Middle Rio Grande Endangered Species Collaborative Program

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Key words: economics, river restoration, valuation

Abstract: This paper provides an analysis of existing non-market valuations of river restoration primarily in the United States and Europe. The goals of the river restoration in terms of ecosystem services are identified, as are the valuation methods used. More than two-thirds of the 38 river restorations reviewed sought to restore and protect fish populations, including in many cases threatened or endangered species. River restorations were also frequently undertaken to improve wildlife habitat, and water quality for boating. In terms of the use of non-market valuations in decision making, six of 38 restorations reviewed involved benefit-cost analyses or environmental assessments or equivalent decision documents. While both revealed preference and stated preference methods were used for valuing river restorations, the majority of restoration valuations (27 out of 38, about 70%) utilized stated preference methods such as the contingent valuation method (CVM) and choice experiments (CE). Annual willingness-to-pay per household estimated from the stated preference methods appear logically and positively related to the miles of river restored demonstrating weak scope.

DOI: 10.1016/j.wre.2016.12.001

Broadbent, C. D., D. S. Brookshire, D. Coursey, and V. Tidwell. 2017. Futures Contracts in Water Leasing: An Experimental Analysis Using Basin Characteristics of the Rio Grande, NM. Environmental and Resource Economics 68:569–594.

Key words: water leasing, futures contracts, experimental economics

Abstract: Providing for increased water demands during periods of persistent drought and climatic variability may require water managers, users and planners to think differently about how water resources are allocated. A water marketing institution that allows water rights holders to reallocate water on a temporary basis could overcome these challenges with minimal conflict. In this paper, a water marketing institution that allows for the temporary reallocation of water rights in a spot and futures market is investigated. The results provide insight into three key questions: (1) how does trading impact the physical system, (2) does the value of water differ by trading agents, (3) how is economic welfare redistributed as a result of trading? Results of experimental treatments display minor impacts to the physical system, that prices differ across the different type of trading agents and the addition of a futures market has the ability to decrease market prices while increasing economic welfare as a futures market allows users to hedge against future water uncertainty.

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Cox, C., L. Jin, G. Ganjegunte, D. Borrok, V. Lougheed, and L. Ma. 2018. Soil quality changes due to flood irrigation in agricultural fields along the Rio Grande in western Texas. Applied Geochemistry 90:87-100.

Key words: salt buildup, pedogenic carbonate, salinity, sodicity

Abstract: Growing populations demand more food, putting more pressure on soil productivity and sustainability around the world. In western Texas along the Rio Grande Valley, the low natural rainfall requires frequent irrigations for sustaining agriculture. To investigate the impacts of irrigation on soil quality, we collected and modelled geochemical data (major elements and nutrients) on irrigation water, soil pore water, drainage water, and soil samples, and monitored soil moisture, temperature, and electrical conductivity with sensors from two pecan, one cotton, and one alfalfa fields in western Texas.

This study showed that flood irrigation with both surface (Rio Grande river) and ground waters significantly increased the root-zone salinity, soil sodicity, and nutrient leaching from soils to the underlying aquifers and Rio Grande river from agricultural fields of the arid southwest. The water used for irrigation was high in total dissolved solids (>500 ppm generally), dominated by Na+, Cl-, Ca2+ and SO42-. After flood irrigation, infiltrating water dissolved salts such as gypsum that have accumulated in the soils due to previous irrigations, or/and mixed existing concentrated soil waters, and approached saturation with respect to these evaporite minerals. Soil water was supersaturated with respect to carbonates as pedogenic calcite precipitated out and reached concentrations of ~ 10 wt% of total soil mass. This suggested that pedogenic carbonate is an important carbon reservoir and precipitation kinetics and controls of such secondary calcite need further investigation for the irrigated agricultural fields in arid regions of the world.

Chemistry of agricultural return flow samples collected from drainage ditches was similar to that of irrigation water, suggesting that most of the irrigation water had taken a shallow and short flowpath through the fields to drains. Between irrigation events, soil water became more concentrated as water was lost through evapotranspiration that led to precipitation of evaporite salts. As a result, sodicity and salinity of soils, especially clayey soils, frequently exceeded the tolerance levels of major crops grown in the region. Here in these fine-textured soils, combination of high evapotranspiration rates, intensive irrigation with water of elevated salinity, and limited infiltration stunted crop growth, decreased soil porosity and permeability, led to poor aeration, and accelerated salt buildup via a positive feedback mechanism.

During initial irrigation where soils were saturated, soil water also percolated and recharged to underlying aquifers, and thus salts, nutrients, and trace metals from agricultural practices (i.e., application of fertilizers, irrigation, soil amendments, and pesticide) could be mobilized to shallow groundwaters. This implied that chemistry of Rio Grande River, groundwater, and soil was closely linked. Thus the sustainability of agriculture depended on appropriate water, soil and crop management practices.

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Dubinsky, J., and A. T. Karunanithi. 2017. Consumptive Water Use Analysis of Upper Rio Grande Basin in Southern Colorado. Environmental Science & Technology 51:4452–4460.

Key words: water use, consumptive water use

Abstract: Water resource management and governance at the river basin scale is critical for the sustainable development of rural agrarian regions in the West. This research applies a consumptive water use analysis, inspired by the Water Footprint methodology, to the Upper Rio Grande Basin (RGB) in south central Colorado. The region is characterized by water stress, high dessert conditions, declining land health, and a depleting water table. We utilize region specific data and models to analyze the consumptive water use of RGB. The study reveals that, on an average, RGB experiences three months of water shortage per year due to the unsustainable extraction of groundwater. Our results show that agriculture accounts for 77% of overall water consumption and it relies heavily on an aquifer (about 50% of agricultural consumption) that is being depleted over time. We find that, even though potato cultivation provides the most efficient conversion of groundwater resources into economic value (m3 GW/ $) in this region, it relies predominantly (81%) on the aquifer for its water supply. However, cattle, another important agricultural commodity produced in the region, provides good economic value but relies significantly less on the aquifer (30%) for water needs.

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Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring Results from December 2016. Prepared by American Southwest Ichyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, population monitoring

Summary: The December population monitoring efforts were conducted at 20 sites throughout the Middle Rio Grande. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and nine sites in the San Acacia Reach. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine in all seasons except winter. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. May–June). Figures illustrating fish densities (i.e., fish per 100 m^2) were prepared for the ten focal species to facilitate comparisons across reaches.

