based on streamflow, stream depth, and streambank accessibility. Each study reach was visited twice (except for Peña Blanca and Bernalillo, which were only sampled in winter 2011–12) (table 1), corresponding to the periods of moderate and low streamflows identified for this study. For the majority of the field mapping, the edge of the water throughout a site reach was extracted from high-resolution, remotely sensed imagery, which was used as a framework for all subsequently mapped mesohabitats within a given reach at a site. The field data collection process required two individuals working in tandem, communicating by using a wireless connection between the GPS receiver and laptop computer. After the edge of water was delineated, the study reach was subdivided into smaller polygons, each representing individual mesohabitats. Individual mesohabitats were created by walking boundaries of each mesohabitat or through photointerpretation in the field. Polygons created through this process were stored and attributed in an ArcGIS 10.0 personal geodatabase (Esri, 2013) and stored as Microsoft Access (1997–2003) files. Collectively, the database information and remotely sensed imagery made it possible to generate a detailed map for each study site at each targeted flow.

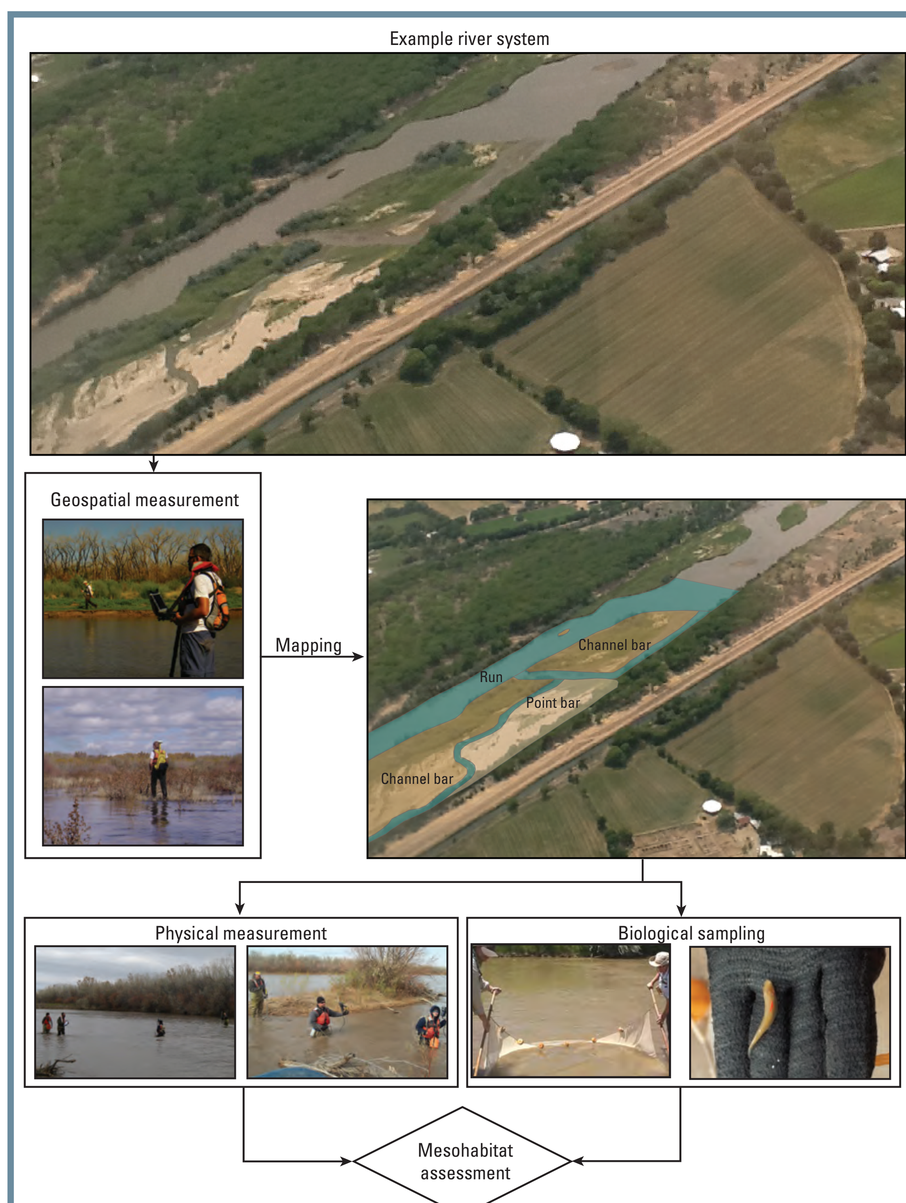

Figure 5. Overview of the approach used to map mesohabitats in the Middle Rio Grande, New Mexico (modified from Parasiewicz and Dunbar, 2001).

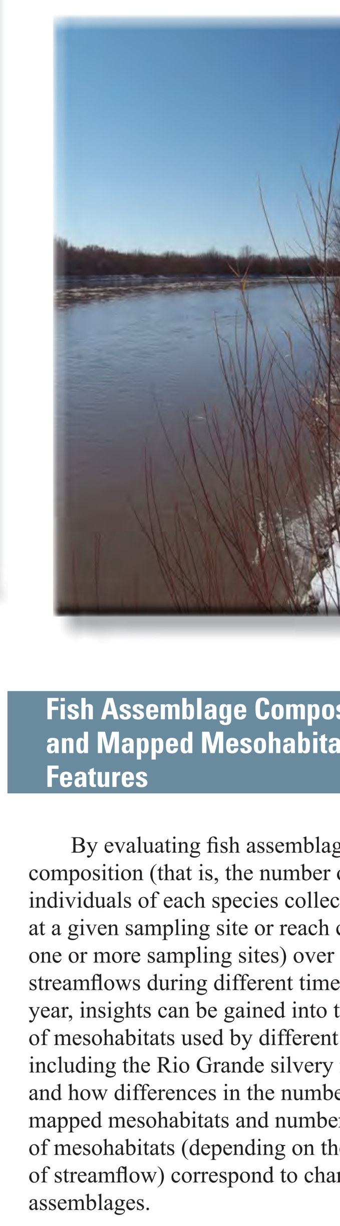

Table 2. Description of mesohabitat types used to describe the study sites as defined by observations and physical parameters measured over the course of the study.

[Mesohabitat types and descriptions are modified from Platania (1993)]

Mesohabitat type	Description
Riffle	Relatively shallow and low to moderate velocity feature characterized by moderately turbulent water
Run	Relatively high velocity feature with laminar flow and a non-turbulent surface
Pool	Feature with little or no velocity that may be deep in places
Channel	Type of pool where current moves in the same flow direction as the channel
Eddy	Type of pool where current moves in the opposite direction relative to flow
Isolated Pool	Type of pool that is separate from the main channel; frequently a portion of a former backwater or forewater that has become disconnected from a secondary channel
Forewater	Slackwater feature oriented into the principal direction of flow
Backwater	Slackwater feature oriented in an opposing direction to the principal flow direction
Embayment	Slackwater feature located adjacent to the channel and oriented perpendicular to flow
Flat	Very shallow, low velocity feature typically located on the periphery of an existing point or channel bar; caused by a slight rise in stage
Point Bar	Crescent-shaped depositional feature located on the inside of a stream bend; typically either devoid of or containing annual vegetation
Channel Bar	Transitory parcel of land surrounded by water; typically either devoid of or containing annual vegetation

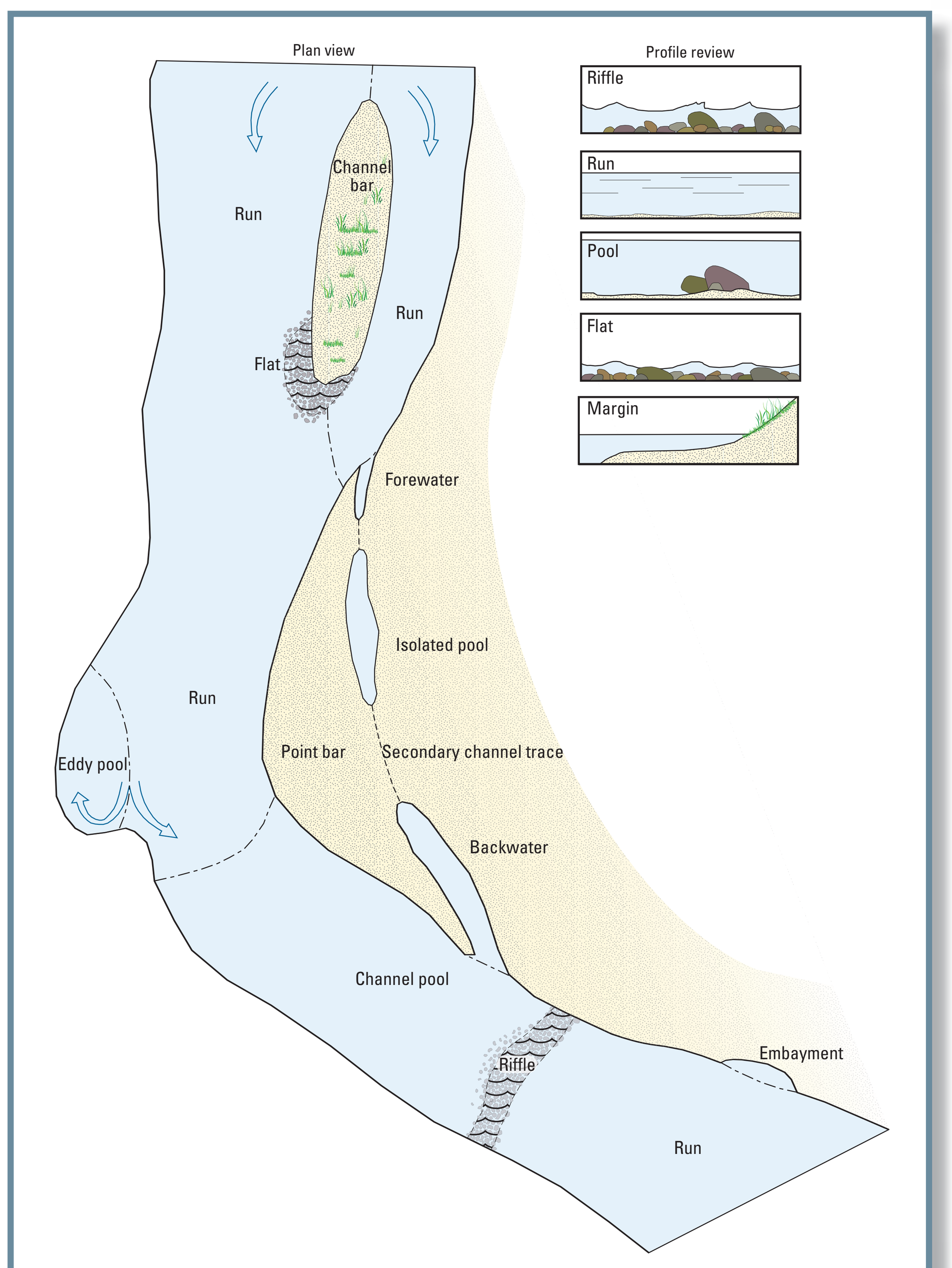

Figure 6. Mapped mesohabitat types identified in the Middle Rio Grande, New Mexico (modified from Platania, 1993).

Fish Collection

Fish assemblage surveys were done at each sampling site (except at the Peña Blanca and Bernalillo sites during summer 2012) at moderate and low streamflows. Mesohabitat types were subsampled (with targeted minimums of 20 mesohabitats per sampling site in winter 2011–12 and 30 mesohabitats per sampling site in summer 2012) in proportion to their relative abundance at each reach. If three or fewer of a given mesohabitat type occurred in a sampling site, then all mesohabitats of that type were typically sampled. Fish were collected by using a seine while wading during both winter and summer sampling. The sampling approach was the same as the sampling approach described in Moring and others (2014) and was deliberately biased toward collecting fish from shallow, low-velocity, nearshore habitats preferred by Rio Grande silvery minnow and similar fish; for example, 3.0-millimeter mesh seines were used, as opposed to a larger mesh size, to increase the likelihood of collecting Rio Grande silvery minnow and other minnow species. Additional details on the fish assemblage surveys are provided in Braun and others (2015).

Physical Characteristics Over a Range of Streamflows

Physical characteristics including stream velocity, depth, and substrate type associated with different mesohabitats were measured over a range of streamflows. Instantaneous discharge measurements were made at most sites in accordance with standard USGS discharge measurement methods (Rantz and others, 1982; Turnipseed and Sauer, 2010). At the Barelas site on November 10, 2011, and August 11, 2012, and the Los Lunas II site on November 15, 2011, the daily mean discharge was obtained from the USGS National Water Information System (NWIS) for the nearest upstream USGS streamflow-gaging station (table 1). Instantaneous discharge measurements were stored in NWIS (U.S. Geological Survey, 2014).

During summer 2012, stream velocity and depth were recorded at the centroid of each seine haul by the crew of technicians collecting fish, whereas stream velocity, depth, dominant substrate type and size, and percent embeddedness were recorded during winter 2011–12 and summer 2012 by a second crew of technicians who were collecting mesohabitat data along randomly selected transects within each sampled mesohabitat. Additional details on the mesohabitat data collection methods are provided in Braun and others (2015). Velocity and depth measurements were made by wading the stream with a FlowTracker hand-held acoustic Doppler velocimeter attached to a wading rod (SonTek, 2013). Standard USGS protocols for measuring velocity were followed (Rantz and others, 1982; Turnipseed and Sauer, 2010). Additional details on the velocity measurements are provided in Braun and others (2015).

Fish Assemblage Composition and Mapped Mesohabitat Features

By evaluating fish assemblage composition (that is, the number of individuals of each species collected either at a given sampling site or reach containing one or more sampling sites) over a range of streamflows during different times of the year, insights can be gained into the types of mesohabitats used by different species, including the Rio Grande silvery minnow, and how differences in the number of mapped mesohabitats and number of types of mesohabitats (depending on the amount of streamflow) correspond to changes in fish assemblages.

Fish Assemblage Composition

The average number of fish collected per site during the winter and summer sampling periods in each of the four reaches (Cochiti, Angostura, Isleta, and San Acacia) was determined by dividing the total number of fish collected per reach by the number of sites sampled per reach. The average number of fish collected decreased in the downstream direction during winter 2011–12, when the average number of fish collected was 1,394 in the Cochiti reach (based on a single sampling at the only site in the Cochiti reach, the Peña Blanca site), 154 in the Angostura reach, 97 in the Isleta reach, and 39 in the San Acacia reach (table 3). During summer 2012, the site in the Cochiti reach was not sampled, and only 3 of the 4 sites in the Angostura reach were sampled (the Bernalillo site was not sampled). In the three reaches sampled during summer 2012, substantially more fish were collected on average in each reach compared to winter 2011–12, with summer averages of 593 fish in the Angostura reach, 946 fish in the Isleta reach, and 697 fish in the San Acacia reach.

In the three reaches sampled in both the winter and summer, the average number of species collected per sampling site was higher in summer 2012 compared to winter 2011–12. The average number of species collected per sampling site within each reach generally decreased between the upstream and downstream reaches in both winter 2011–12 (6.5, 4.4, and 2.2, respectively, in the Angostura, Isleta, and San Acacia reaches) and summer 2012 (8.0, 8.0, and 7.2, respectively, in the Angostura, Isleta, and San Acacia reaches). The Angostura reach likely maintains greater fish diversity in part because it maintains a more consistent discharge relative to the reaches downstream and does not go dry from year to year.

The relative abundance of Rio Grande silvery minnows, calculated as the number of Rio Grande silvery minnows collected at a sampling site during a sampling period (winter 2011–12 or summer 2012) divided by the total number of Rio Grande silvery minnows collected at all sampling sites during the same sampling period, was highest in the San Acacia reach during both winter 2011–12 (about 62 percent) and summer 2012 (about 54 percent). The relative abundance of Rio Grande silvery minnows was higher in the Angostura reach (about 26 percent) in winter 2011–12 than in the Isleta reach (about 12 percent), but the reverse was true in summer 2012, when the relative abundance was about 41 percent in the Isleta reach and about 5 percent in the Angostura reach. No Rio Grande silvery minnows were collected at the Peña Blanca site in the Cochiti reach during the one time it was sampled (winter 2011–12).

The catch per unit effort of Rio Grande silvery minnows (RCPUE) was calculated by dividing the number of Rio Grande silvery minnows collected at a sampling site during a sampling period (winter 2011–12 or summer 2012) by the sum of the total area seined (in square meters [m^2]); the resulting quotient was multiplied by 100 m^2 to obtain the RCPUE. The use of RCPUE to standardize fish data allows for direct comparisons between stream reaches or mesohabitats of different sizes (Nielsen and Johnson, 1983). The RCPUE was highest on average per sampling site in the San Acacia reach during both winter 2011–12 (2.91) and summer 2012 (0.20). Like the relative abundance, the average RCPUE per site was higher in the Angostura reach (1.33) in winter 2011–12 compared to the Isleta reach (0.47), but the reverse was true in summer 2012, when the RCPUE was 0.14 in the Isleta reach and 0.03 in the Angostura reach. The RCPUE was substantially higher in winter 2011–12 relative to summer 2012 because not only were there far more Rio Grande silvery minnows caught in winter 2011–12 (163) than in summer 2012 (22), but the seined area tended to be higher in summer 2012 because of a change in methodology between the two sampling events (as many as 20 mesohabitats were selected for seining in winter 2011–12 as compared to 30 mesohabitats in summer 2012). The RCPUE in the Cochiti reach was 0 percent in winter 2011–12 because no Rio Grande silvery minnows were collected at the Peña Blanca site.

Among all sampling sites, the highest fish-species richness for the winter sampling period was measured at the Abeytas site (9 species); the highest fish-species richness for the summer sampling period was measured at the Los Lunas I site (10 species). The lowest fish-species richness for the winter sampling period was measured at the Los Lunas II and Bosque del Apache II sites (one species each); the lowest fish-species richness for the summer sampling period was measured at the Rio Salado site (five species) (table 3). In all cases, the number of species collected at each sampling site in winter 2011–12 was less than (or equal to, in the case of the Los Padillas and Abeytas sites) the number of species collected at the same sampling site in summer 2012. In all cases, the total number of fish collected at each sampling site in winter 2011–12 was less than the number of fish collected at the same sampling site in summer 2012. In winter 2011–12, the most fish were collected at Peña Blanca (1,394), and the least were collected at Los Lunas II (1); whereas in summer 2012, the most fish were collected at Lemitar (1,729), and the least were collected at San Pedro (269). It stands to reason that there would be greater species richness and a larger number of fish collected in summer 2012 relative to winter 2011–12 because lower flows (and subsequently shallower mesohabitats) in summer 2012 increased the likelihood of seining success. Not only is seining easier at shallow depths (because of the potential for increased speed and mobility from the crew of technicians collecting fish), but the overall fish density for each sampling site is also higher in the summer (assuming the number of fish remains relatively consistent) because the volume of water in which the fish are confined is smaller. However, it should be noted that the fishing effort was commensurate with the number of mesohabitats sampled for fish. In most cases, the number of mesohabitats sampled for fish increased from about 20 in winter 2011–12 to about 30 in summer 2012. Fewer than 20 mesohabitats were mapped in winter 2011–12 at Bernalillo (17), La Joya (18), and Lemitar (16) (fig. 7), so the number of mesohabitats where fish were collected was less than 20 at these three sites.