During December, sampling covered 11,928.5 m^2 (surface area) of water and yielded 2,042 fish. Cumulative fish density during December was 17.1 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (n = 1,061), Red Shiner (n = 648), and Flathead Chub (n = 124). The 20 sampling sites yielded a total of 11 fish species. Rio Grande Silvery Minnow was present in 170 of the 220 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 19 of the 20 sampling sites, and its overall density was 8.89 (n = 1,061) individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 8.71 (n = 1,039) and 0.18 (n = 22) individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 8.50 (n = 1,014), 0.29 (n = 35), and 0.10 (n = 12) individuals/100 m^2 sampled, respectively.

Rio Grande Silvery Minnow that were stocked during autumn 2015 (ca. 200,000; Thomas P. Archdeacon, New Mexico Fish and Wildlife Conservation Office, pers. comm.) resulted in modest densities of this species during the winter of 2015/2016. However, the overwinter mortality of Rio Grande Silvery Minnow resulted in substantial losses of individuals from December 2015 to May 2016. The abundance of this species increased substantially in June and July, following elevated flows and spawning during spring. Densities of age-0 Rio Grande Silvery Minnow were much higher in December 2016 than in other December collections taken during recent years. Ensuring elevated and extended spring flows will be crucial for the successful survival of Rio Grande Silvery Minnow during 2017.

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Key words: silvery minnow, population monitoring

Summary: The population status of Rio Grande Silvery Minnow and the associated Middle Rio Grande ichthyofaunal community has been systematically monitored since 1993. This effort is unique among ichthyofaunal research studies in the Middle Rio Grande in that it has been providing consistent sampling of fishes over a long duration. Long-term sampling studies also provide the data necessary to test specific ecological hypotheses. Thus, our primary research objective was to evaluate how seasonal and annual changes in river flows affect the distribution and abundance of Rio Grande Silvery Minnow throughout its current range.

The occurrence and density of this imperiled species has fluctuated widely over the past two decades (1993–2016). Its estimated density (E(x); fish per 100 m^2), using October data, was highest in 2005 (44.84) but remained very low (< 0.20) from 2012 to 2015. While estimated densities were notably lower from 2010 to 2015 as compared with 2007 to 2009, there was a marked improvement in 2016. Population monitoring efforts in 2016 revealed a marked increase in density (E(x) = 7.20), which was over 10 times higher than in 2015 and over 100 times higher than in 2013. While Rio Grande Silvery Minnow represented only 0.91% of the total fish community in 2015, it had increased to 20.87% by 2016.

Ecological models revealed that changes in the density and occurrence of Rio Grande Silvery Minnow were reliably predicted by seasonal differences in river flows across years. Further, our findings were consistent regardless of whether dry sampling sites were or were not included in the analyses (see Introduction). Out of 441 models considered, we found that extended high flows during spring were crucial (i.e., > 90% of model weight) in explaining why some years had dramatically elevated densities of Rio Grande Silvery Minnow. In contrast, we found that extended low flows during summer were key to explaining changes in the occurrence of this species across years. Thus, prolonged high flows during spring were most predictive of increased density and prolonged low flows during summer were most predictive of decreased occurrence of Rio Grande Silvery Minnow over the study period.

Additional analyses revealed that population trends in different mesohabitats (October [2002–2016]), or on different days during repeated sampling (November [2005–2016]), were remarkably similar to population trends obtained from the long-term dataset (October [1993–2016]). These results suggest that the current sampling protocols are resulting in a reliable level of sampling precision and population trend consistency, especially when considering the substantial changes in both the occurrence and abundance of Rio Grande Silvery Minnow over time. Also, the variance in estimated densities was consistently highest across years (77.01), followed distantly by sampling site (2.56), river reach (0.76), and sampling day (0.00). Thus, changes in the density and occurrence of Rio Grande Silvery Minnow were much more strongly related to seasonal flow conditions across years than to subtleties in local sampling conditions (e.g., mesohabitats, sites, reaches, or sampling days).

Site occupancy models lend further support to these findings. We found that Rio Grande Silvery Minnow occupancy probabilities declined progressively from 2010 to 2013 before increasing markedly from 2014 to 2016. While estimated extinction probabilities were highly elevated during recent drought years (i.e., 2012–2013), they have decreased substantially since

2014 as seasonal river flows have progressively improved. Likewise, estimated colonization probabilities for this species increased considerably in recent years (2014–2016). While the balance of estimated extinction and colonization probabilities from 2015–2016 was still not as favorable as it was during the earliest years of the site occupancy study (2005–2009), the conservation status of Rio Grande Silvery Minnow showed encouraging signs of improvement from 2014 to 2016.

Pronounced changes in the occurrence and abundance of Rio Grande Silvery Minnow over the past two decades appear to be closely related to the duration, magnitude, and timing of river flows during spring and summer. Prolonged and elevated spring flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline pools and backwaters; these habitats are characterized by low-velocity, warm, and productive waters. The early life history of this species ensures that its propagules (drifting eggs and larvae) are rapidly dispersed throughout these habitats when spring flows begin to rise. These conditions, combined with the delayed onset of low flows following spring runoff, help ensure the persistence of these nursery habitats that are required for successful growth, survival, and recruitment of newly spawned Rio Grande Silvery Minnow. As growth from the egg through the vulnerable early larval stages (i.e., protolarvae and mesolarvae) requires about one month, the longer-term persistence of these habitats is essential to help ensure the successful recruitment of young to later life stages (i.e., metalarvae and juveniles).

Further, the occurrence and density of this species is consistently highest in the downstream-most reaches of the Middle Rio Grande. This pattern has persisted over time even though upstream reaches have been regularly augmented with large numbers of hatchery-reared fish. One explanation for this pattern is the cumulative downstream transport of propagules (drifting eggs and larvae) past instream barriers over time. Also, river channelization, habitat degradation, abandonment of the floodplain, and reductions in suspended sediments downstream of Cochiti Dam are likely limiting the amount of appropriate habitat available for the successful retention and recruitment of early life stages, especially in the Cochiti and Angostura reaches. While it is evident that seasonally elevated flows, combined with habitat restoration, should lead to increased recruitment success, the long-term efficacy of these efforts will also depend on assuring their utility and permanence by restoring a more dynamic flow regime and reestablishing river connectivity across select fragmented reaches.