To account for differences in sampling effort between winter 2011–12 and summer 2012 associated with differences in the number of mesohabitats seined, relative abundances of Rio Grande silvery minnows were calculated for each of the sampling sites during both winter 2011–12 and summer 2012 (table 3). The highest relative abundance of Rio Grande silvery minnows during winter 2011–12 occurred at Arroyo del Tajo (46.0 percent) followed by La Orilla (12.9 percent). Conversely, no Rio Grande silvery minnows were collected at 3 of the 15 sites sampled (Peña Blanca, Los Lunas II, and Abeytas) during winter 2011–12. The highest relative abundance of Rio Grande silvery minnows during summer 2012 occurred at Lemitar (45.5 percent) followed in succession by Los Lunas I (22.7 percent) and Los Lunas II (18.2 percent). Conversely, no Rio Grande silvery minnows were collected at 7 of the 13 sites sampled (La Orilla, Los Padillas, Abeytas, La Joya, Rio Salado, Bosque del Apache I, and Bosque del Apache II) during summer 2012.

At the mesohabitat scale, Rio Grande silvery minnows were collected in 6 of the 8 mesohabitat types mapped in this study (table 4). Rio Grande silvery minnows were collected most often in runs (101 individuals from 35 mesohabitats), followed by flats (32 individuals from 9 mesohabitats) and pools (28 individuals from 9 mesohabitats). The RCPUE by mesohabitat type was highest in pool mesohabitat types (1.44), followed by riffles (1.06) and runs (0.77).

Table 3. Relative abundance of Rio Grande silvery minnows collected during sampling events in winter 2011-12 and summer 2012 on the Middle Rio Grande, New Mexico.

[MRGBI, Middle Rio Grande Bosque Initiative; RGSM, Rio Grande silvery minnow; CPUE, catch per unit effort; m2, square meters; —, no data were collected during this time period]

MRGBI Reach Name	Short Name	Winter 2011–12						Summer 2012					
		Relative abundance of RGSM[1], in percent	CPUE for RGSM[2]	Fish species richness[3]	Number of RGSM collected	Total number of fish collected	Total area seined (m^2)	Relative abundance of RGSM[1], in percent	CPUE for RGSM[2]	Fish species richness[3]	Number of RGSM collected	Total number of fish collected	Total area seined (m^2)
Cochiti	Peña Blanca	0	0	4	0	1,394	661	—	—	—	—	—	—
Aggostura	Bernalillo	1.23	0.38	8	2	450	531	—	—	—	—	—	—
	La Orilla	12.9	2.82	6	21	107	744	0	0	8	0	479	1,089
	Barelas	7.98	1.03	5	13	23	1,259	4.55	0.08	9	1	530	1,254
	Los Padillas	4.29	1.10	7	7	34	634	0	0	7	0	770	1,185
Isleta	Los Lunas I	2.45	0.58	3	4	29	693	22.7	0.35	10	5	1,490	1,442
	Los Lunas II	0	0	1	0	1	651	18.2	0.35	9	4	817	1,155
	Abeytas	0	0	9	0	165	717	0	0	9	0	1,216	1,176
	La Joya	0.61	0.18	5	1	218	564	0	0	7	0	791	924
	Rio Salado	8.59	1.58	4	14	74	885	0	0	5	0	417	780
San Acacia	Lemitar	7.98	2.46	3	13	57	529	45.5	0.88	8	10	1,729	1,142
	Arroyo del Tajo	46.0	10.3	3	75	125	729	4.55	0.07	8	1	290	1,416
	San Pedro	3.07	0.68	2	5	6	738	4.55	0.08	7	1	269	1,314
	Bosque del Apache I	1.23	0.27	2	2	3	735	0	0	6	0	528	1,002
	Bosque del Apache II	3.68	0.82	1	6	6	735	0	0	7	0	670	1,260

[1]Calculated as the number of RGSMs collected at a site during a sampling period divided by total number of RGSMs collected at all sites during the same sampling period multiplied by 100. Percentages may not sum to 100 because of rounding differences.

[2]Calculated as the number of RGSMs collected at a site during a sampling period divided by the total area (in square meters) seined multiplied by 100.

[3]Total number of species collected.

Table 4. Rio Grande silvery minnow collection information based on mesohabitat type in the Middle Rio Grande, New Mexico, 2011–12.

[RGSM, Rio Grande silvery minnows; m^2, square meters; RCPUE, catch per unit effort; —, not applicable because no RGSM were collected in these mesohabitat types]

Mesohabitat type	Number of mesohabitats where RGSM were collected	Number of RGSM collected in each mesohabitat type	Number of seine hauls made in each mesohabitat type	Total area seined (m^2)	RCPUE[1]
riffle	6	13	47	1,227	1.06
run	35	101	458	13,161	0.77
pool	9	28	97	1,941	1.44
isolated pool	2	5	52	930	0.54
forewater	0	0	10	324	—
backwater	1	6	66	1,521	0.39
embayment	0	0	21	654	—
flat	9	32	237	6,185	0.52

[1]Calculated as the number of RGSMs collected within a given mesohabitat type divided by the total area (in square meters) seined within that mesohabitat type × 100.

Mapped Mesohabitat Features

The total number and number of types of mesohabitats were generally larger at sampling sites during summer 2012, when streamflows were low, compared to winter 2011–12, when streamflows were moderate. During summer, streamflow also tended to decrease in the downstream direction in the study area. Decreases in streamflow in the summer compared to the winter typically led to increases in channel complexity in terms of the number of different wetted mesohabitat types present (fig. 7*A*), total number of mesohabitats present (fig. 7*B*), and the number of channel bars mapped (fig. 7*C*). Decreases in streamflow also led to reductions in wetted area at all of the sampling sites that were mapped in both winter 2011–12 and summer 2012 (fig. 7*D*). Summary statistics associated with winter 2011–12 are based on maps generated in November and December 2011 as well as February 2012. For sampling sites that were mapped more than once during winter 2011–12 (San Pedro and Bosque del Apache II), the data associated with sampling in February 2012 was used in the calculation of summary statistics because the data were accompanied by the collection of physical habitat and fish data, whereas no such data were collected in association for San Pedro and Bosque del Apache II from December 2011 because of inclement weather.

Decreases in streamflow between winter 2011–12 and summer 2012 also led to decreased wetted areas of mesohabitats that were mapped at each sampling site. Sampling sites in the lower part of the Angostura reach and the upper part of the Isleta reach that pass through or near the city limits of Albuquerque, N. Mex., remain perennially wet throughout the year. Six sampling sites within these reaches (La Orilla, Barelas, Los Padillas, Los Lunas I, Los Lunas II, and Abeytas) had the largest wetted area for the winter 2011–12 period, and 5 of these 6 sites had the largest wetted area for the summer 2012 period (fig. 7*D*). The wide channel conditions and sustained flow at the Barelas site produced the largest wetted areas (113,199 m^2 during winter 2011–12 and 103,094 m^2 during summer 2012) of all sampling sites. The greatest difference between wetted areas at a single sampling site between winter 2011–12 and summer 2012 was measured at the Abeytas site, where a difference in wetted area of 60,314 m^2 was measured. The smallest wetted area in winter 2011–12 was measured at the Bernalillo site (37,144 m^2), whereas the smallest wetted area in summer 2012 was measured at the Lemitar site (13,547m^2).

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Fish Assemblage Composition and Mapped Mesohabitat Features Over a Range of Streamflows in the Middle Rio Grande, New Mexico, Winter 2011–12, Summer 2012

By

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Mapped Mesohabitat Features—Continued

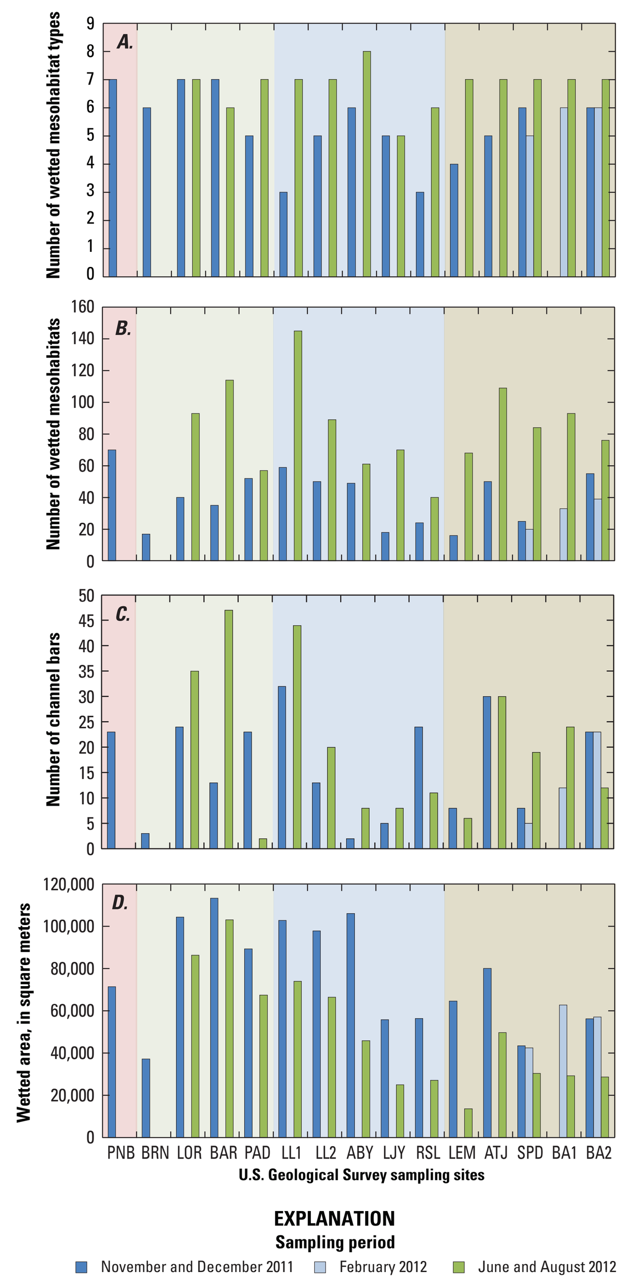


Figure 7. Number of *A*, wetted mesohabitat types mapped; *B*, wetted mesohabitats mapped; *C*, channel bars mapped; and *D*, wetted area at 15 sampling sites on the Middle Rio Grande, winter 2011–12 and summer 2012.

A total of eight different types of wetted mesohabitats were mapped across the entire study area: riffles, runs, pools, isolated pools, forewaters, backwaters, embayments, and flats. The only sampling site that contained all 8 wetted mesohabitat types was Abeytas on June 7, 2012, but 10 of the 13 sampling sites mapped in summer 2012 contained at least 7 of the 8 potential wetted mesohabitat types. In contrast, only 3 out of 15 sampling sites (Peña Blanca, La Orilla, and Barelas) that were mapped in winter 2011–12 contained as many as seven different wetted mesohabitat types, and all 3 of these sampling sites were located in the most upstream part of the study area (3 of the 4 most upstream sampling sites). La Joya contained the fewest types of wetted mesohabitats in summer 2012 with five, whereas Los Lunas I and Rio Salado contained the fewest types of wetted mesohabitats in winter 2011–12 with three each. The average number of different wetted mesohabitat types per site mapped in winter 2011–12 and summer 2012 were 5.3 and 6.8, respectively. In general, decreases in streamflow between winter 2011–12 and summer 2012 led to increased complexity in terms of the number of different types of wetted mesohabitats that were mapped at each sampling site. Barelas was the only sampling site where a greater number of wetted mesohabitats was mapped in winter 2011–12 compared to summer 2012.

Decreases in streamflow between winter 2011–12 and summer 2012 also led to increased complexity in terms of the total number of wetted mesohabitats that were mapped at each sampling site. More than half of the sampling sites that were mapped during winter 2011–12 contained fewer than 40 mesohabitats. During summer 2012, more than 40 mesohabitats were mapped at all of the sites except for the Rio Salado site, where 40 mesohabitats were mapped. In winter 2011–12, the largest number of wetted mesohabitats mapped at a sampling site was 70 at Peña Blanca, and the smallest was 16 at Lemitar. In summer 2012, more than 100 wetted mesohabitats were mapped at three different sampling sites (Barelas, Los Lunas I, and Arroyo del Tajo) with Los Lunas I having the most at 145. The average number of wetted mesohabitats mapped in winter 2011–12 was 38.1, whereas the average number of wetted mesohabitats mapped in summer 2012 was 84.5. In other words, decreases in streamflow between winter 2011–12 and summer 2012 resulted on average in more than twice as many wetted mesohabitats at each sampling site in summer 2012 relative to winter 2011–12.

In many cases, decreases in streamflow between winter 2011–12 and summer 2012 also led to increased complexity in terms of the total number of channel bars mapped. Channel bars are defined as a transitory parcel of land surrounded by water and typically either devoid of or containing annual vegetation (table 2). Reductions in stage associated with decreased streamflow resulted in the emergence of channel bars in areas that were shallow wetted mesohabitats, particularly flats and shallow runs, under higher streamflow conditions (figs. 8*A* and 8*B* show an example of this change in channel complexity at the Los Lunas I site). The emergence of channel bars contributes to the creation of additional wetted mesohabitats and higher complexity (particularly along the margins and at the downstream end of the channel bars) because of the flow-altering effects caused by the channel bars (figs. 8*A* and 8*B*).

Los Lunas I had the most channel bars (32) of any of the reaches in winter 2011–12 and the second most in summer 2012 (44), and not surprisingly, it had the second most wetted mesohabitats in winter 2011–12 (59) and the most in summer 2012 (145). The average and median number of channel bars mapped in winter 2011–12 was 16.0 and 13.0, respectively, whereas the average and median number of channel bars mapped in summer 2012 was 20.5 and 19, respectively. Figure 8*C* shows the relation between the number of channel bars and the number of wetted mesohabitats mapped at each of the 15 sampling sites on the Middle Rio Grande during winter 2011–12 and summer 2012.

Least-squares linear regression analyses were done to assess the relations between the number of wetted mesohabitats and the number of channel bars. In least-squared linear regression analyses, the R-squared (R^2) or coefficient of determination is one indicator of the goodness of fit, that is, how well the regression equation fits the data (Iman and Conover, 1982; Helsel and Hirsch, 2002).

The largest R^2 value was 0.89, which was measured at each of the three sites that were sampled in February 2012 (San Pedro, Bosque del Apache I, and Bosque del Apache II); the identical R^2 values for these three sites were not surprising because these three sampling sites are in close proximity to one another at the downstream part of the study area. There was also a relatively strong correlation (R^2=0.78) between the number of channel bars and the number of wetted mesohabitats for all sites sampled in June and August 2012; however, the correlation in sites sampled in November and December 2011 was relatively low (R^2=0.38).

Another factor that can contribute to channel complexity is bed-substrate composition. The bed-substrate composition of the Peña Blanca and Bernalillo sites was dominated by coarse-grained bed materials, particularly coarse gravels and cobble in samples collected in winter 2011–12 (fig. 9). Downstream from these two sampling sites, the Rio Grande is characterized by a broader, more low-gradient channel dominated by sand. Fine-grained silts and clays are more prevalent in the mid-reach sampling sites including Los Lunas I and II, Abeytas, La Joya, and Rio Salado. The increase in silts and clays at these sampling sites could be the result of finer-grained contributions from two large tributaries to the Rio Grande, the Rio Puerco and Rio Salado, both of which join the Rio Grande downstream from Albuquerque (fig. 3).

Consistent with the preceding discussion, decreases in streamflow typically led to increases in channel complexity in terms of the number of different wetted mesohabitat types present, total number of mesohabitats present, and the number of channel bars. Decreases in streamflow also led to reductions in wetted area for all sampling sites mapped in both winter 2011–12 and summer 2012. A graphical representation of discharge measured at or near each sampling site as it relates to channel complexity (represented by the number of wetted mesohabitats mapped) is shown in figure 10. In general, sampling sites that were mapped at higher discharge during winter 2011–12 resulted in the lowest number of wetted mesohabitats mapped, whereas sampling sites mapped at lower discharge in summer 2012 resulted in the highest number of wetted mesohabitats. Lower discharge rates result in increased mesohabitat fragmentation, increased numbers of slack water mesohabitats (isolated pools, backwaters, forewaters, and embayments), smaller (area) mesohabitats, greater numbers of mesohabitats, and a more braided stream channel. For higher discharge rates, smaller mesohabitats are flooded, and the stream channel is simplified overall, resulting in fewer slack water mesohabitats, larger (area) mesohabitats, and a stream channel that is less braided. Based on field experience, it is expected that during high magnitude discharge conditions when the channel is bankfull, each reach should consist of no more than a few mesohabitats.

Maps showing the mesohabitats for each of the 15 sites are presented in sheets 3–7. Maps are arranged from upstream to downstream order and grouped by MRGBI reach name. Numbered mesohabitats labeled in yellow correspond to the subset of mesohabitats where Rio Grande silvery minnows were caught. Numbered mesohabitats outlined in black on maps correspond to the subset of mesohabitats where physical habitat measurements (and water-quality properties were measured in summer 2012) and fish collection were attempted. In addition, graphs showing mesohabitat characteristics and selected photographs of field activities and site conditions are shown for each site.

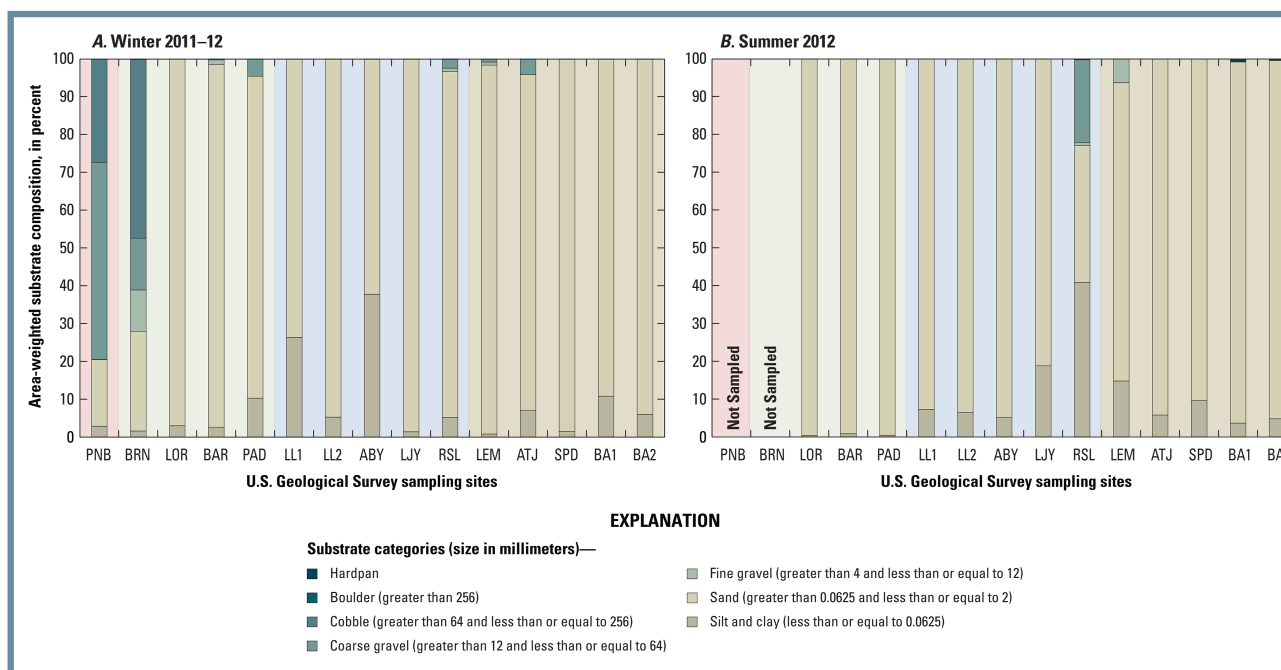


Figure 9. Area-weighted substrate composition at 15 sampling sites on the Middle Rio Grande, *A*, winter 2011–12; and *B*, summer 2012.