While extensive management efforts over the past two decades have provided invaluable protection against the extinction of Rio Grande Silvery Minnow in the wild, continued and ongoing efforts (e.g., restoring dynamic river flows, reconnecting fragmented reaches, and reestablishing a functional floodplain) should help to promote resilient and self-sustaining populations over time. Encouragingly, both the occurrence and abundance of this imperiled species increased markedly in 2015 and 2016, as compared with recent drought years (2012–2014), following notably improved spring and summer flow conditions. Continued efforts to provide reasonable spring spawning and summer survival conditions, even if at threshold levels during consecutive drought years, will be essential for securing a self- sustaining population in the Middle Rio Grande. Additionally, the reestablishment of resilient populations of this species at other locations within its historical range would help to further ensure its long-term persistence in the wild. Future study of the relationships among fish species and seasonal river flows in the Rio Grande Basin should continue to elucidate key factors that control this complex aquatic ecosystem, which will be essential for developing and implementing successful management strategies for the long-term recovery of Rio Grande Silvery Minnow.

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Key words: silvery minnow, population monitoring

Abstract: The April population monitoring efforts were conducted at 20 sites throughout the Middle Rio Grande. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and nine sites in the San Acacia Reach. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine in all seasons except winter. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m^2) were prepared for the ten focal species to facilitate comparisons across reaches.

During April, sampling covered 9,348.7 m^2 (surface area) of water and yielded 500 fish. Cumulative fish density during April was 5.3 individuals/100 m^2 sampled. The three most common species were Red Shiner (n = 159), Rio Grande Silvery Minnow (n = 111), and Channel Catfish (n = 86). The 20 sampling sites yielded a total of 11 fish species. Rio Grande Silvery Minnow was present in 49 of the 155 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 10 of the 20 sampling sites, and its overall density was 1.19 (n = 111) individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 1.18 (n = 110) and 0.01 (n = 1) individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.00 (n = 0), 1.11 (n = 104), and 0.07 (n = 7) individuals/100 m^2 sampled, respectively.

Rio Grande Silvery Minnow that were stocked during autumn 2016 (ca. 66,000; Thomas P. Archdeacon, New Mexico Fish and Wildlife Conservation Office, pers. comm.) were present at low densities during the spring of 2017. The overwinter mortality of Rio Grande Silvery Minnow resulted in substantial losses of individuals (both unmarked and marked) from December 2016 to April 2017. However, the abundance of Rio Grande Silvery Minnow in April 2017 was higher than it was in April 2016. Ensuring elevated and extended spring flows will be crucial for the successful survival of Rio Grande Silvery Minnow during 2017.

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Key words: silvery minnow, population monitoring

Summary: The May population monitoring efforts were conducted at the 20 standard sites and at 10 additional sites, located in each of the three sampling reaches. The Middle Rio Grande Endangered Species Collaborative Program requested that the additional sampling be conducted once in the spring and fall of each year. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine in all seasons except winter. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age- 2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. May–June).

Standard Sites (n = 20) During May, sampling covered 8,737.1 m^2 (surface area) of water and yielded 892 fish. Cumulative fish density during May was 10.2 individuals/100 m^2 sampled. The three most common species were Red Shiner (406), Flathead Chub (154), and Common Carp (74). The 20 sampling sites yielded a total of 16 fish species. Rio Grande Silvery Minnow was present in 27 of the 172 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 12 of the 20 sampling sites, and its overall density was 0.77 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 0.76 and 0.01 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.00, 0.76, and 0.01 individuals/100 m^2 sampled, respectively.

All Sites (n = 30) During May, sampling covered 13,412.2 m^2 (surface area) of water and yielded 1,331 fish. Cumulative fish density during May was 9.9 individuals/100 m^2 sampled. The three most common species were Red Shiner (602), Flathead Chub (215), and Common Carp (149). The 30 sampling sites yielded a total of 17 fish species. Rio Grande Silvery Minnow was present in 58 of the 259 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 21 of the 30 sampling sites, and its overall density was 0.89 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 0.88 and 0.01 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.00, 0.88, and 0.01 individuals/100 m^2 sampled, respectively.

Comparison of Standard Sites to All Sites Population monitoring during May included sampling efforts taken at the 20 standard sampling sites and the 10 additional sites. There were five sites added to the Angostura Reach, four sites to the Isleta Reach, and one site to the San Acacia Reach. This raised the total sampling effort to 10 sites per sampling reach. Comparisons of Rio Grande Silvery Minnow densities (i.e., overall and reach-specific) include estimates based on the 20 standard sites and based on all 30 sites. There was a 53.5% increase in the sampling effort and a 49.2% increase in the number of fish based on the addition of the 10 new sampling sites. The overall density of fish (individuals/100 m^2) was 10.2 for the standard sites and 9.9 for all sites. The overall density of Rio Grande Silvery Minnow was 0.77 for the standard sites and 0.89 for all sites.

Reach-specific comparisons also revealed similarities between the sampling data collected from the 20 standard sites and from all 30 sites. Based on the standard sites, the density of Rio Grande Silvery Minnow was 2.02 in the Angostura Reach, 0.19 in the Isleta Reach, and

0.48 in the San Acacia Reach. Based on all sites, the density of Rio Grande Silvery Minnow was 1.50 in the Angostura Reach, 0.34 in the Isleta Reach, and 0.83 in the San Acacia Reach. The inclusion of the new sites has helped supplement the overall dataset, particularly in the Angostura and Isleta reaches.

Recent Population Trends Rio Grande Silvery Minnow that were stocked during autumn 2016 were present at low densities during the spring of 2017. The overwinter mortality of Rio Grande Silvery Minnow resulted in substantial losses of individuals from December 2016 to May 2017. However, the abundance of Rio Grande Silvery Minnow in May 2017 was higher than it was in May 2016. Higher river flows have recently resulted in substantial inundation of floodplain and former side channel habitats. Ensuring elevated and extended spring flows will be crucial for the successful survival of Rio Grande Silvery Minnow during 2017.

DOI: Report

Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring Results from August 2017. Prepared by American Southwest Ichyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, population monitoring

Summary: The August population monitoring efforts were conducted at 20 sites throughout the Middle Rio Grande. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and nine sites in the San Acacia Reach. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June).

During August, sampling covered 10,381.6 m^2 (surface area) of water and yielded 9,353 fish. There were no dry sampling sites. Cumulative fish density, at all sites combined, was 90.09 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (4,339), Red Shiner (1,651), and Western Mosquitofish (1,298). The 20 sampling sites yielded a total of 18 fish species. Rio Grande Silvery Minnow was present in 192 of the 313 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 20 of the 20 sampling sites, and its overall density was 41.79 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 41.79 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 41.27, 0.50, and 0.02 individuals/100 m^2 sampled, respectively.

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Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Reproductive Monitoring During 2017. Prepared by American Southwest Ichthyological Research Foundation. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, spawning, eggs

Summary: Systematic monitoring of the reproduction of Rio Grande Silvery Minnow has been conducted annually since 2001. Previous studies demonstrated mid-April to mid-June as the primary period of spawning activity. The 2017 study was a continuation of the long-term monitoring effort in the lower portion of the San Acacia Reach, just upstream of Elephant Butte Reservoir. Two additional sites (one in the Angostura Reach and one in the Isleta Reach), which had been sampled periodically from 2006 to 2011, were also sampled intensively in 2017.

Rio Grande Silvery Minnow mixture-model estimates (E(x)), using standardized egg passage rate data (Ep = eggs / s) from 2003 to 2017, were highest in 2011 (6.05 x 101) and lowest in 2004 (1.36 x 10-3). Values of Ep are indicative of the relative downstream transport of eggs across years, corrected for annual differences in flow magnitude. There was a steady decline in estimated egg passage rates from 2011 to 2013, followed by an increase in 2014. Egg passage rates declined (P < 0.05) from 2015 (7.75 x 10-1) to 2016 (6.12 x 10-2), but increased slightly in 2017.

Ecological models revealed that changes in the density and occurrence of Rio Grande Silvery Minnow eggs were reliably predicted by seasonal differences in river flows over time (2003–2017). Out of 129 models considered, we found that high flows during spring were crucial (i.e., > 70% of model weight) in explaining why some years had substantially lower egg passage rates (i.e. reduced downstream transport of eggs) than others. In summary, we found that low egg passage rates were most common during years with elevated and extended spring flows, whereas high egg passage rates occurred most frequently during years with lower and more abbreviated peak spring flows.

Logistic regression modeling of Rio Grande Silvery Minnow egg presence-absence data revealed strong associations with the percentage change in mean daily discharge just prior to egg collection (X 2 = 28.44 and P < 0.001). The probability of collecting eggs was predicted to increase rapidly up to about a 100% increase in mean daily discharge between days just prior to egg collection. The probability of collecting eggs during a 100% increase in flow was 0.83 and during a 200% increase was 0.97.

Rio Grande Silvery Minnow egg presence-absence data also revealed associations with water temperatures, though not as robust as the discharge relationships, during the study period (X 2 = 11.98 and P < 0.001). The probability of collecting eggs ranged from 0.64 (temperature = 14°C) to 0.27 (temperature = 26°C). The trend in the probability of collecting eggs showed a steady decrease as a function of elevated water temperatures.

Sampling was reinitiated at the Albuquerque and Sevilleta sites in 2017, which allowed for historical comparisons of longitudinal egg passage rates from 2006 to 2017. The annual trends in egg passage rates for all three sites were relatively similar over time. Overall, the estimated egg passage rates at Sevilleta and San Marcial were consistently higher than at Albuquerque. The mixture-model was used to estimate and compare longitudinal egg passage rates in 2017 at the Albuquerque (0.06), Sevilleta (0.50), and San Marcial (0.27) sampling sites. While the 2017 egg passage rates at Sevilleta were significantly higher (P < 0.05) than at

Albuquerque, there were no significant differences between the Albuquerque and San Marcial estimates or the Sevilleta and San Marcial estimates.

Despite the seemingly large number of Rio Grande Silvery Minnow eggs transported downstream every year, some portion remains upstream. The physical conditions produced by prolonged and elevated flows during spring result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline and island backwaters. It is likely that the proportion of individuals retained and successfully recruited upstream is related to the complexity of instream habitat conditions and the long-term availability of nursery habitat. As successful growth and survival of Rio Grande Silvery Minnow, from the egg through the early larval stages, requires about one month, the persistence of these nursery habitats is essential during this crucial developmental phase. The future conservation status of Rio Grande Silvery Minnow appears strongly dependent on reliably ensuring appropriate seasonal flow and habitat conditions to support the crucial spawning and early recruitment phases of this imperiled species.

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Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring Results from September 2017. Prepared by American Ichthyological Researchers, L.L.C. Prepared for Middle Rio Grande Endangered Species Collaborative Program.

Key words: silvery minnow, population monitoring

Summary: The September population monitoring efforts were conducted at the 20 standard sites and at one replacement site. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and ten sites in the San Acacia Reach. The Middle Rio Grande Endangered Species Collaborative Program requested that replacement sites be added when there was drying at any of the standard sites. For September 2017, comparisons were made between standard sites and all sites. For the 2017 monthly trends, data were based on all sites to maintain consistency across all monthly reports. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June).

Standard Sites (n = 20) During September, sampling covered 9,795.9 m^2 (surface area) of water and yielded 4,590 fish. There was one dry sampling site. Cumulative fish density during September was 46.86 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (1,679), Red Shiner (1,074), and Western Mosquitofish (1,002). The 20 sampling sites yielded a total of 17 fish species. Rio Grande Silvery Minnow was present in 181 of the 327 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 19 of the 20 sampling sites, and its overall density was 17.14 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 17.14 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 16.86, 0.28, and 0.00 individuals/100 m^2 sampled, respectively.

All Sites (n = 21) During September, sampling covered 10,284.0 m^2 (surface area) of water and yielded 4,754 fish. There was one dry sampling site, which was replaced by the nearest wetted upstream site in the same reach. Cumulative fish density during September was 46.23 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (1,760), Red Shiner (1,120), and Western Mosquitofish (1,005). The 21 sampling sites yielded a total of 17 fish species. Rio Grande Silvery Minnow was present in 197 of the 345 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 20 of the 21 sampling sites, and its overall density was 17.11 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 17.11 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 16.85, 0.26, and 0.00 individuals/100 m^2 sampled, respectively.