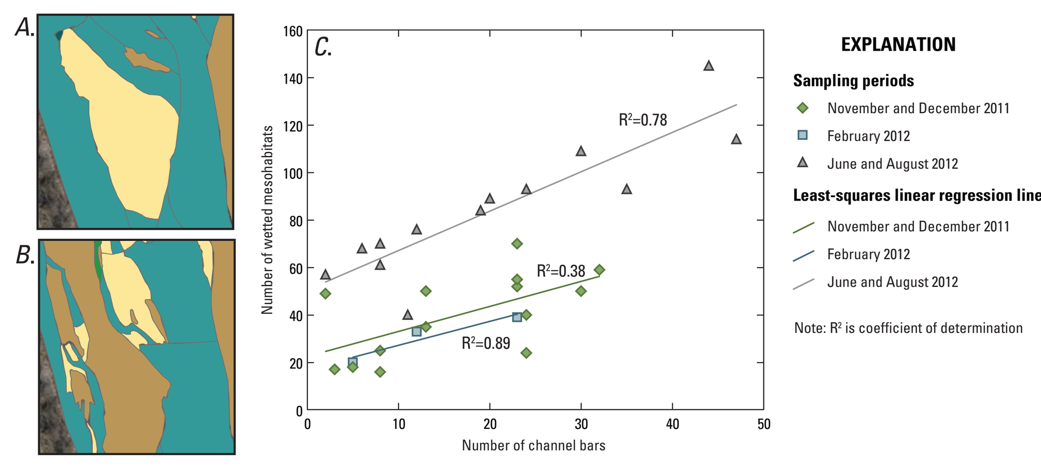
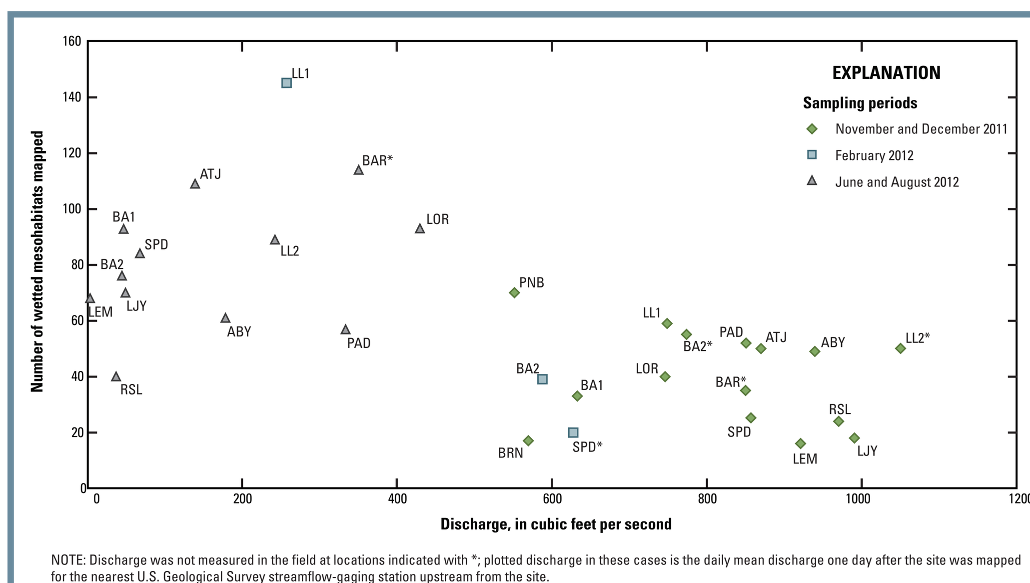


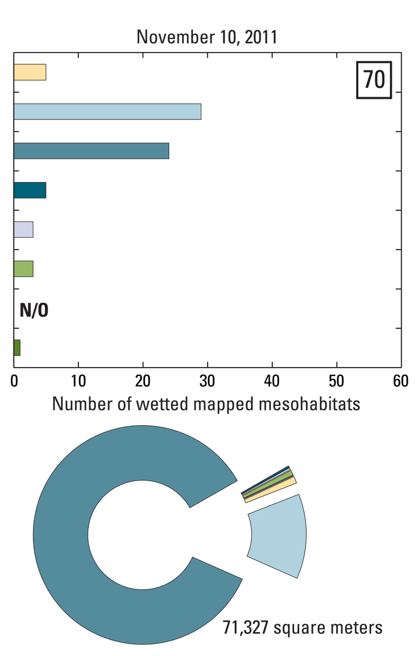
Figure 8. Comparison of differences in channel complexity at the Los Lunas I site during *A*, November 12, 2011, and *B*, June 5, 2012, following a reduction in stage; *C*, correlation between the number of channel bars and the number of wetted mesohabitats mapped at each site during winter 2011–11 and summer 2012.

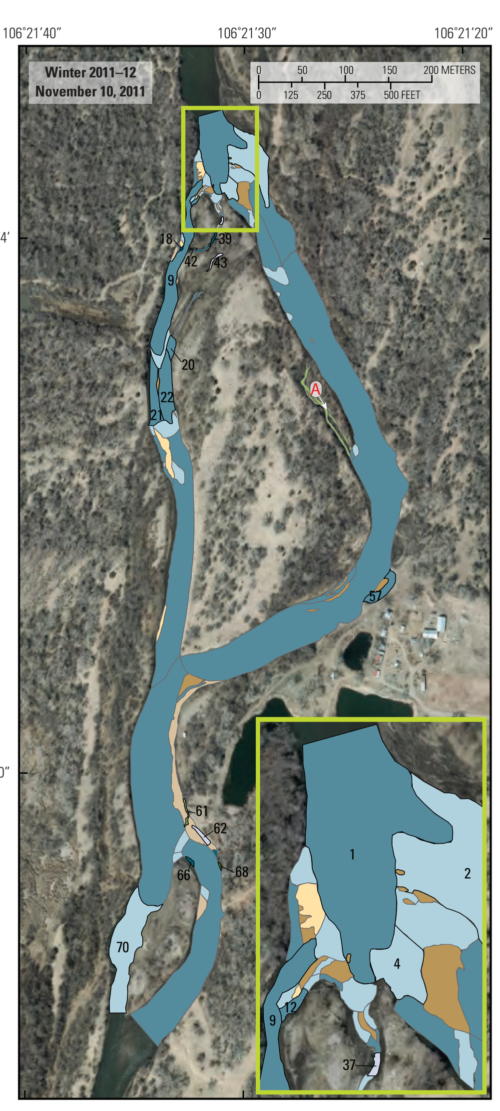


NOTE: Discharge was not measured in the field at locations indicated with *; plotted discharge in these cases is the daily mean discharge one day after the site was mapped for the nearest U.S. Geological Survey streamflow-gaging station upstream from the site.

Figure 10. Graphical representation of discharge as it relates to channel complexity (represented by the number of wetted mesohabitats mapped).

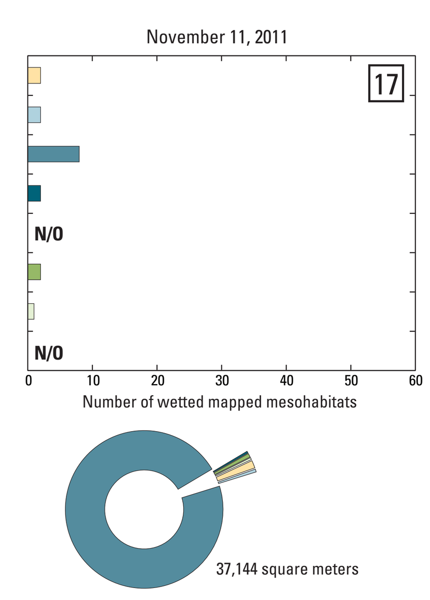
Peña Blanca Sampling Site

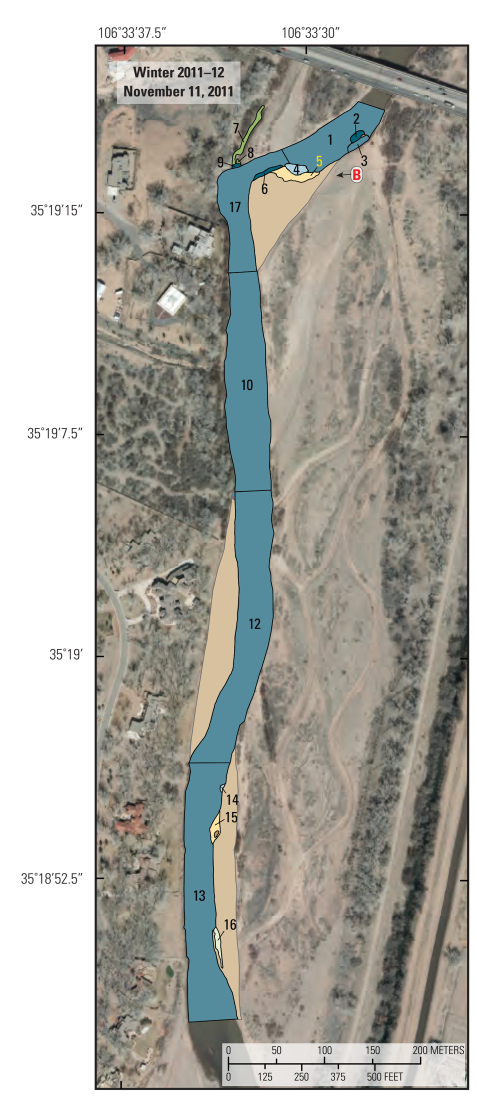




U.S. Geological Survey hydrologist delineates backwaters at Peña Blanca sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 10, 2011.

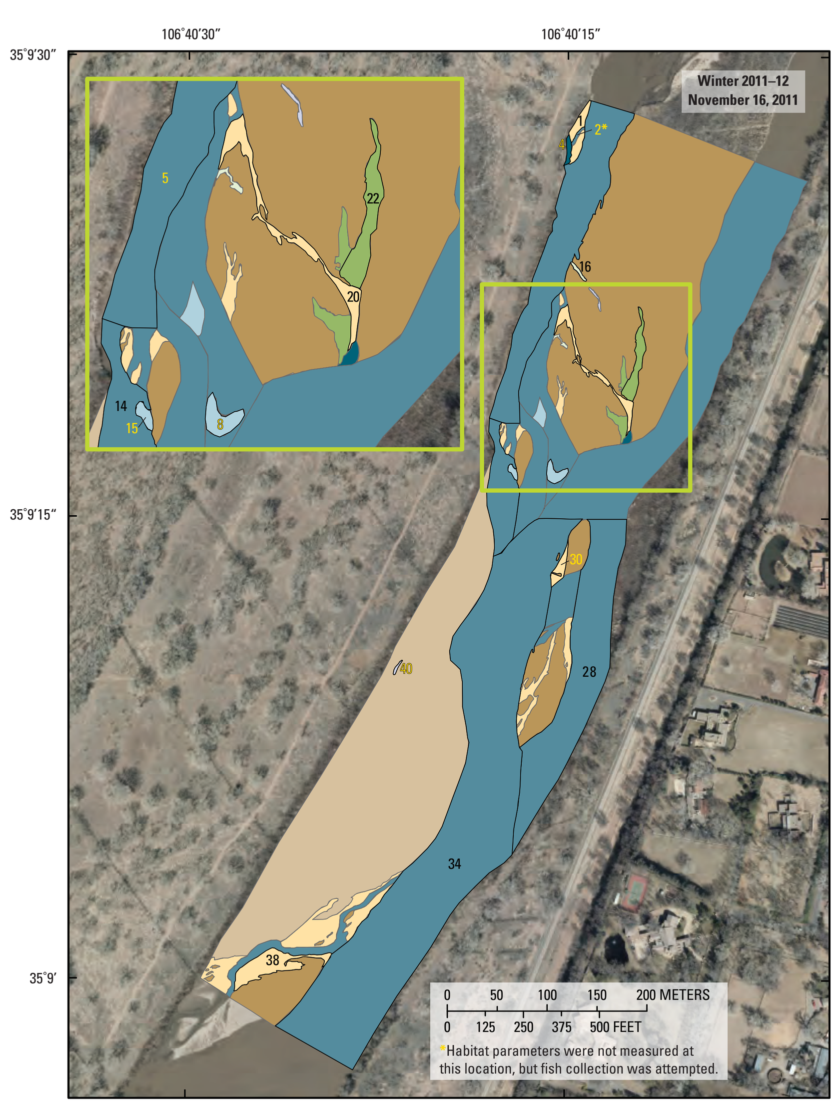
Bernalillo Sampling Site



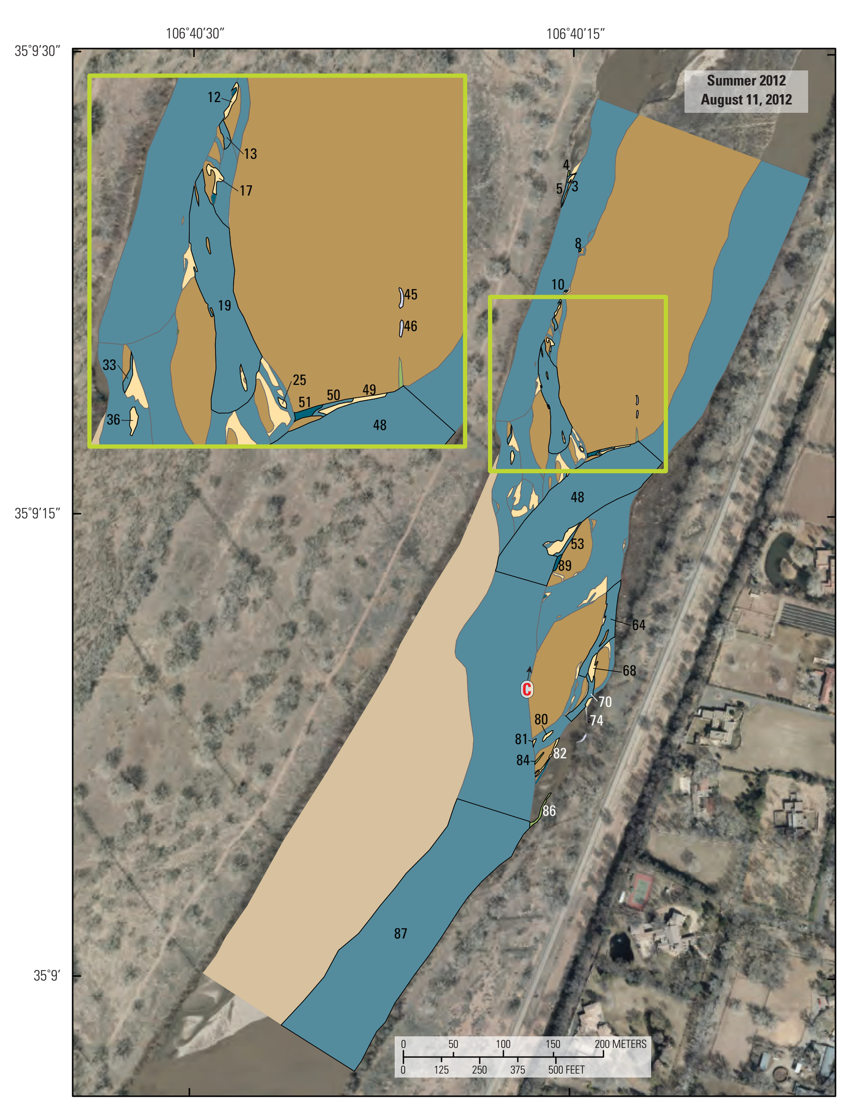


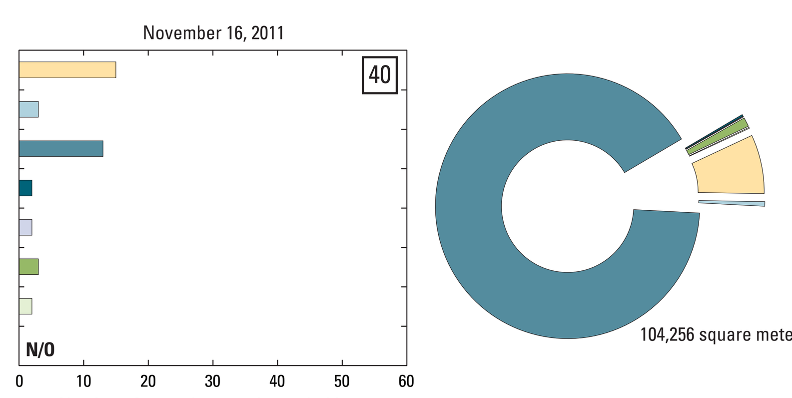
Upper end of Bernalillo sampling site showing submerged bar/riffle/run complex (from left to right) in the foreground and cut bank in the background. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 11, 2011.

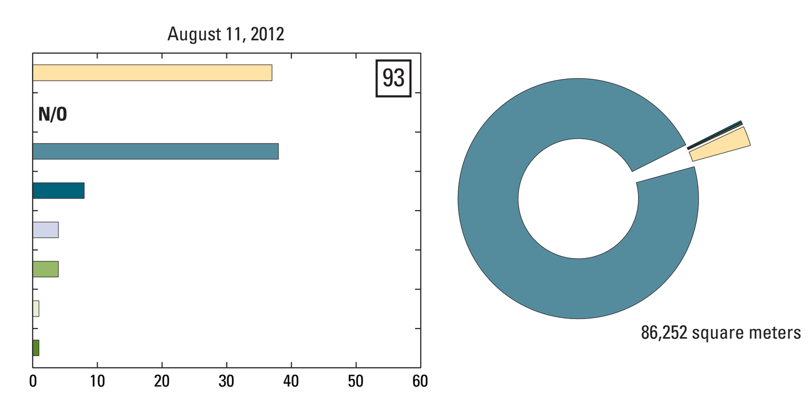
La Orilla Sampling Site



Habitat parameters were not measured at this location, but fish collection was attempted.

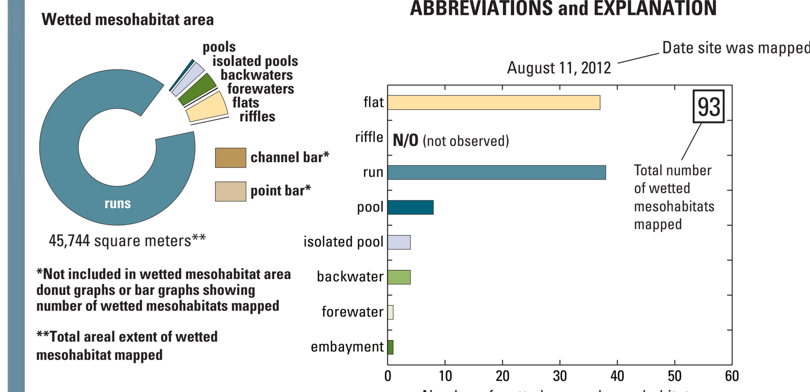






Looking upstream from western edge of channel bar towards the bottom end of the large channel bar that occupies mid-channel at the top of the La Orilla reach. Photograph by Daniel K. Pearson, U.S. Geological Survey, August 13, 2012.

ABBREVIATIONS and EXPLANATION



*Not included in wetted mesohabitat area donut graphs or bar graphs showing number of wetted mesohabitats mapped

**Total areal extent of wetted mesohabitat mapped

U.S. Geological Survey sampling sites short names and map identifier

Peña Blanca, PNB
Bernalillo, BRN
La Orilla, LOR
Barelas, BAR
Los Padillas,PAD
Los Lunas I, LL1
Los Lunas II, LL2
Abeytas, ABY
La Joya, LJY
Rio Salado, RSL
Lemitar, LEM
Arroyo delTajo, ATJ
San Pedro, SPD
Bosque del Apache I, BA1
Bosque del Apache II, BA2

Photo identifier and direction facing when photograph was taken

NOTE: Mesohabitat area donut plots are scaled relative to one another as a function of area.
NOTE: Numbered mesohabitats labeled in yellow correspond to the subset of mesohabitats where Rio Grande silvery minnows were caught.
NOTE: Numbered mesohabitats that are outlined in black on maps correspond to the subset of mesohabitats where physical habitat measurements (and water-quality properties were measured in summer 2012) and fish collection was attempted.