DOI: Report

Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring Results From June 2017. Prepared by American Southwest Ichyological Research Foundation. Prepared for Middle Rio Grande Endangered Species Collaborative Program.

Key words: silvery minnow, Rio Grande, population, monitoring

Summary: The June population monitoring efforts were conducted at 20 sites throughout the Middle Rio Grande. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and nine sites in the San Acacia Reach. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine in all seasons except winter. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June).

During June, sampling covered 9,207.8 m^2 (surface area) of water and yielded 4,924 fish. Cumulative fish density during June was 53.48 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (2,327), Red Shiner (1,264), and Flathead Chub (426). The 20 sampling sites yielded a total of 16 fish species. Rio Grande Silvery Minnow was present in 93 of the 272 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 18 of the 20 sampling sites, and its overall density was 25.27 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 25.27 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 24.38, 0.89, and 0.00 individuals/100 m^2 sampled, respectively.

Rio Grande Silvery Minnow that were stocked during autumn 2016 were present at low densities during the spring of 2017. Overwinter mortality of Rio Grande Silvery Minnow apparently resulted in substantial losses of individuals from December 2016 to June 2017. However, the abundance of Rio Grande Silvery Minnow in June 2017 was higher than it was in June 2016. Ensuring reasonable summer flows will be crucial for the successful survival of Rio Grande Silvery Minnow during 2017.

DOI: Report

Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring Results from July 2017. Prepared by American Southwest Ichthyological Research Foundation. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, Rio Grande, population, monitoring

Summary: The July population monitoring efforts were conducted at 20 sites throughout the Middle Rio Grande. Five sites were located in the Angostura Reach, six sites in the Isleta Reach, and nine sites in the San Acacia Reach. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (3/16th inch) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (1/16th inch) seine in all seasons except winter. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June).

During July, sampling covered 10,624.3 m^2 (surface area) of water and yielded 10,876 fish. Cumulative fish density during July was 102.37 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (6,920), Red Shiner (2,388), and Western Mosquitofish (650). The 20 sampling sites yielded a total of 18 fish species. Rio Grande Silvery Minnow was present in 247 of the 344 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 20 of the 20 sampling sites, and its overall density was 65.13 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 65.13 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 63.61, 1.47, and 0.06 individuals/100 m^2 sampled, respectively.

Rio Grande Silvery Minnow that were stocked during autumn 2016 were present at low densities during the spring of 2017. Overwinter mortality of Rio Grande Silvery Minnow apparently resulted in substantial losses of individuals. However, the abundance of Rio Grande Silvery Minnow in July 2017 was substantially higher than it was in July 2016. Ensuring reasonable summer flows will be crucial for the successful survival of Rio Grande Silvery Minnow during 2017.

DOI: Report

Dudley, R. K., S. P. Platania, and G. C. White. 2017. Rio Grande Silvery Minnow Population Monitoring During October 2017. Prepared by American Southwest Ichthyological Research Foundation. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, Rio Grande, population, monitoring

Summary: The October population monitoring efforts were conducted at the 20 standard sites and at 10 additional sites, located in each of the three sampling reaches. The Middle Rio Grande Endangered Species Collaborative Program requested that the additional sampling be conducted once in the spring and fall of each year. For October 2017, comparisons were made between standard sites and all sites. For the 2017 monthly trends, data were based on all sites to maintain consistency across all monthly reports. Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June).

Standard Sites (n = 20) During October, sampling covered 10,166.1 m^2 (surface area) of water and yielded 5,618 fish. There were no dry sampling sites. Cumulative fish density during October was 55.26 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (2,192), Red Shiner (1,796), and Channel Catfish (879). The sampling sites yielded a total of 17 fish species. Rio Grande Silvery Minnow was present in 213 of the 309 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 19 of the 20 sampling sites, and its overall density was 21.56 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 21.56 and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 19.62, 1.86, and 0.08 individuals/100 m^2 sampled, respectively.

All Sites (n = 30) During October, sampling covered 15,171.9 m^2 (surface area) of water and yielded 8,033 fish. There were no dry sampling sites. Cumulative fish density during October was 52.95 individuals/100 m^2 sampled. The three most common species were Rio Grande Silvery Minnow (2,867), Red Shiner (2,631), and Channel Catfish (1,126). The sampling sites yielded a total of 18 fish species. Rio Grande Silvery Minnow was present in 313 of the 466 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 29 of the 30 sampling sites, and its overall density was 18.90 individuals/100 m^2 sampled. Densities of unmarked and marked individuals were 18.90, and 0.00 individuals/100 m^2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 17.44, 1.39, and 0.07 individuals/100 m^2 sampled, respectively.

DOI: Report

Frey, J. 2017. A Review and the Conservation Implications of Aquatic Behaviour and Drowning in Jumping Mice (Dipodidae: Zapodinae). Canadian Field Naturalist 131:141–143.

Key words: Endangered species; jumping mouse; Eozapus; Zapus; Napaeozapus; pitfall trap

Abstract: Jumping mice (Dipodidae: Zapodinae) have a generalized terrestrial quadrupedal locomotion with specializations for salutatory and scansorial locomotion. The author reviewed first-hand accounts of aquatic behavior in the literature and confirmed that jumping mice are semi-aquatic, using both primitive quadrupedal paddling on the surface as well as the more derived simultaneous bipedal pelvic paddling while swimming underwater. Although proficient swimmers, jumping mice are also prone to drowning, especially in human-made pools. Management of populations of jumping mice with conservation concern should consider potential hazards faced by jumping mice in an aquatic environment.

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González, E., A. A. Sher, R. M. Anderson, R. F. Bay, D. W. Bean, G. J. Bissonnete, B. Bourgeois, D. J. Cooper, K. Dohrenwend, K. D. Eichhorst, H. El Waer, D. K. Kennard, R. Harms-Weissinger, A. L. Henry, L. J. Makarick, S. M. Ostoja, L. V. Reynolds, W. W. Robinson, and P. B. Shafroth. 2017. Vegetation response to invasive Tamarix control in southwestern U.S. rivers: a collaborative study including 416 sites. Ecological Applications 27:1789–1804.

Key words: Diorhabda; exotic species control; management of biological invasions; plant communities; saltcedar; tamarisk

Abstract: Most studies assessing vegetation response following control of invasive Tamarix trees along southwestern U.S. rivers have been small in scale (e.g., river reach), or at a regional scale but with poor spatial-temporal replication, and most have not included testing the effects of a now widely used biological control. We monitored plant composition following Tamarix control along hydrologic, soil, and climatic gradients in 244 treated and 172 reference sites across six U.S. states. This represents the largest comprehensive assessment to date on the vegetation response to the four most common Tamarix control treatments. Biocontrol by a defoliating beetle (treatment 1) reduced the abundance of Tamarix less than active removal by mechanically using hand and chain-saws (2), heavy machinery (3) or burning (4). Tamarix abundance also decreased with lower temperatures, higher precipitation, and follow-up treatments for Tamarix re-sprouting. Native cover generally increased over time in active Tamarix removal sites, however, the increases observed were small and was not consistently increased by active revegetation. Overall, native cover was correlated to permanent stream flow, lower grazing pressure, lower soil salinity and temperatures, and higher precipitation. Species diversity also increased where Tamarix was removed. However, Tamarix treatments, especially those generating the highest disturbance (burning and heavy machinery), also often promoted secondary invasions of exotic forbs. The abundance of hydrophytic species was much lower in treated than in reference sites, suggesting that management of southwestern U.S. rivers has focused too much on weed control, overlooking restoration of fluvial processes that provide habitat for hydrophytic and floodplain vegetation. These results can help inform future management of Tamarix-infested rivers to restore hydrogeomorphic processes, increase native biodiversity and reduce abundance of noxious species.

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González, E., A. A. Sher, R. M. Anderson, R. F. Bay, D. W. Bean, G. J. Bissonnete, D. J. Cooper, K. Dohrenwend, K. D. Eichhorst, H. El Waer, D. K. Kennard, R. Harms-Weissinger, A. L. Henry, L. J. Makarick, S. M. Ostoja, L. V. Reynolds, W. W. Robinson, P. B. Shafroth, and E. Tabacchi. 2017. Secondary invasions of noxious weeds associated with control of invasive Tamarix are frequent, idiosyncratic and persistent. Biological Conservation 213:106–114.

Key words: ecological restoration, invasive species management, noxious weeds, riparian systems, secondary invasions, tamarix control

Abstract: Control of invasive species within ecosystems may induce secondary invasions of non-target invaders replacing the first alien. We used four plant species listed as noxious by local authorities in riparian systems to discern whether 1) the severity of these secondary invasions was related to the control method applied to the first alien; and 2) which species that were secondary invaders persisted over time. In a collaborative study by 16 research institutions, we monitored plant species composition following control of non-native tamarix trees along southwestern U.S. rivers using defoliation by an introduced biocontrol beetle, and three physical removal methods: mechanical using saws, heavy machinery, and burning in 244 treated and 79 untreated sites across six U.S. states. Physical removal favored secondary invasions immediately after tamarix removal (0–3 yrs.), while in the biocontrol treatment, secondary invasions manifested later (> 5 yrs.). Within this general trend, the response of weeds to control was idiosyncratic; dependent on treatment type and invader. Two annual tumbleweeds that only reproduce by seed (Bassia scoparia and Salsola tragus) peaked immediately after physical tamarix removal and persisted over time, even after herbicide application. Acroptilon repens, a perennial forb that vigorously reproduces by rhizomes, and Bromus tectorum, a very frequent annual grass before removal that only reproduces by seed, were most successful at biocontrol sites, and progressively spread as the canopy layer opened. These results demonstrate that strategies to control tamarix affect secondary invasions differently among species and that time since disturbance is an important, generally overlooked, factor affecting response

DOI: 10.1016/j.biocon.2017.06.043

Hutson, A. M., L. A. Toya, D. Tave, and M. D. Porter. 2017. Lower lethal temperature of the endangered Rio Grande silvery minnow and its implications for propagation and reintroduction. Journal of Applied Aquaculture 29:117–125.

Key words: Endangered species, *Hybognathus amarus*, temperature guideline for culture and reintroduction

Abstract: The lower lethal temperature of the endangered Rio Grande silvery minnow, *Hybognathus amarus*, was estimated from survival rates of fish overwintered in above-ground tanks. Temperature went to 0.0°C both winters. In 2012–2013, survival of Age class 0 fish was 79.87%, and in 2013–2014, survival of Age class 1 fish was 97.1%, suggesting that if Rio Grande silvery minnow is subjected to seasonal temperature changes, lower lethal temperature is ≤0.0°C. Results show that heating hatchery water in the winter is unnecessary. Additionally, current management guidelines that preclude reintroduction of the species into river sections where winter temperatures are ≤1°C must be reevaluated.

DOI: 10.1080/10454438.2016.1274934

Ji, W., L. Wang, and A. E. Knutson. 2017. Detection of the spatiotemporal patterns of beetle-induced tamarisk (Tamarix spp.) defoliation along the Lower Rio Grande using Landsat TM images. Remote Sensing of Environment 193:76–85.

<u>Key words:</u> Tamarisk leaf beetle, *Diorhabda sublineata,* defoliation, biocontrol

<u>Abstract:</u> The invasive Tamarisk (Tamarix spp.) has long been targeted for removal by land managers in the western United States. Biocontrol of the non-native tamarisk started in 2001 by introducing the tamarisk leaf beetle (Diorhabda spp.) to the riparian ecosystems. Since then, the beetles quickly established and substantial tamarisk defoliation was subsequently observed along river corridors in the western states. The ability to monitor and track the patterns of beetle-induced tamarisk defoliation across space and time is key to understand its impact on ecosystem functioning and processes. In the present study, spatiotemporal patterns of tamarisk defoliation caused by the subtropical tamarisk leaf beetle (D. sublineata) were successfully detected using a classification based method along the Lower Rio Grande in West Texas from 2009 to 2014. Our results indicated that the subtropical beetle species can sustain a dispersal rate of approximately 102 km/yr 1 during the first year after release. Tamarisk abundance was the most important factor in directing beetle dispersal. We also found that the beetles preferred to forage within dense, connected tamarisk stands along wide sections of the riparian river corridors. These new findings of our study will help inform the land managers of the possible outcomes of tamarisk biocontrol to make effective management plans.