Base credit in maps for Peña Blanca, Bernalillo, La Orilla, Barelas, Los Padillas, Los Lunas I, and Los Lunas II (sheets 3 and 4)

Base from Middle Rio Grande Conservation District,
March–May 2012, 0.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

Base credit in maps for Abeytas, La Joya, Rio Salado, Lemitar, Arroyo del Tajo, San Pedro, Bosque del Apache I, and Bosque del Apache II (sheets 5, 6, and 7)

Base from Bureau of Reclamation,
February 2012, 1.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

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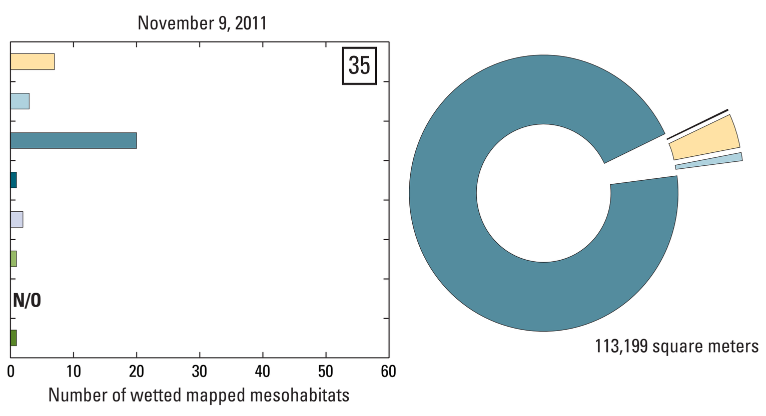
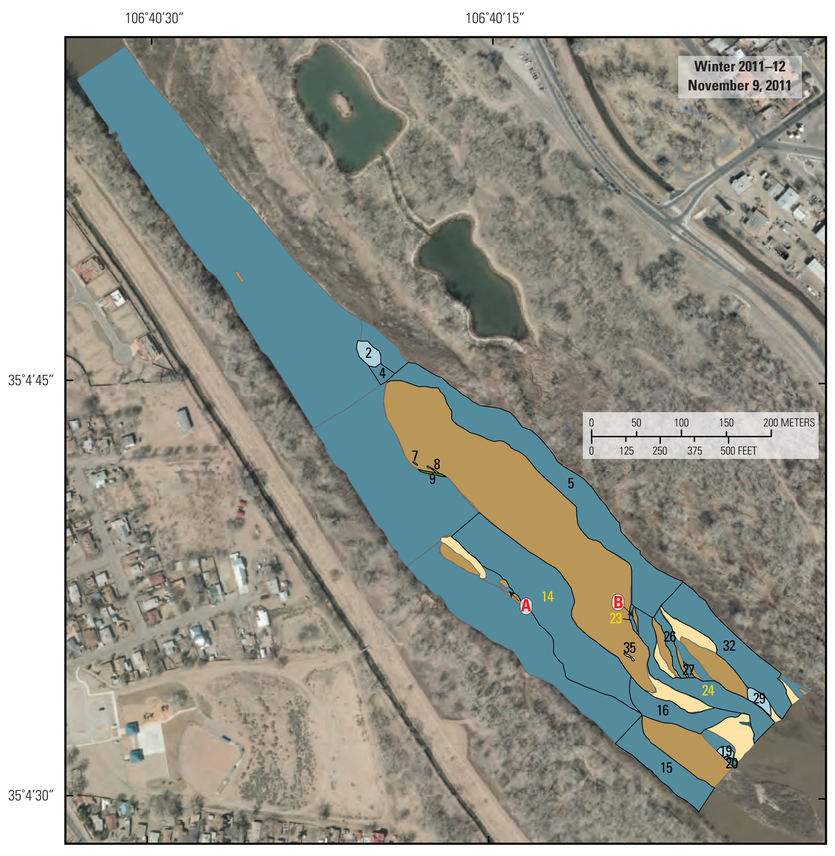
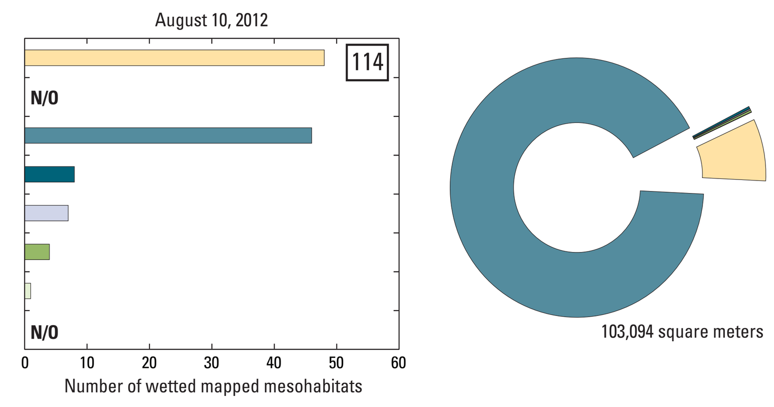
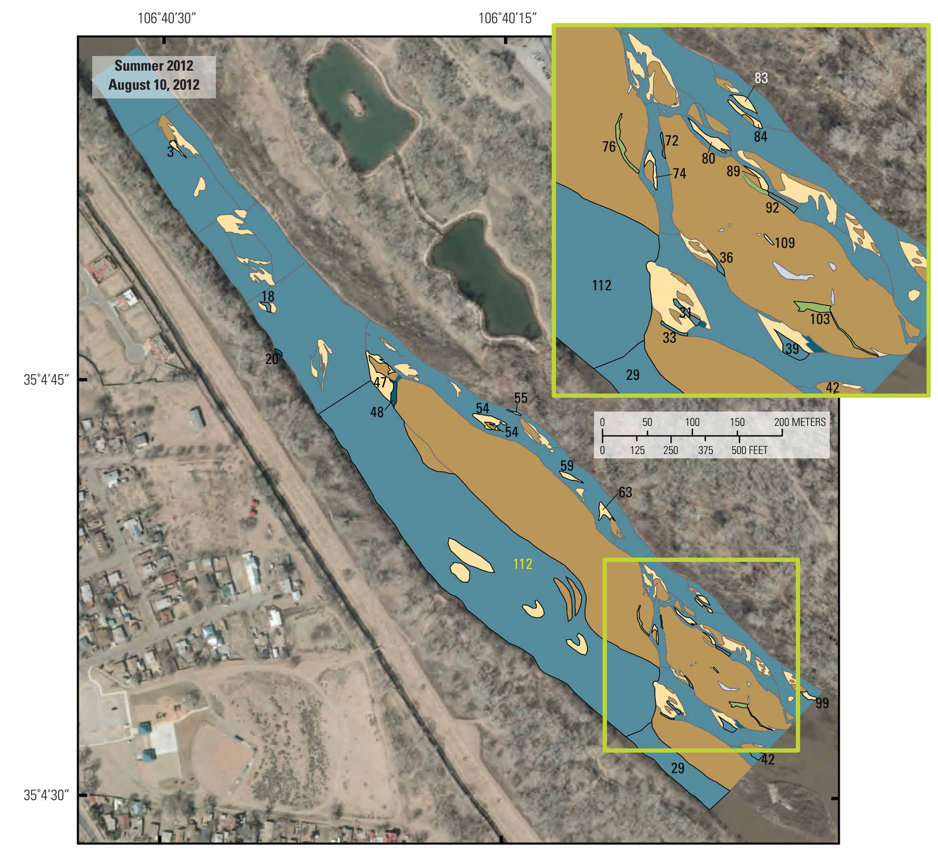
Scientific Investigations Map 3350

Barelas Sampling Site





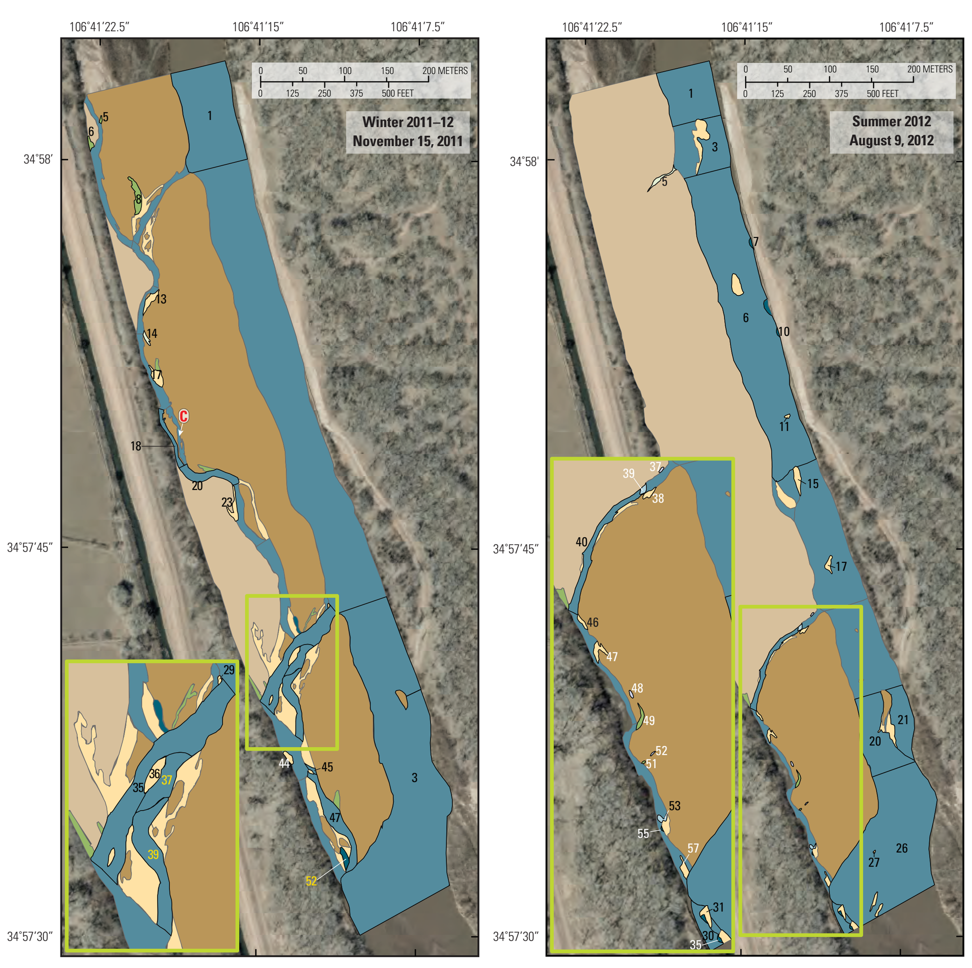


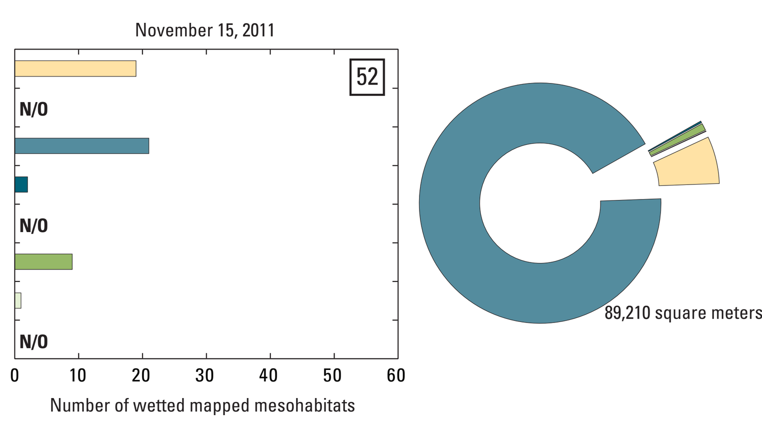


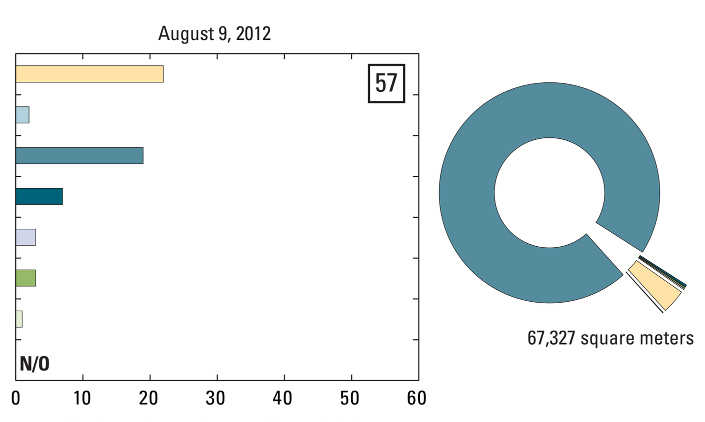
U.S. Geological Survey hydrologist delineates a channel bar using GPS at the Barelas sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 9, 2011.

Downstream end of Barelas sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 9, 2011.

Los Padillas Sampling Site



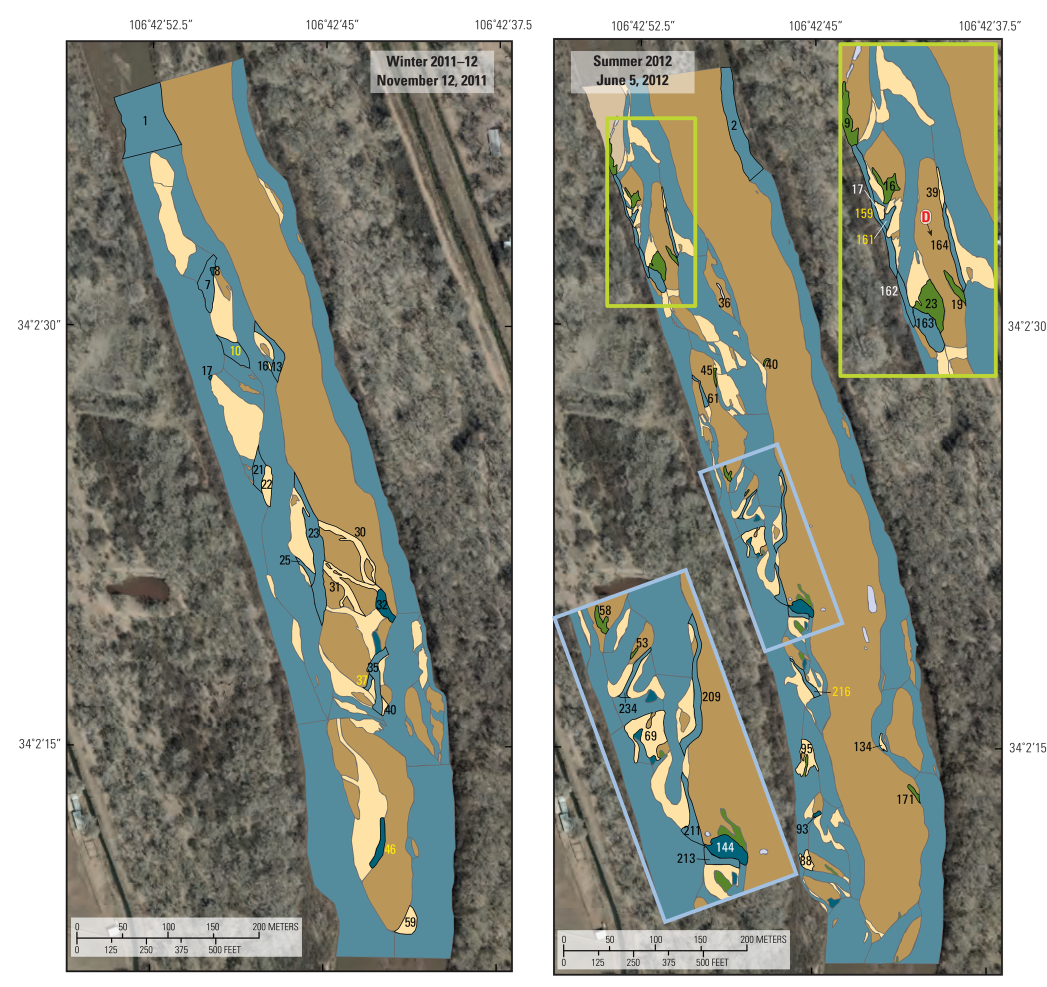


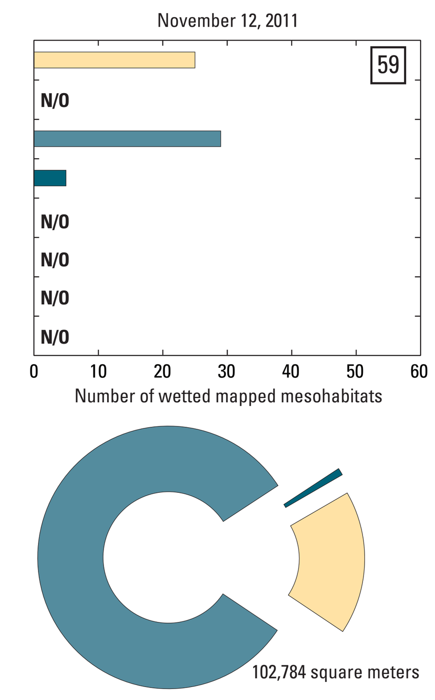


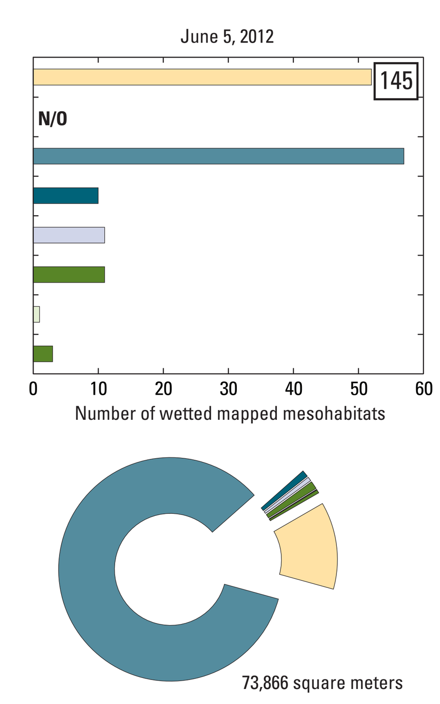
Oblique aerial photograph showing downstream end of Los Padillas sampling site with approximate extents of readily identifiable mesohabitats delineated. Delineated mesohabitats do not correspond to mapped mesohabitats from either November 15, 2011, or August 9, 2012. Photograph by Daniel K. Pearson, U.S. Geological Survey, June 4, 2012.

Looking downstream along secondary channel at Los Padillas sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 15, 2011.