<u>DOI:</u> 10.1016/j.rse.2017.02.019

Johnson, M. J., J. R. Hatten, J. A. Holmes, and P. B. Shafroth. 2017. Identifying western yellow-billed cuckoo breeding habitat with a dual modelling approach. Ecological Modelling 347:50–62.

Key words: Yellow -billed cuckoo, habitat suitability models, riparian conservation, NDVI, logistic regression, lower Colorado River

Abstract: The western population of the yellow-billed cuckoo (Coccyzus americanus) was recently listed as threatened under the federal Endangered Species Act. Yellow -billed cuckoo conservation efforts require the identification of features and area requirements associated with high quality, riparian forest habitat at spatial scales that range from nest microhabitat to landscape, as well as lower-suitability areas that can be enhanced or restored. Spatially explicit models in form conservation efforts by increasing ecological understanding of a target species, especially at landscape scales. Previous yellow -billed cuckoo modelling efforts derived plant-community m aps from aerial photography, an expensive and often times inconsistent approach. Satellite models can remotely map vegetation features (e.g., vegetation density, heterogeneity in vegetation density or structure) across large areas with near perfect repeatability, but they usually cannot identify plan t communities. We used aerial photos and satellite imagery, and a hierarchical spatial scale approach, to identify yellow-billed cuckoo breeding habitat along the Lower Colorado River and its tributaries. Aerial-photo an d satellite models identified several key features associated with yellow -billed cuckoo breeding locations: (1) a 4.5 h a core area of dense cotton wood-willow vegetation , (2) a large native, heterogeneously dense forest (72 h a) around the core area, an d (3) moderately rough topography. The odds of yellow-billed cuckoo occurrence decreased rapidly as the amount of tamarisk cover increased or when cotton wood-willow vegetation was limited. We achieved model accuracies of 75–80% in the project area the following year after updating the imagery and location data. The two model types had very similar probability maps, largely predicting the same areas as high quality habitat. While each model provided unique in formation, a dual-modelling approach provided a more complete picture of yellow-billed cuckoo habitat requirements and will be useful for management and conservation activities.

DOI: 10.1016/j.ecolmodel.2016.12.010

Krabbenhoft, C. A., A. S. Burdett, and T. F. Turner. 2017. Direct and indirect effects of predatory young-of-year fishes in a dryland river food web. Freshwater Biology 62:1410–1421.

Key words: experimental ecology, invertebrates, predation, stable isotopes, temporary pools

Abstract: Young-of-year (YOY) fishes are sometimes numerically dominant vertebrate consumers in many large river systems, but their effects as predators are not as well understood as those of adult fishes. We predicted that YOY fishes influence community composition and abundance of invertebrate prey. Predation effects could be especially important in recruitment-driven dryland river systems, where YOY fishes seasonally comprise a large portion of overall fish biomass. We conducted a mesocosm experiment to quantify effects of YOY fishes on trophic dynamics and interactions with environmental factors in a dryland river food web. We manipulated presence of YOY fishes (an assemblage of cyprini- form species) and supplemental allochthonous carbon (LEAF treatments) in 24 mesocosms, and measured invertebrate abundance and diversity over 6 weeks. Experimental conditions mimicked a seasonal river drying regime that occurs during YOY fish growth. Seasonal drying in the Rio Grande frequently results in isolated pools with altered habitat complexity and riparian connectivity.

DOI: 10.1111/fwb.12954

Mott Lacroix, K. E., E. Tapia, and A. Springer. 2017. Environmental flows in the desert rivers of the United States and Mexico: Synthesis of available data and gap analysis. Journal of Arid Environments 140:67–78.

Key words: environmental flows, riparian, aquatic, deserts, databases, United States, Mexico

Abstract: Although riparian and aquatic ecosystems make up a small fraction of the area in arid and semi-arid lands, they are critical for the survival of desert life. There are, however, few compendia of efforts to define the quantity of water needed to maintain these ecosystem s and understand the risks and stressors to them. Through our analysis we found that 62% of the rivers examined in the deserts of the U.S. and Mexico have had just one study over the past four decades and 67% of studies used qualitative methods. Furthermore, only one-third of the 312 species catalogued in our work have been studied more than once and only 5% have been considered five or more times. The most common risks or stressors to riparian and aquatic species were engineered structures, invasive species, and altered flows; and while 10% of studies included climate stressor, climate change impacts were infrequently examined. Ultimately, we found that although research has been conducted across the desert watersheds of the U.S. and Mexico, there are significant gaps in our know ledge of basic data such as the location and extent of perennial and intermittent streams, let alone studies of environmental flow needs.

DOI:10.1016/j.jaridenv.2017.01.011

Muldavin, E. H., E. R. Milford, N. E. Umbreit, and Y. D. Chauvin. 2017. Long-term Outcomes of Natural-process Riparian Restoration on a Regulated River Site: The Rio Grande Albuquerque Overbank Project after 16 Years. Ecological Restoration 35:341–353.

Key words: dynamic patch mosaic, Populus deltoides var. wislizenii, Elaeagnus angustifolia, Tamarix spp., Saccharum ravennae, beavers, vegetation monitoring

Abstract: In 1998, a riparian restoration demonstration project was initiated with a target of efficiently establishing a dynamic patch mosaic of vegetation communities along a regulated river using available water and sediment and remaining natural hydrological processes. A point bar along the Middle Rio Grande, Albuquerque, New Mexico, dominated by the non- native shrub Elaeagnus angustifolia (Russian olive), was mechanically treated by removing all vegetation and lowering a portion of the bar to allow overbank flooding during typical spring releases from an upstream dam (Cochiti Dam). Side channels and small islands were engineered in the lowered bar to slow flood waters, aid sediment deposition, and add site complexity. After treatment, a high-resolution monitoring grid was installed to track vegetation changes. Following an initial flood in the spring of 1998, over 10,000 cottonwoods per ha naturally established, but densities varied based on the fluvial landforms. Zones that were sufficiently wetted or naturally formed behind large woody debris were the most successful, while the artificial fill zone and the portion of the bar not lowered had the least native riparian tree recruitment. Over 15 years, cottonwood numbers declined through intraspecific competition and beaver browsing at all sites, but they continued to dominate. Natives also dominated a species-rich herbaceous layer, particularly on the lowered sites. The incursion of a new herbaceous invader, Saccharum ravennae (ravennagrass), was an unexpected outcome revealed by the long-term monitoring record. Yet, based on several criteria, the site reflects a successful application of a natural-process approach to restoration that can lead to increased ecosystem complexity and resilience.