Los Lunas I Sampling Site

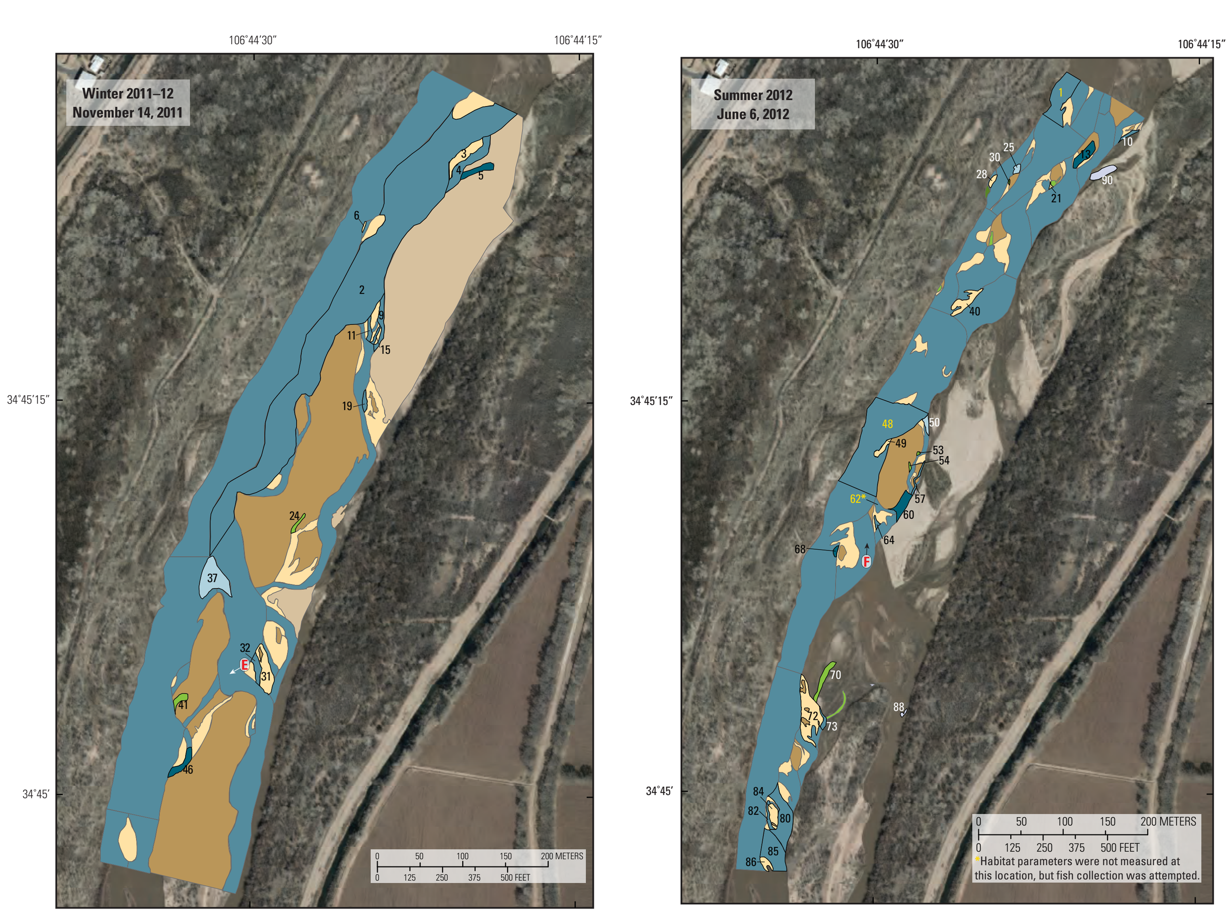






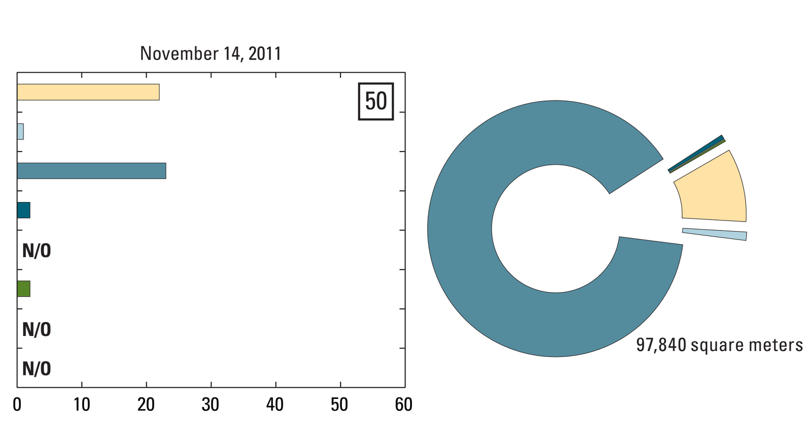
Looking downstream from a channel bar near the upstream end of the Los Lunas I sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, June 5, 2012.

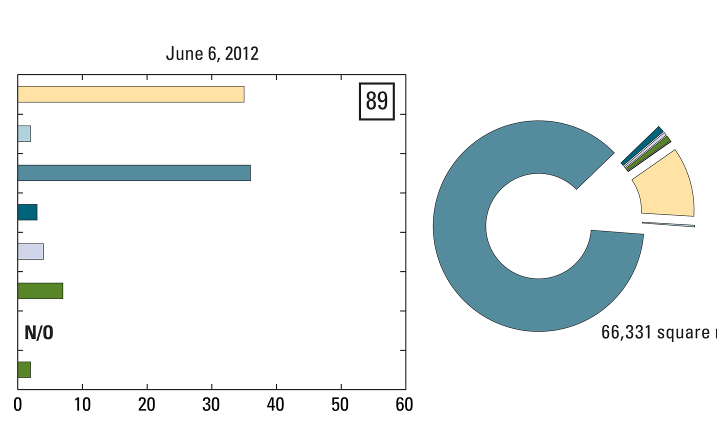
Los Lunas II Sampling Site



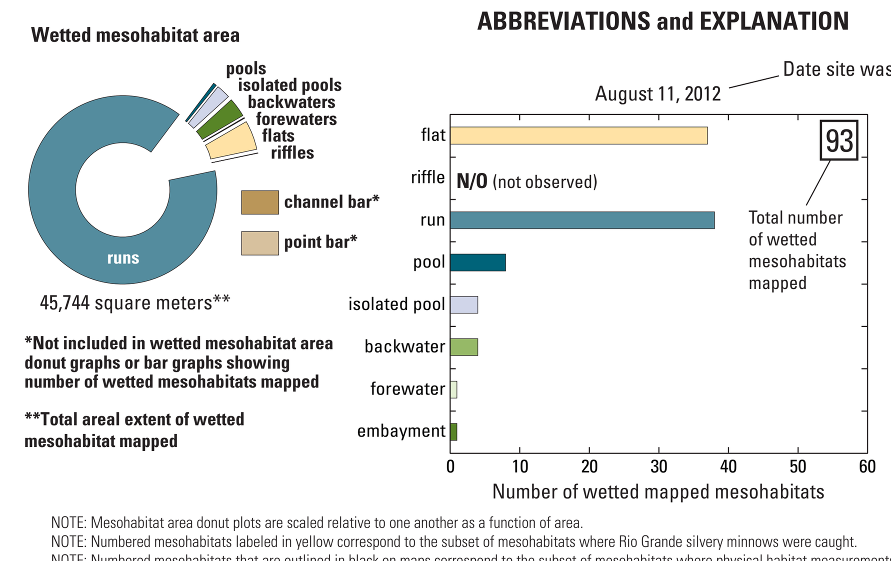
Looking downstream towards narrow run between two channel bars; U.S. Geological Survey geographer processing mapped data in the foreground. Photograph by Christopher L. Braun, U.S. Geological Survey, November 14, 2011.

Looking upstream from a run near mid-reach at Los Lunas II sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, June 6, 2012.





ABBREVIATIONS and EXPLANATION



*Not included in wetted mesohabitat area donut graphs or bar graphs showing number of wetted mesohabitats mapped

**Total areal extent of wetted mesohabitat mapped

U.S. Geological Survey sampling sites short names and map identifier

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- Lemitar, LEM
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- San Pedro, SPD
- Bosque del Apache I, BA1
- Bosque del Apache II, BA2

A — Photo identifier and direction facing when photograph was taken

NOTE: Mesohabitat area donut plots are scaled relative to one another as a function of area.
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Base credit in maps for Peña Blanca, Bernalillo, La Orilla, Barelas, Los Padillas, Los Lunas I, and Los Lunas II (sheets 3 and 4)

Base from Middle Rio Grande Conservation District,
March–May 2012, 0.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

Base credit in maps for Abeytas, La Joya, Rio Salado, Lemitar, Arroyo del Tajo, San Pedro, Bosque del Apache I, and Bosque del Apache II (sheets 5, 6, and 7)

Base from Bureau of Reclamation,
February 2012, 1.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1–888–ASK–USGS

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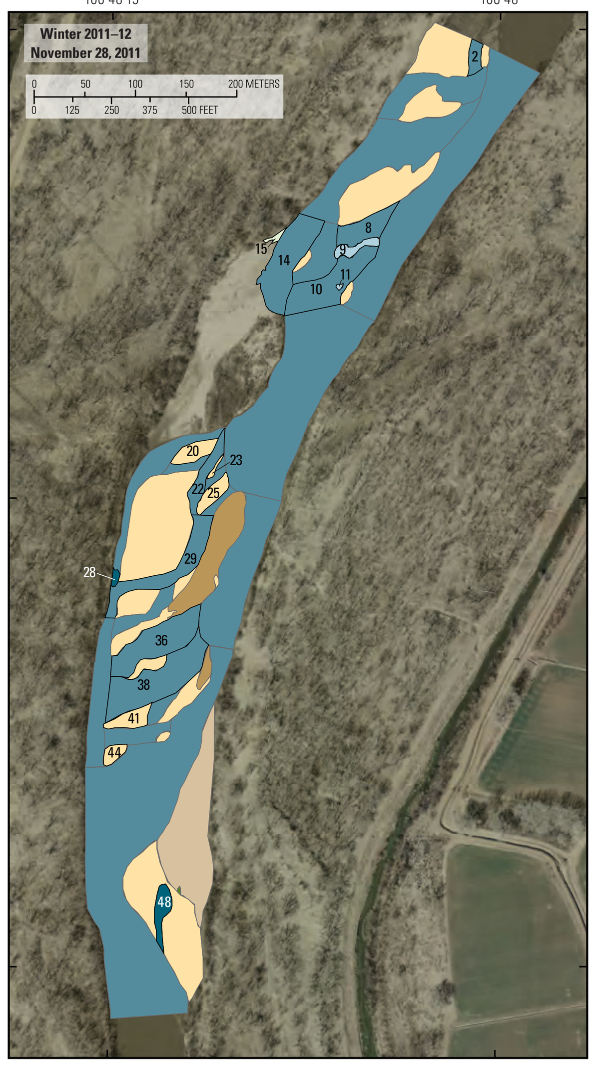
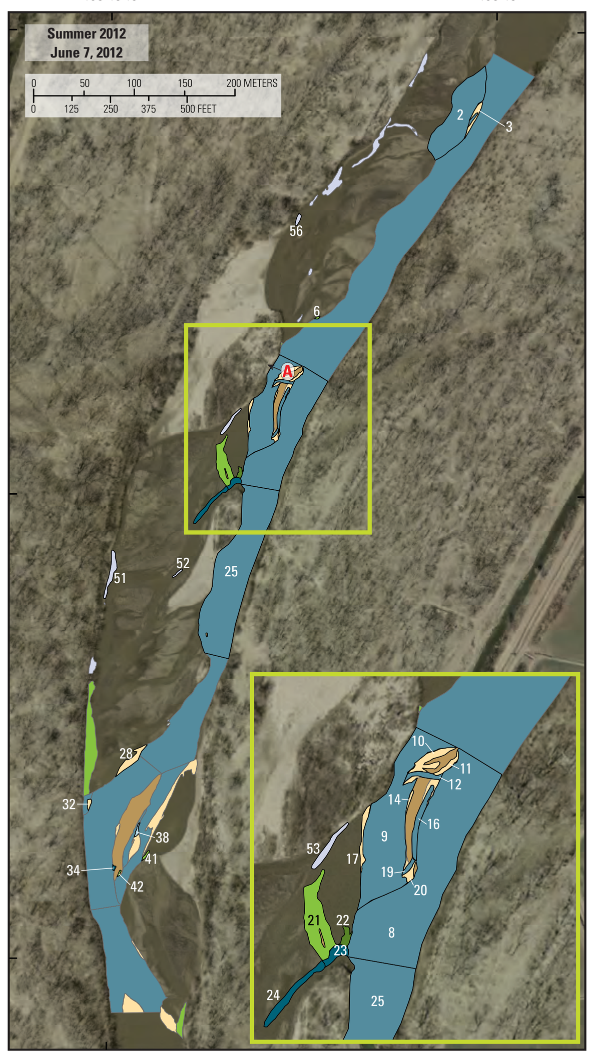
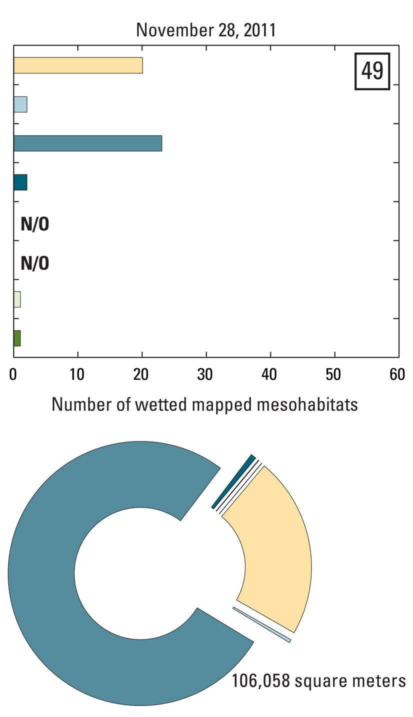
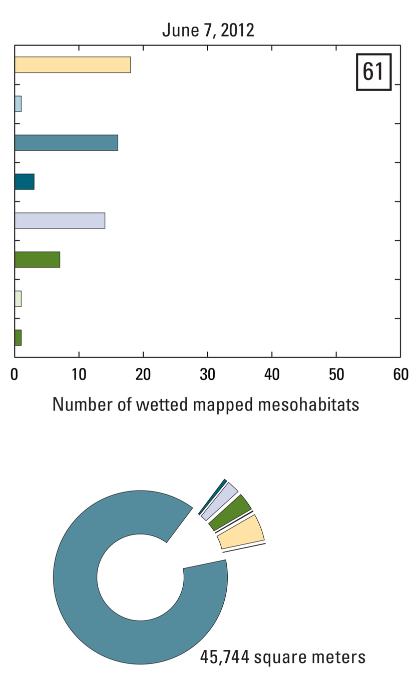
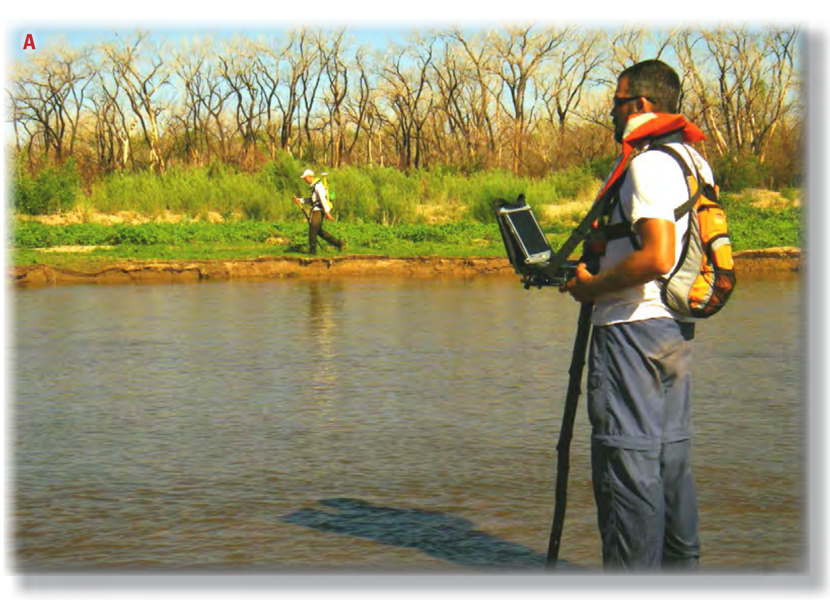
Abeytas Sampling Site





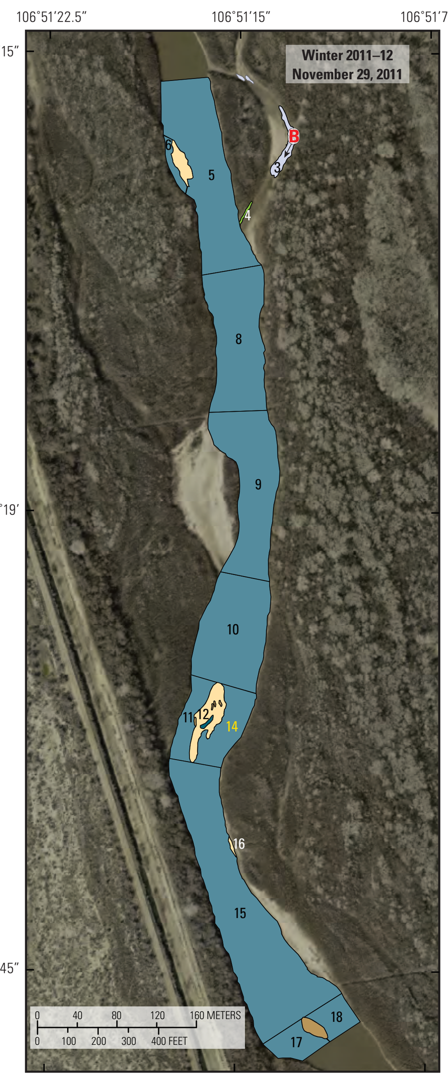


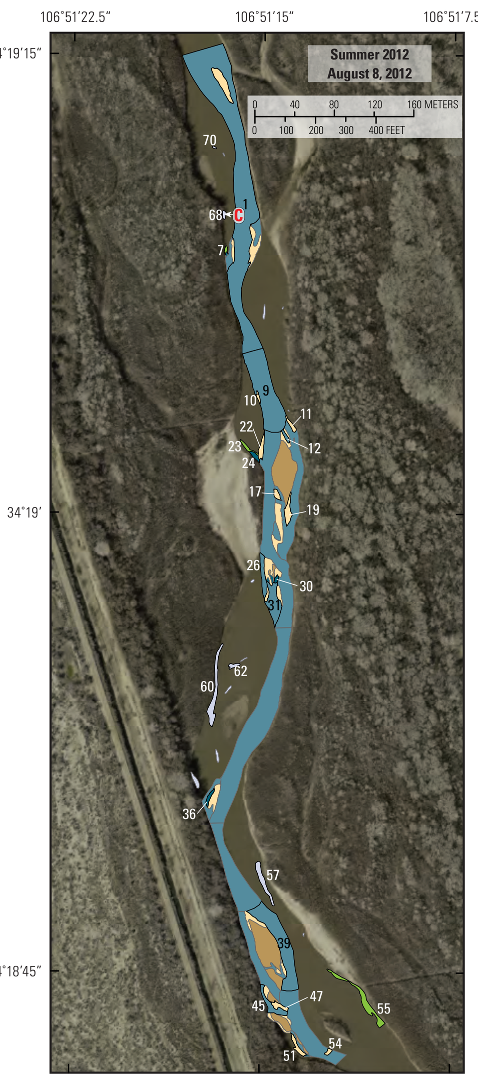


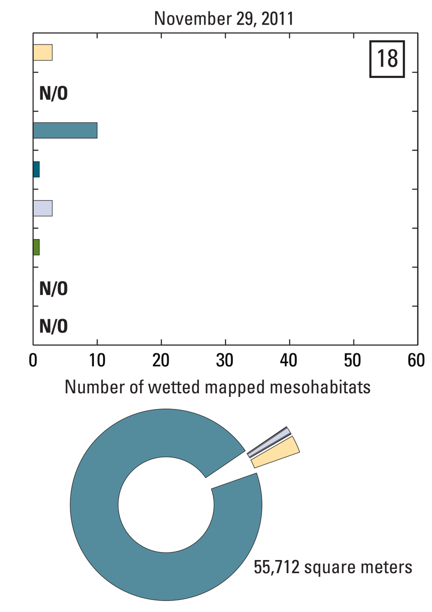


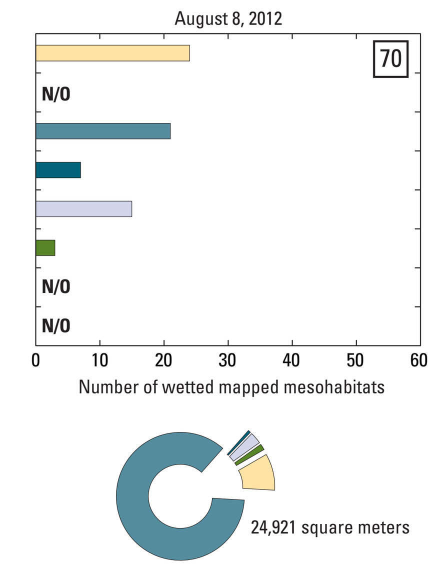
Looking west toward a burn-scarred area from a submerged channel bar in the upstream end of the Abeytas sampling site. U.S. Geological Survey personnel delineating mesohabitats and editing the map product output. Photograph by Michael D. Porter, U.S. Army Corps of Engineers, June 7, 2012.

La Joya Sampling Site





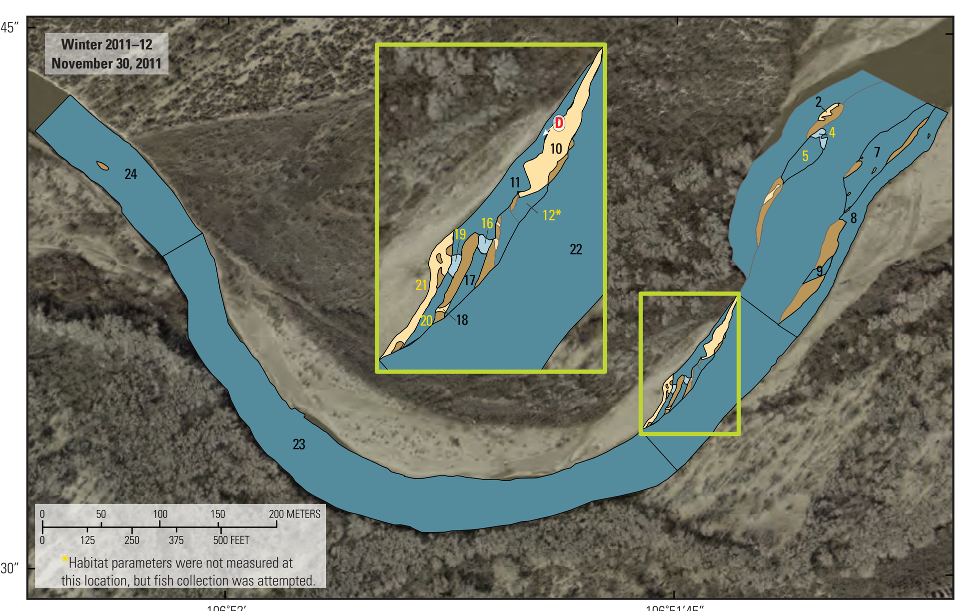


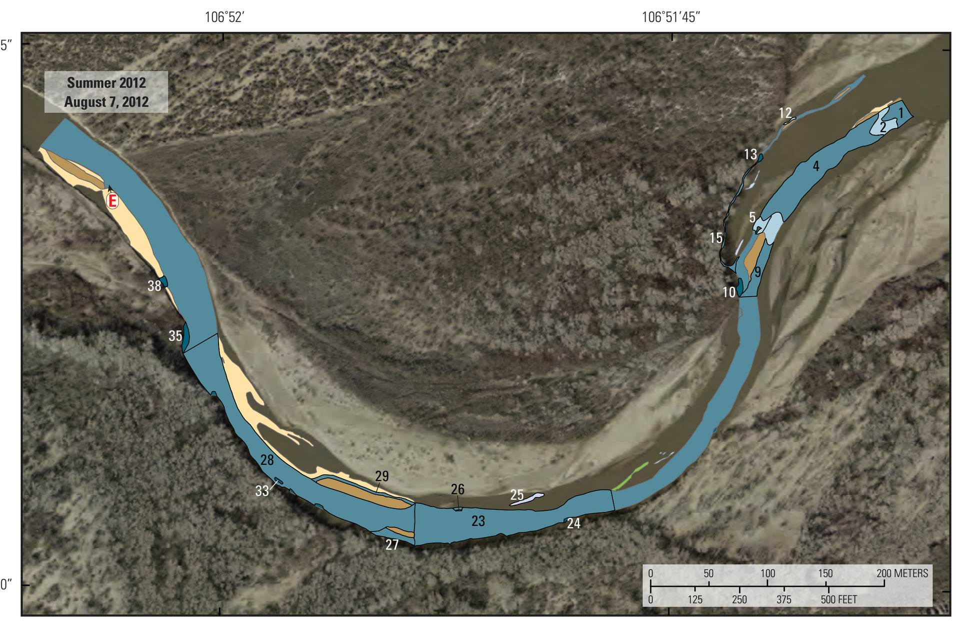


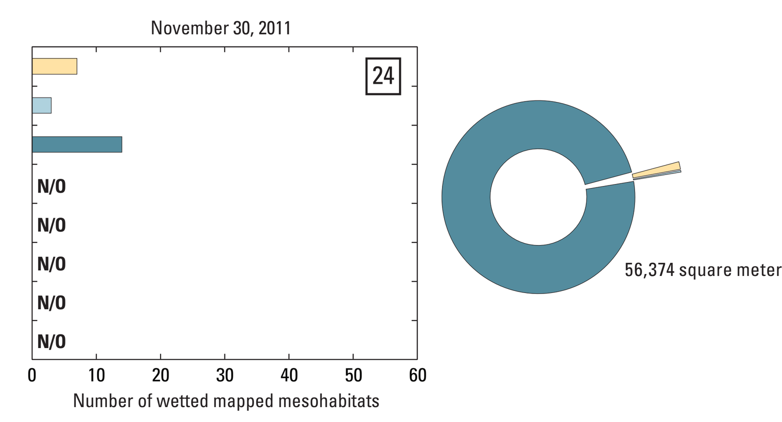
Looking southwest at isolated pool near the upstream end of the La Joya sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 29, 2011.

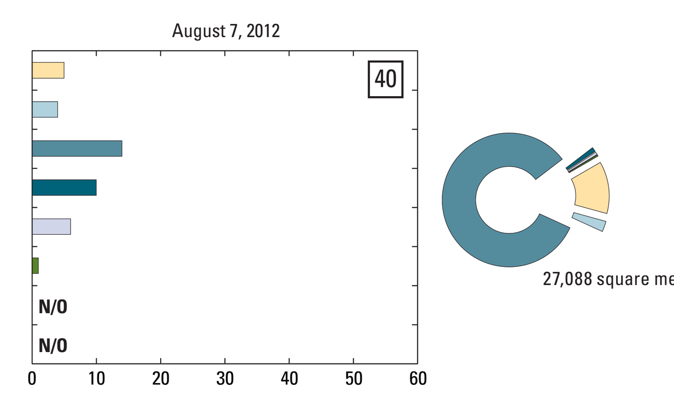
Looking west toward an isolated pool that U.S. Geological Survey hydrologist is delineating in the upper half of the La Joya sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, August 8, 2012.

Rio Salado Sampling Site





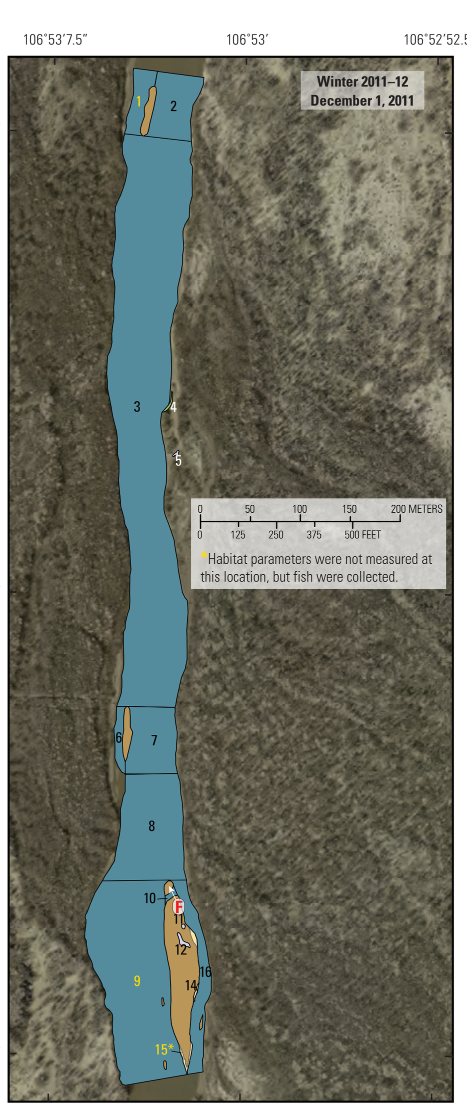


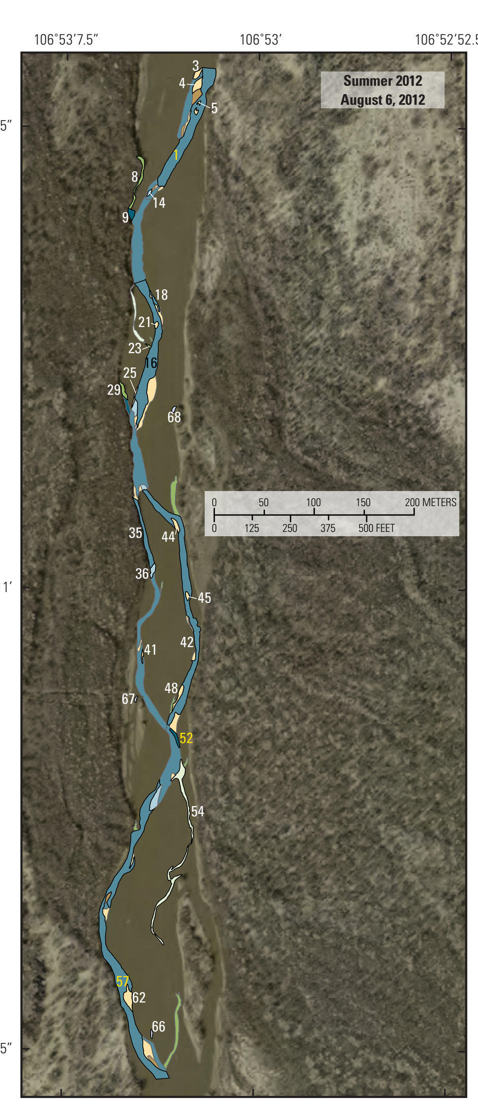


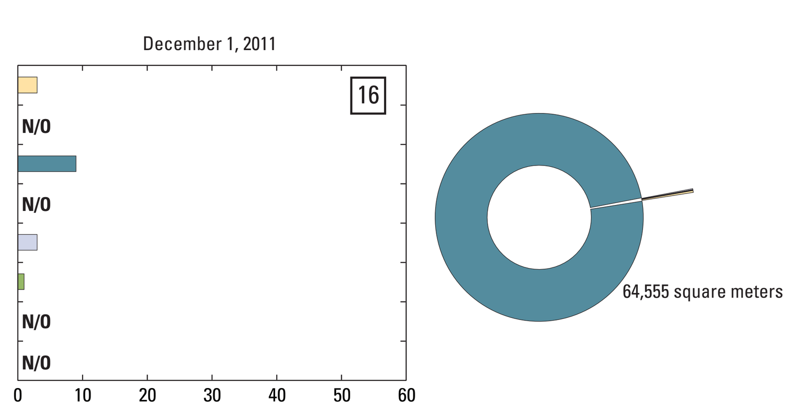
Looking southwest toward point bar with loose livestock in the Rio Salado sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, November 30, 2011.

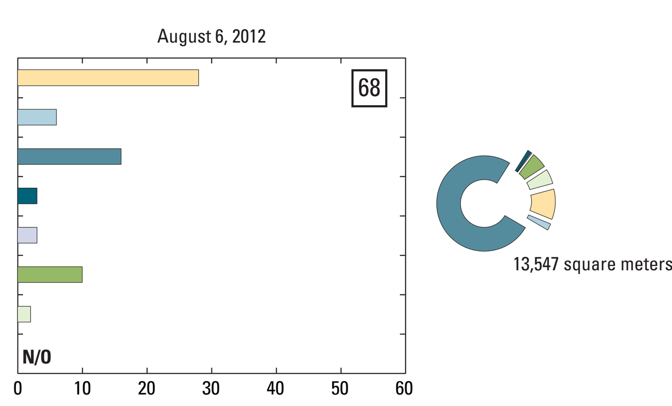
Looking northwest toward the downstream end of the Rio Salado sampling site. Suspended sediment (visible in the run shown in the foreground) is caused by reduced channel velocity associated with local hydraulics caused by San Acacia Diversion Dam. Photograph by Daniel K. Pearson, U.S. Geological Survey, August 7, 2012.

Lemitar Sampling Site





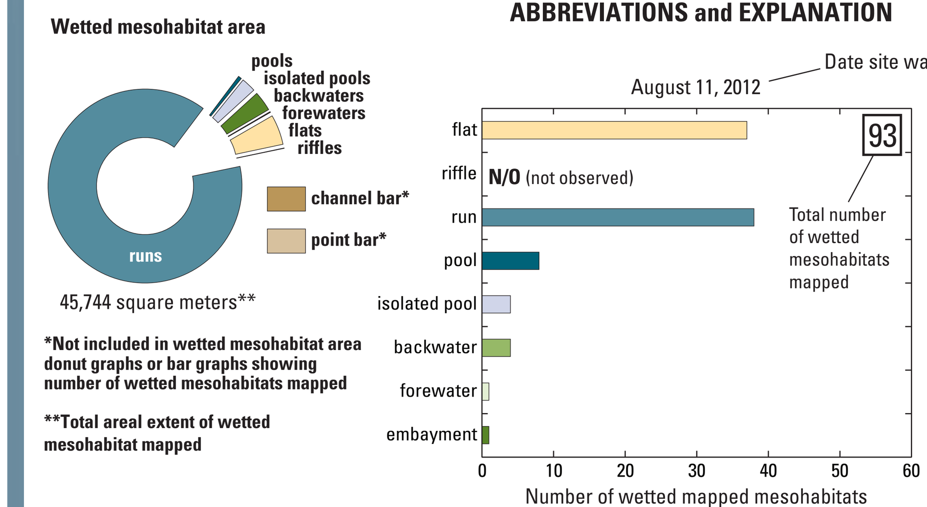




Measuring depths and velocities in a run (mesohabitat ID 10). Photograph by Daniel K. Pearson, U.S. Geological Survey, December 2, 2011.

Facing northward from the Chaparral Loop Bridge approximately 4.6 miles downstream from the Lemitar site. Photograph by Daniel K. Pearson, U.S. Geological Survey, August 6, 2012.

ABBREVIATIONS and EXPLANATION



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San Pedro, SPD
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NOTE: Mesohabitat area donut plots are scaled relative to one another as a function of area.
NOTE: Numbered mesohabitats labeled in yellow correspond to the subset of mesohabitats where Rio Grande silvery minnows were caught.
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A Photo identifier and direction facing when photograph was taken

Base credit in maps for Peña Blanca, Bernalillo, La Orilla, Barelas, Los Padillas, Los Lunas I, and Los Lunas II (sheets 3 and 4)
Base from Middle Rio Grande Conservation District, March–May 2012, 0.5-foot resolution compressed mosaic, New Mexico State Plane Central Zone, North American Datum of 1983

Base credit in maps for Abeytas, La Joya, Rio Salado, Lemitar, Arroyo del Tajo, San Pedro, Bosque del Apache I, and Bosque del Apache II (sheets 5, 6, and 7)
Base from Bureau of Reclamation, February 2012, 1.5-foot resolution compressed mosaic, New Mexico State Plane Central Zone, North American Datum of 1983

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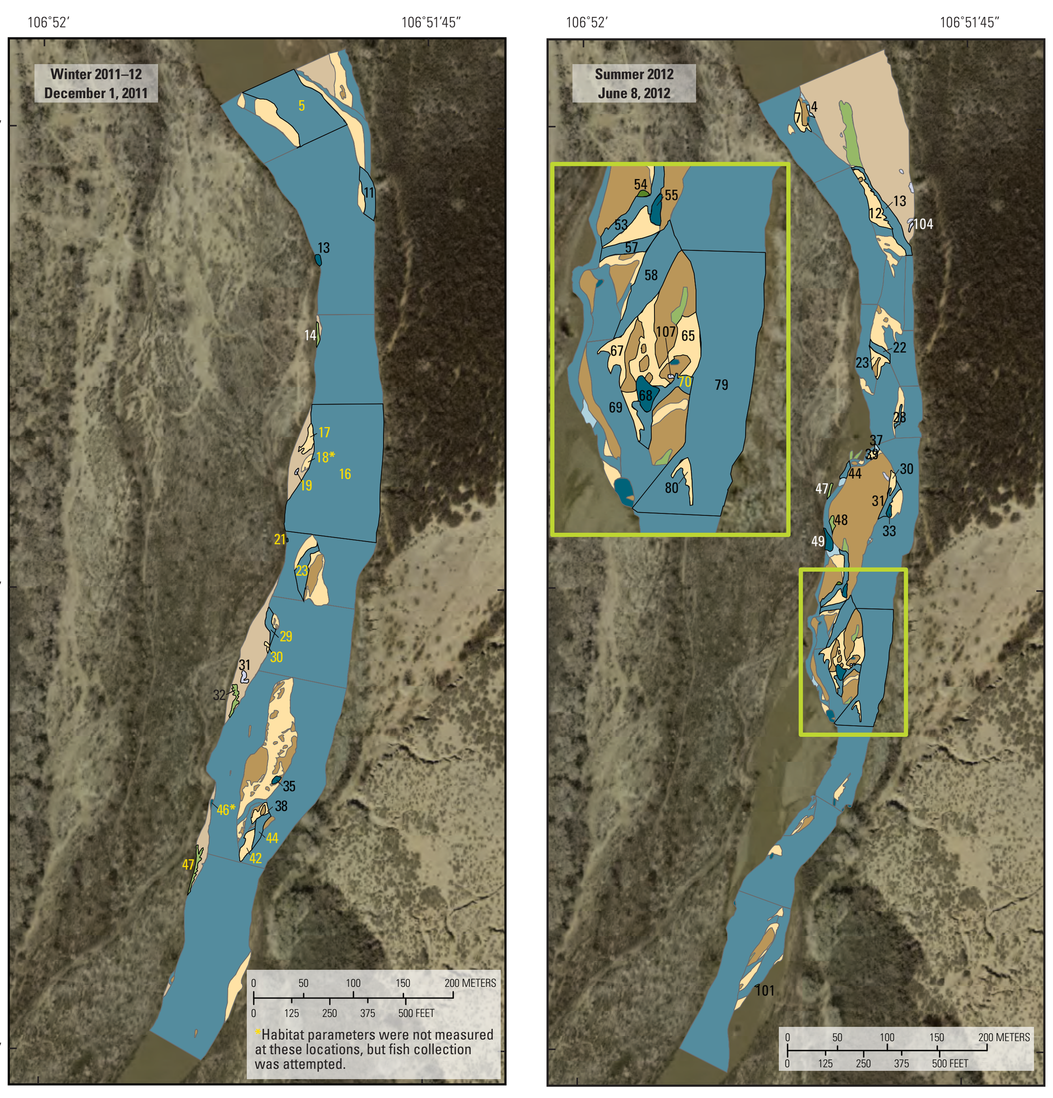
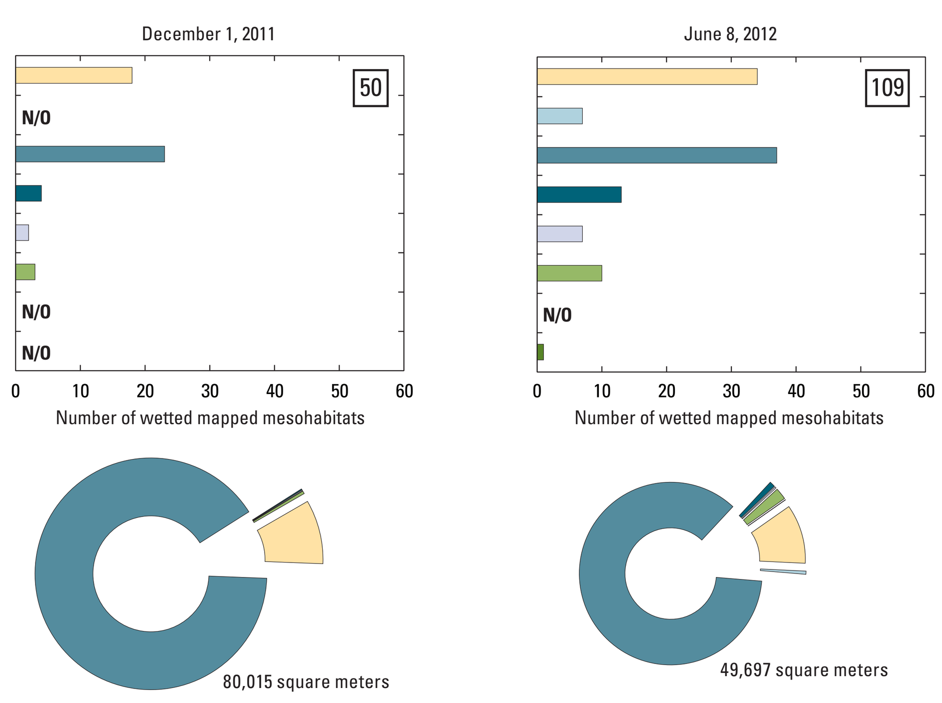
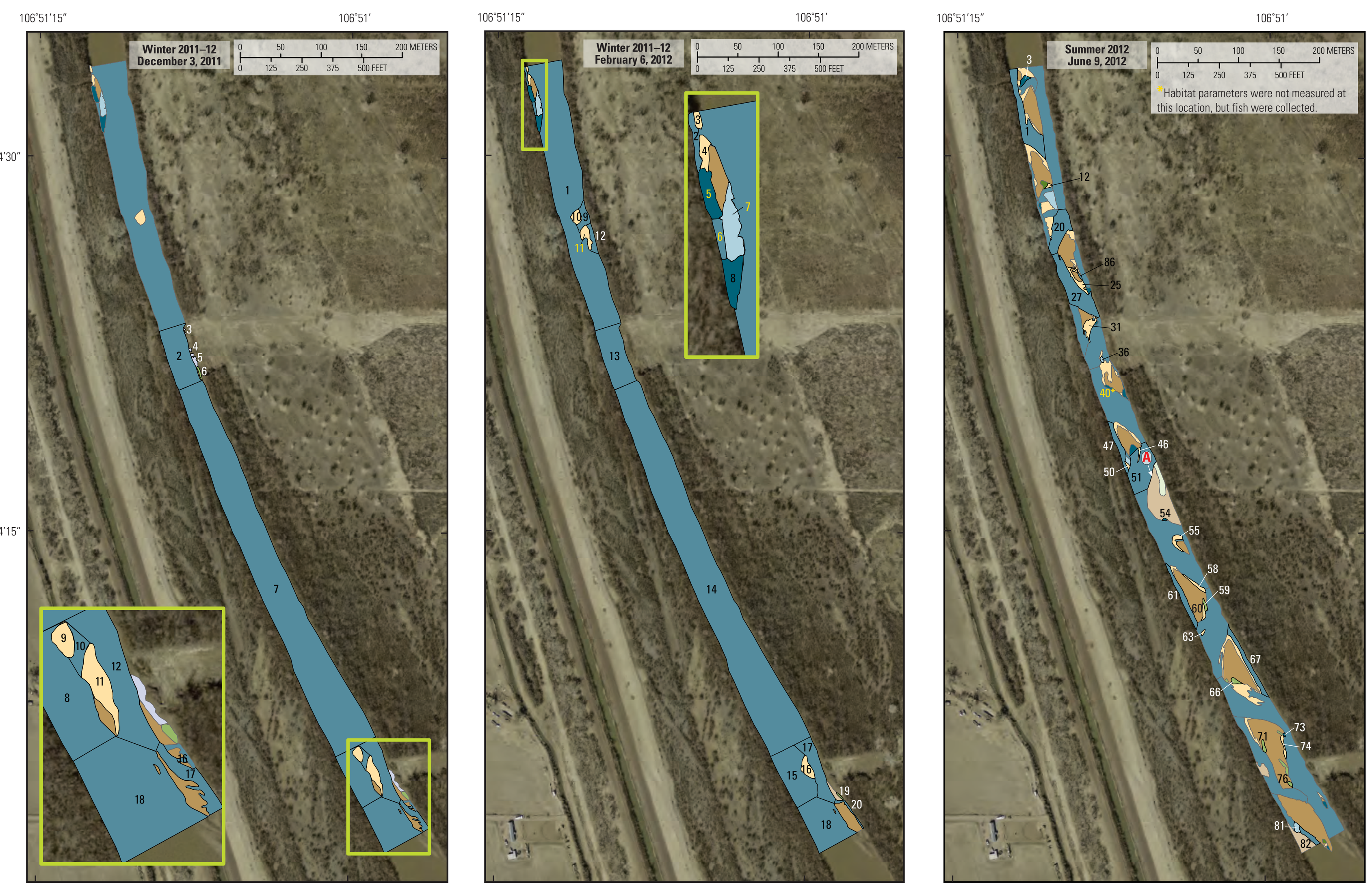
Arroyo del Tajo Sampling Site

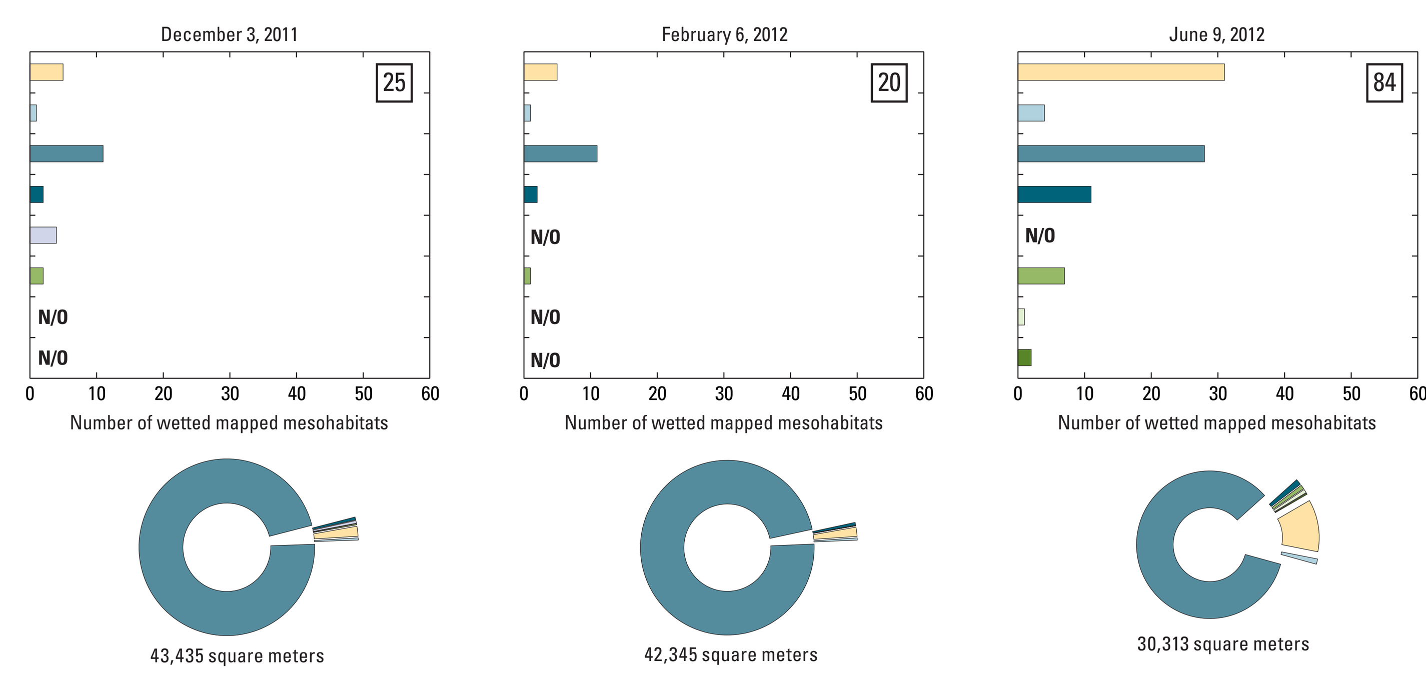




Seining by U.S. Fish and Wildlife personnel at unknown location within the Arroyo del Tajo sampling site. Photograph by U.S. Geological Survey on June 9, 2012.

San Pedro Sampling Site

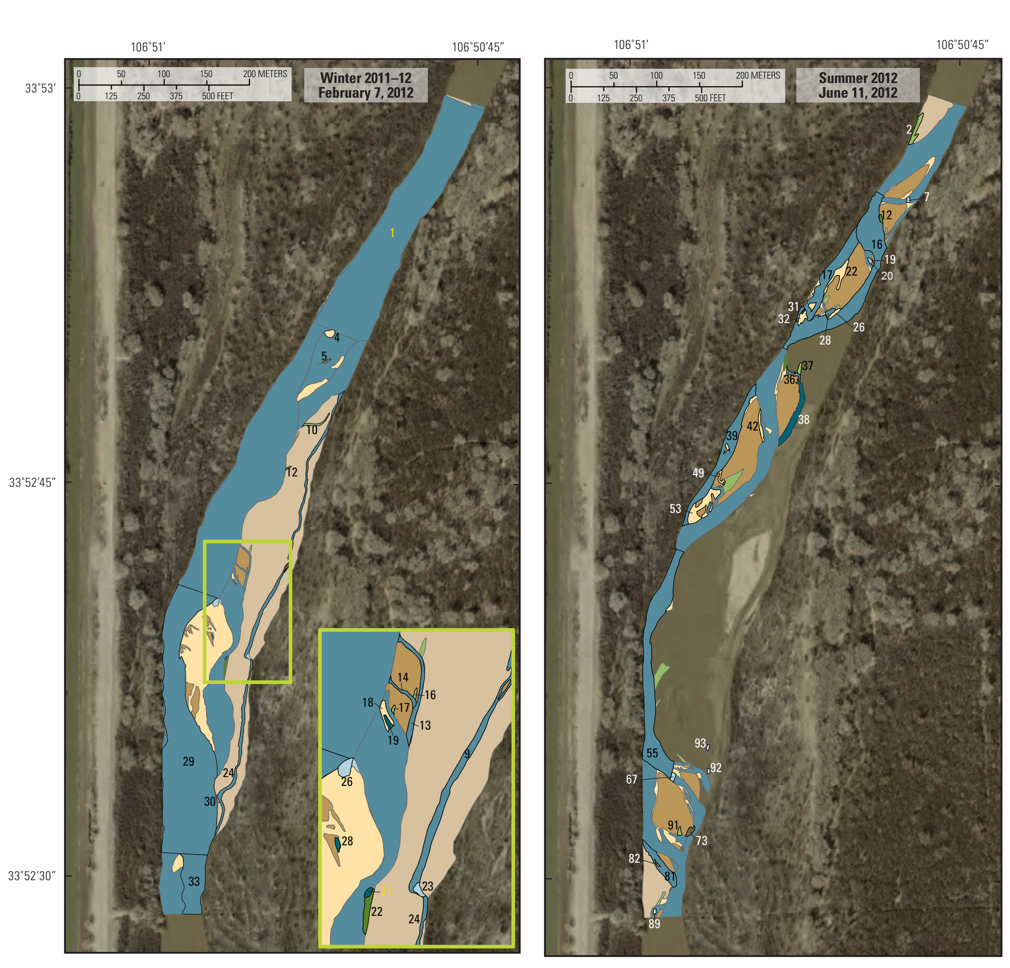




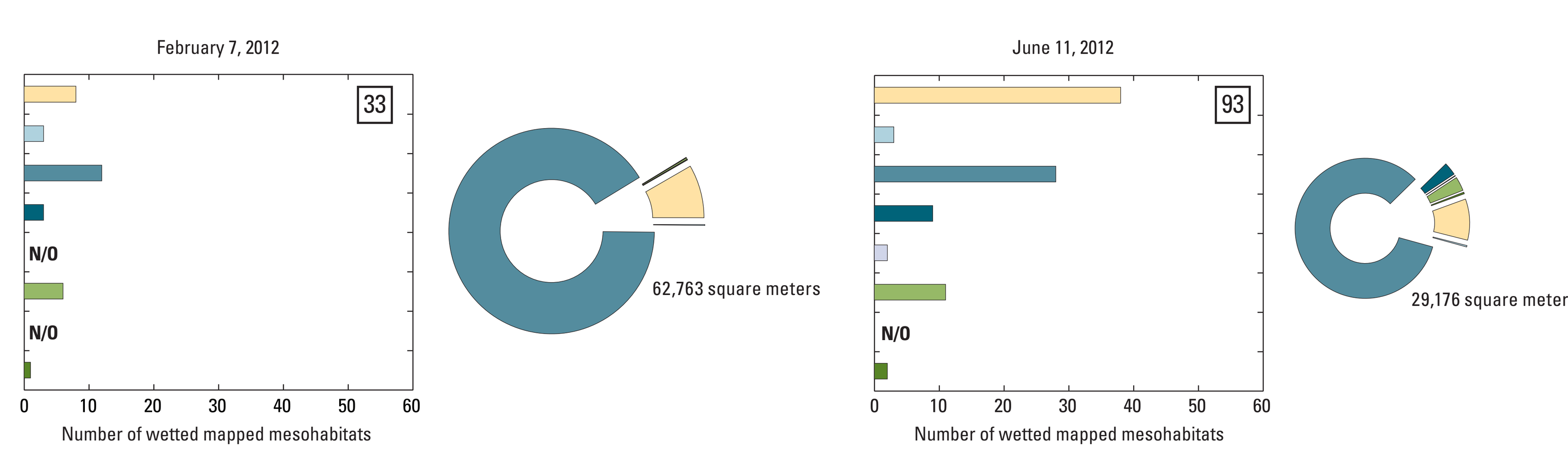
Pumps transferring water from the conveyance channel to the main channel of the Rio Grande near San Pedro; the photograph was taken outside the mapped area shown. Photograph by Daniel K. Pearson, U.S. Geological Survey, June 9, 2012.

Facing downstream at midchannel and approximately mid-reach in the San Pedro sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey, June 9, 2012.

Bosque del Apache I Sampling Site



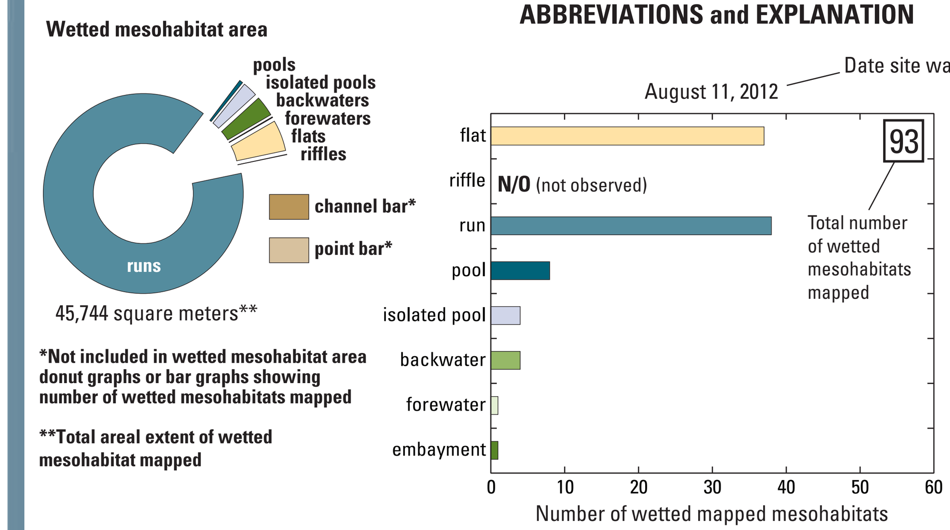
Looking southwest toward the upstream boundary of the Bosque del Apache I sampling site. Photograph taken by Daniel K. Pearson, U.S. Geological Survey, on September 28, 2011, when river bed was nearly dry and diversions for agriculture were still taking place.



Delineation of secondary channel within point bar. Location where photo was taken is not shown on map because the mapping effort at the Bosque del Apache I sampling site on December 7, 2011, could not be completed because snow and ice made determination and delineation of mesohabitat types problematic. Photograph by Daniel K. Pearson, U.S. Geological Survey, December 7, 2011.

Water being transferred from the conveyance channel to the main channel of the Rio Grande approximately 700 feet downstream from the Bosque del Apache I site. Photograph by Daniel K. Pearson, U.S. Geological Survey.

ABBREVIATIONS and EXPLANATION



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A — Photo identifier and direction facing when photograph was taken

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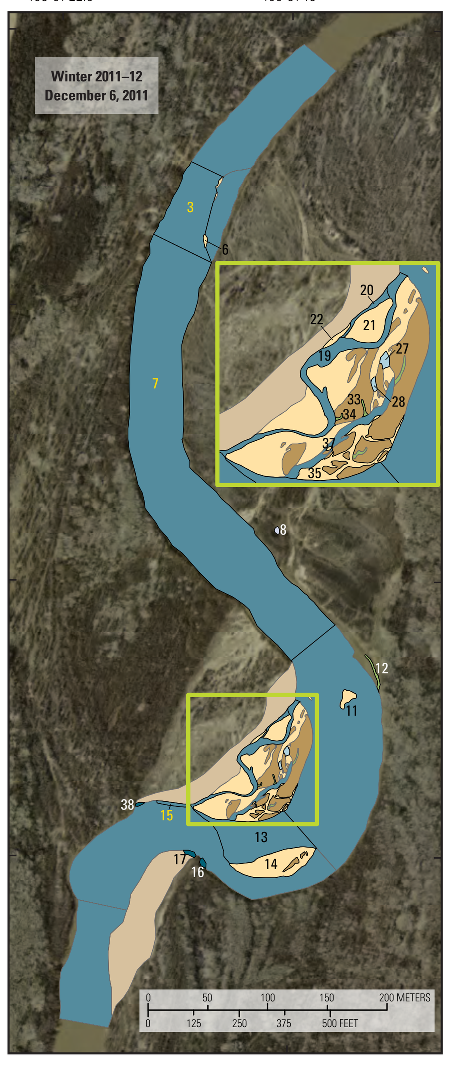
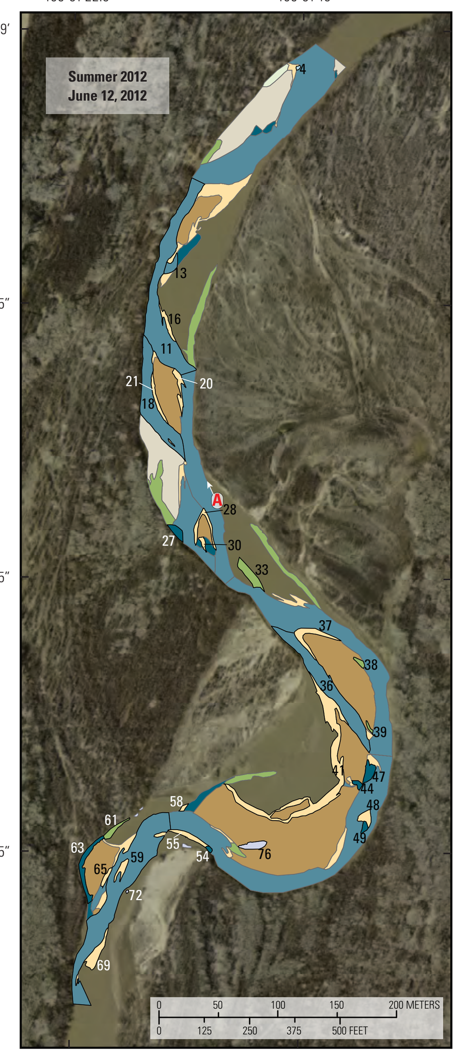
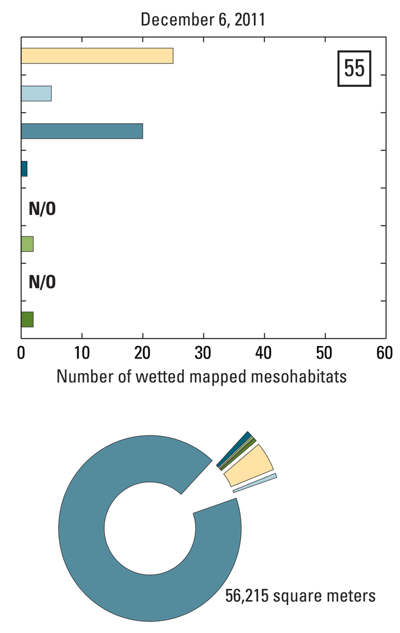
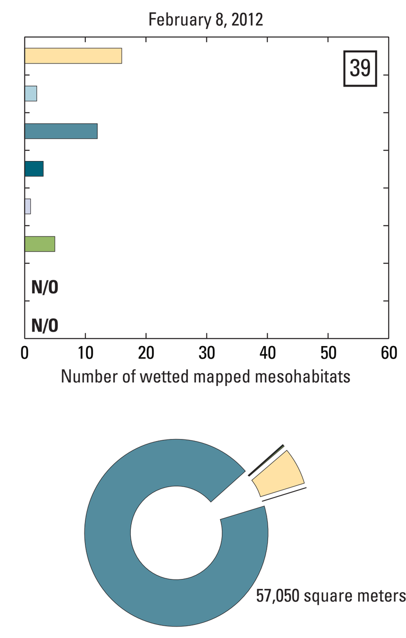
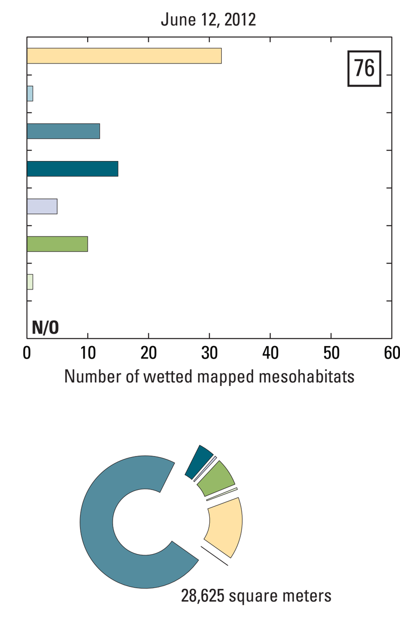
Bosque del Apache II Sampling Site











Delineation of left bank looking upstream in the Bosque del Apache II sampling site. Photograph by Daniel K. Pearson, U.S. Geological Survey.

Selected References

Bovee, K.D., Lamb, B.L., Bartholow, J.M., Stalnaker, C.B., Taylor, Jonathan, and Henriksen, J., 1998, Stream habitat analysis using the instream flow incremental methodology: U.S. Geological Survey Biological Resources Division Information Technology Report USGS/BRD 1998–0004, 131 p.

Bovee, K.D., Waddle, T.J., and Spears, J.M., 2008, Streamflow and endangered species habitat in the lower Isleta reach of the Middle Rio Grande: U.S. Geological Survey Open-File Report 2008–1323, 177 p.

Braun, C.L., Pearson, D.K., Porter, M.D., and Moring, J.B., 2015, Physical characteristics and fish assemblage composition at site and mesohabitat scales over a range of streamflows in the Middle Rio Grande, New Mexico, winter 2011–12, summer 2012: U.S. Geological Survey Scientific Investigations Report 2015–5025, 90 p.

Cook, J.A., Bestgen, K.R., Propst, D.L., and Yates, T.L., 1992, Allozymic divergence and systematics of the Rio Grande silvery minnow, *Hybognathus amarus* (Teleostei—Cyprinidae): Copeia, v. 1992, no. 1, p. 36–44.

Cowley, D.E., Alleman, J.C., McShane, R.R., Shirey, P.D., and Sallenave, Rossana, 2005, Effects of salinity and suspended sediment on physical properties of the egg of the Rio Grande silvery minnow (*Hybognathus amarus*): New Mexico Water Resources Research Institute and the Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, New Mexico, 19 p.

Crawford, C.S., Cully, A.C., Leutheuser, R., Sifuentes, M.S., White, L.H., and Wilber, J.P., 1993, Middle Rio Grande Ecosystem—Bosque biological management plan: Report to the U.S. Fish and Wildlife Service, Albuquerque, N. Mex., 291 p.

Dudley, R.K., and Platania, S.P., 1997, Habitat use of Rio Grande silvery minnow: Report submitted to New Mexico Department of Game and Fish and Bureau of Reclamation, 96 p.

Dudley, R.K., and Platania, S.P., 2007, Flow regulation and fragmentation imperil pelagic-spawning riverine fishes: Ecological Applications, v. 17, no. 7, p. 2074–2086.

Dudley, R.K., Platania, S.P., and White, G.C., 2013, Rio Grande silvery minnow population monitoring program results from December 2011 to October 2012: American Southwest Ichthyological Researchers, LLC, Report to the Middle Rio Grande Endangered Species Act Collaborative Program, 160 p.

Dudley, R.K., White, G.C., Platania, S.P., and Helfrich, D.A., 2012, Rio Grande silvery minnow population estimation program results from October 2011: American Southwest Ichthyological Researchers, LLC, Report to the Middle Rio Grande Endangered Species Collaborative Program, 87 p.

Edwards, R.J., 2005, Feasibility of reintroducing Rio Grande silvery minnows (*Hybognathus amarus*) to the Rio Grande, Big Bend region, Texas: Final report to the U.S. Fish and Wildlife Service, 54 p.

Esri, 2013, GIS mapping software, solutions, services, map apps, and data: Accessed on May 15, 2013, at http://www.esri.com.

Fitzpatrick, F.A., Waite, I.R., D'Arconte, P.J., Meador, M.R., Maupin, M.A., and Gurtz, M.E., 1998, Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Water-Resources Investigations Report 98–4052, 77 p.

Gonzales, E.J., Tave, Douglas, and Haggerty, G.M., 2014, Endangered Rio Grande silvery minnow use constructed floodplain habitat: Ecohydrology, v. 7, p. 1087–1093, accessed January 26, 2015, at http://onlinelibrary.wiley.com/doi/10.1002/eco.1438/abstract.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water Resources Investigations, book 5, chap. C1, 58 p.

Happ, S.C., 1948, Sedimentation in the Middle Rio Grande Valley, New Mexico: Geological Society of America Bulletin, v. 59, no. 12, p. 1191–1216.

Harper, D., and Everard, M., 1998, Why should the habitat-level approach underpin holistic river survey and management: Regulated Rivers, v. 8, p. 395–413.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 510 p., available online at http://pubs.usgs.gov/twri/twri4a3/.

Iman, R.L., and Conover, W.J., 1983, A modern approach to statistics: New York, John Wiley, 496 p.

Lagasse, P.F., 1980, An assessment of the response of the Rio Grande to dam construction—Cochiti to Isleta reach: Technical report prepared for the U.S. Army Engineer District, Albuquerque Corps of Engineers, Albuquerque, New Mexico, 133 p.

Lapointe, N.W.R., Cooke, S.J., Imhof, J.G., Boisclair, D., Casselman, J.M., Curry, R.A., Langer, O.E., McLaughlin, R.L., Minns, C.K., Post, J.R., Power, M., Rassmussen, J.B., Reynolds, J.D., Richardson, J.S., and Tonn, W.M., 2013, Principles for ensuring healthy and productive freshwater ecosystems that support sustainable fisheries: Environmental Reviews, v. 22, p. 1–25.

Leopold, L.B., Wolman, M.G., and Miller, J.P., 1964, Fluvial processes in geomorphology: New York, New York, Dover Publications, 522 p.

Makar, P., and AuBuchon, J., 2012, Channel conditions and dynamics of the Middle Rio Grande: U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Sedimentation and River Hydraulics Group, Denver, Colorado, and Upper Colorado Region, Albuquerque Area Office, Technical Services Division, Albuquerque, N. Mex.

Makar, P.W., and Massong, T.M., 2009, Contemporary physical system: San Acacia—Developing a Vision for a Sustainable Reach Workshop, Middle Rio Grande Endangered Species Collaborative Program.

Medley, C.N., and Shirey, P.D., 2013, Review and interpretation of Rio Grande silvery minnow reproductive ecology using egg biology, life history, hydrology, and geomorphology information: Ecohydrology, v. 6, no. 3, p. 491–505, accessed January 26, 2015, at http://onlinelibrary.wiley.com/doi/10.1002/eco.1373/abstract.

Middle Rio Grande Endangered Species Collaborative Program, 2013, Recovery Implementation Program: Final Draft Action Plan, 71 p.

Moring, J.B., Braun, C.L., and Pearson, D.K., 2014, Mesohabitats, fish assemblage composition, and mesohabitat use of the Rio Grande silvery minnow over a range of seasonal flow regimes in the Rio Grande/Rio Bravo del Norte, in and near Big Bend National Park, Texas, 2010–11: U.S. Geological Survey Scientific Investigations Report 2013–5210, 89 p., http://pubs.usgs.gov/sir/2013/5210/.

Newson, M.D., and Newson, C.L., 2000, Geomorphology, ecology and river channel habitat—Mesoscale approaches to basin-scale challenges: Progress in Physical Geography, v. 24, no. 2, p. 195–217.

Nielsen, L.A., and Johnson, D.L., 1983, Fisheries techniques: Blacksburg, Va., Southern Printing Company, 468 p.

Parasiewicz, P., 2001, MesoHABSIM—A concept for application of instream flow models in river restoration planning: Fisheries, v. 26, no. 9, p. 6–13.

Parasiewicz, P., and Dunbar, M.J., 2001, Physical habitat modeling for fish—A developing approach: Archives for Hydrobiologia Supplement, v. 135, no. 2–4, p. 1–30.

Pardo, Isabel, and Armitage, P.D., 1997, Species assemblages as descriptors of mesohabitats: Hydrobiologia, v. 344, p. 111–128, accessed May 6, 2013, at http://link.springer.com/article/10.1023%2FA%3A1002958412237.

Pease, A.A., Davis, J.J., Edwards, M.S., and Turner, T.F., 2006, Habitat and resource use by larval and juvenile fishes in an arid-land river (Rio Grande, New Mexico): Freshwater Biology, v. 51, p. 475–486.

Platania, S.P., 1993, The fishes of the Rio Grande between Velarde and Elephant Butte Reservoir and their habitat associations: Report to the New Mexico Department of Game and Fish, Santa Fe, and U.S. Bureau of Reclamation (Albuquerque Projects Office), Albuquerque, N. Mex., 188 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow—Volumes 1 and 2: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

Remshardt, W.J., and Tashjian, P.L., 2003, Habitat preference of the Rio Grande silvery minnow in relation to fluvial geomorphology and streamflow regime, Middle Rio Grande Valley, New Mexico: U.S. Fish and Wildlife Service Interim Report for Funding Year 2003, 76 p.

Richard, G.A., 2001, Quantification and prediction of lateral channel adjustments downstream from Cochiti Dam, Rio Grande, NM: Ph.D. Dissertation, Colorado State University, Fort Collins, Colo., 276 p., accessed January 30, 2015, at http://www.engr.colostate.edu/~pierre/ce_old/resume/Theses%20and%20Dissertations/Gigi%20Richards%20Dissertation.pdf.

Schmidt, J.C., Everitt, B.L., and Richard, G.A., 2003, Hydrology and geomorphology of the Rio Grande and implications for river rehabilitation, *in* Garrett, G.P., and Allan, A.L., eds., Aquatic fauna of the northern Chihuahuan Desert—Contributed papers from a special session within the Thirty-Third Annual Symposium of the Desert Fishes Council: Lubbock, Tex., Museum of Texas Tech University, Special Publications no. 46, p. 22–45.

Scurlock, D., 1998, From the Rio to the Sierra—An environmental history of the Middle Rio Grande Basin: U.S. Department of Agriculture General Technical Report RMRS–GTR–5, 454 p.

SonTek, 2013, FlowTracker handheld acoustic Doppler velocimeter: Accessed February 6, 2013, at http://www.sontek.com/flowtracker/.

Sublette, J.E., Hatch, M.D., and Sublette, M., 1990, The fishes of New Mexico: Albuquerque, New Mexico, University of New Mexico Press, 393 p.

Tetra Tech, Inc., 2014, Ecohydrological relationships along the Middle Rio Grande of New Mexico for the endangered Rio Grande silvery minnow: Final Report submitted to the U.S. Army Corps of Engineers, Albuquerque District, Albuquerque, New Mexico, 109 p. (Available online from the Middle Rio Grande Collaborative Program at http://mrgescp.dbstephens.com/Documents.aspx).

Trimble, 2015a, DSM 232 Support—Documentation: Accessed January 28, 2015, at http://www.trimble.com/support_trl.aspx?Nav=Collection-4061&pt=DSM%20232.

Trimble, 2015b, Trimble positioning services—OmniSTAR differential GNSS services: Accessed January 28, 2015, at http://www.trimble.com/positioning-services/omnistar.aspx.

Turnipseed, D.P., and Sauer, V.B., 2010, Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods, book 3, chap. A8, 87 p. [Also available at http://pubs.usgs.gov/tm/tm3-a8/.]

U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and New Mexico Interstate Stream Commission, 2007, Upper Rio Grande water operations review—Final environmental impact statement, April 2007, appendices K (Aquatic Habitat Model) and L (Biological Resources): Accessed on November 20, 2014, at http://www.spa.usace.army.mil/Missions/CivilWorks/URGWOM/URGWOPS.aspx.

U.S. Bureau of Reclamation, 2012, Middle Rio Grande River maintenance program comprehensive plan and guide: Accessed October 15, 2014, at http://www.usbr.gov/uc/albuq/envdocs/reports/mrgRivMaint/CompPlan/Plan_Guide.pdf.

U.S. Fish and Wildlife Service, 1994, Endangered and threatened wildlife and plants—Final rule to list the Rio Grande silvery minnow as an endangered species: Federal Register v. 59, p. 36988–37001.

U.S. Fish and Wildlife Service, 2010, Rio Grande silvery minnow (*Hybognathus amarus*) recovery plan, first revision: Albuquerque, N. Mex., 210 p., accessed May 18, 2013, at http://ecos.fws.gov/docs/recovery_plan/022210_v2.pdf.

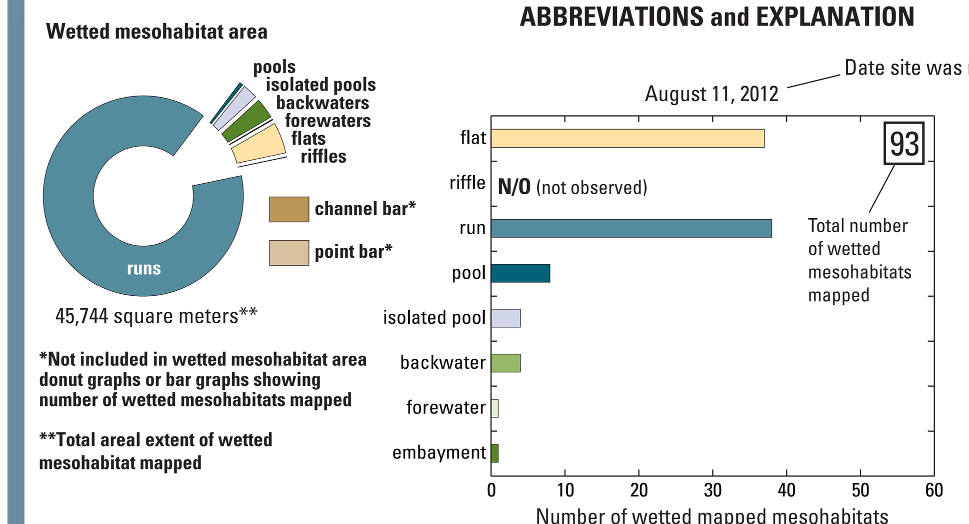
U.S. Fish and Wildlife Service, 2014, Middle Rio Grande Bosque Initiative: Accessed October 21, 2004, at https://web.archive.org/web/20070220040054/http://www.fws.gov/southwest/mrgbi/.

U.S. Geological Survey, 2014, National Water Information System: Accessed September 22, 2014, at http://waterdata.usgs.gov/tx/nwis/.

Vogt, B, 2003, The arroyo problem in the southwestern United States: Accessed February 19, 2014, at http://geochange.er.usgs.gov/sw/impacts/geology/arroyos/.

Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: The Journal of Geology, v. 30, no. 5, p. 377–392.

ABBREVIATIONS and EXPLANATION



*Not included in wetted mesohabitat area donut graphs or bar graphs showing number of wetted mesohabitats mapped

**Total areal extent of wetted mesohabitat mapped

U.S. Geological Survey sampling sites short names and map identifier

- Peña Blanca, PNB
- Bernalillo, BRN
- La Orilla, LOR
- Barelas, BAR
- Los Padillas,PAD
- Los Lunas I, LL1
- Los Lunas II, LL2
- Abeytas, ABY
- La Joya, LJY
- Rio Salado, RSL
- Lemitar, LEM
- Arroyo delTajo, ATJ
- San Pedro, SPD
- Bosque del Apache I, BA1
- Bosque del Apache II, BA2

NOTE: Mesohabitat area donut plots are scaled relative to one another as a function of area.
NOTE: Numbered mesohabitats labeled in yellow correspond to the subset of mesohabitats where Rio Grande silvery minnows were caught.
NOTE: Numbered mesohabitats that are outlined in black on maps correspond to the subset of mesohabitats where physical habitat measurements (and water-quality properties were measured in summer 2012) and fish collection was attempted.

A — Photo identifier and direction facing when photograph was taken

Base credit in maps for Peña Blanca, Bernalillo, La Orilla, Barelas, Los Padillas, Los Lunas I, and Los Lunas II (sheets 3 and 4)
Base from Middle Rio Grande Conservation District,
March–May 2012, 0.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

Base credit in maps for Abeytas, La Joya, Rio Salado, Lemitar, Arroyo del Tajo, San Pedro, Bosque del Apache I, and Bosque del Apache II (sheets 5, 6, and 7)
Base from Bureau of Reclamation,
February 2012, 1.5-foot resolution compressed mosaic,
New Mexico State Plane Central Zone,
North American Datum of 1983

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By
Daniel K. Pearson, Christopher L. Braun, and J. Bruce Moring

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