DOI: 10.3368/er.35.4.341

Noon, B., D. Hankin, T. Dunne, and G. Grossman. 2017. Independent Science Panel Findings Report: Rio grande silvery minnow key scientific uncertainties and study recommendations. Review Panel, Prepared by GeoSystems Analysis. Prepared for U.S. Army Corps of Engineers, Albuquerque, NM.

Key words: Middle Rio Grande, Rio Grande silvery minnow, independent science panel

Abstract: GeoSystems Analysis, Inc. (GSA) was contracted by the US Army Corps of Engineers (USACE) to support the Middle Rio Grande (MRG) Endangered Species Collaborative Program (Program) by identifying management-relevant scientific uncertainties pertaining to biology, life-history and habitat associations of the federally endangered Rio Grande silvery minnow (Hybognathus amarus; RGSM). Although the RGSM was listed as endangered in 1994, there continues to be substantive debate among regional scientists surrounding fundamental aspects of the fish's life-history and habitat requirements. Several of these contrasting scientific perspectives were identified and documented by GSA using formal questionnaires and follow-up interviews with RGSM "subject matter experts" (SMEs) identified by various Program signatories. After compiling survey and interview results, a subset of SMEs were asked to participate in a structured review process with an independent science panel to discuss the scientific basis for their perspectives. Independent science panel members had special expertise in fish biology, population dynamics, geomorphology, sampling theory, and assessment of endangered species. An independent science panel review meeting was held February 1-2, 2017, in Bernalillo, New Mexico. This report is a product of the panel review process, and culminates in a list of study recommendations intended to reduce scientific uncertainty on numerous topics considered relevant to water management and habitat restoration decisions for improving the RGSM population status.

The Panel was "charged," with three main objectives:

- Review the available science that addresses how population characteristics relevant to the recovery of RGSM vary over space and time and what environmental factors best explains this variation.
- Identify aspects of the species' life history that are characterized by significant uncertainty and those that are sufficiently well understood to inform management decisions, and provide recommendations for priority studies that address key scientific uncertainties relevant to management decisions.
- Provide a foundation for the adaptive management of RGSM populations within the MRG.

DOI: Report

Osborne, M. J., and T. F. Turner. 2017. Genetics Monitoring of the Rio Grande Silvery Minnow: Genetic Status of Wild and Captive Stocks in 2017. Annual Report, Prepared by Department of Biology and Museum of Southwestern Biology; University of New Mexico. Prepared for U.S. Bureau of Reclamation.

Key words: silvery minnow, Middle Rio Grande, genotyping

Summary: We have conducted genetic monitoring of the Middle Rio Grande population of Rio Grande Silvery Minnow annually from 1999-2012 and resumed monitoring from 2014 through 2017. This work has included monitoring stocks that were bred or reared in captivity and released to the Rio Grande in New Mexico since 2002 at the commencement of the augmentation program. Monitoring in 2017 was based on genotyping 469 'wild' Rio Grande Silvery Minnow collected in all three occupied reaches of the Middle Rio Grande, and progeny of captive stocks from Southwestern Native Aquatic Resources and Recovery Center (n=298), Uvalde (n=100), and the Albuquerque Biological Park (n=89). In 2017, we also genotyped all broodstock used to produce fish for release in the fall of 2017, from Southwestern Native ARRC and Albuquerque Biological Park.

Major Findings

1. Gene diversity and heterozygosity were essentially unchanged from 2016-2017 values and exceeded minimum benchmark levels of diversity. This stability is partly a result of strong recruitment in fall 2016, as well as augmentation of the wild population with hatchery produced fish; acting to buffer the population against loss of diversity (particularly prior to 2015). Average number of alleles (estimated by resampling to account for differences in sample size) was relatively stable between 2006-2016 but in 2017, we saw this metric decline to approach the minimum benchmark. From analysis of microsatellite data by river reach we observed a notable decline heterozygosity between 2016 and 2017 in the Angostura Reach. In the Isleta and San Acacia Reaches there was little change in diversity values between 2016 and 2017.
2. In 2017, mitochondrial gene diversity and haplotype richness remained within the range seen in previous years but both values declined from those seen in 2016. Across all 2017 samples (including hatchery collections) eleven haplotypes were detected including three rare haplotypes; likely a result of the increased number of samples genotyped. Detection of these rare haplotypes may also represent reproductive contribution of old broodstock released in spring 2016. Like previous years, there were no significant differences detected in haplotype frequencies between the three reaches occupied by Rio Grande silvery minnow. Mitochondrial DNA diversity metrics declined in all river reaches between 2016 and 2017.
3. Variance genetic effective size estimates for the temporal comparison 2016-2017 were greater (NeV=1028-2325) than for the previous comparison 2015-2016 (NeV=514-744). Higher NeV for the most recent sampling period suggests more stable allele frequencies between years and is consistent with higher densities in the wild.
4. Mitochondrial DNA (mtDNA) was used to estimate female variance effective population size using a maximum likelihood approach (MLNE). Nef remained less than 100 for the moments method and was Nef = 155 for the 2016-2017 temporal comparison suggesting relatively few females made a reproductive contribution. However, values for Nef were

higher than for the previous temporal comparison; consistent with higher densities of Rio Grande Silvery Minnow in fall 2016.

5. Approximately 65,880 Rio Grande Silvery Minnow reared in captivity were released to the Middle Rio Grande in fall 2016. These fish were released to supplement reproduction by ‘wild’ fish; together these fish produce the 2017 year-class. In addition, 3,122 Rio Grande Silvery Minnow (old broodstock) were released in April 2016. We genotyped representatives from six captive lots, including Southwestern Native Aquatic Resources and Recovery Center (n = 3 lots), Albuquerque Biopark (2 lots) and Uvalde (1 lot). Pooled hatchery samples released to the middle Rio Grande had diversity that was comparable to the ‘wild’ population. Hence, we do not expect to observe large changes in allele frequencies or reduction of diversity of ‘wild’ fish if the hatchery reared individuals contribute to the next generation.
6. Broodstock used for captive spawning in 2017 from Southwestern Native Aquatic Resources and Recovery Center and Albuquerque Biopark were also genotyped. Gene diversity measured from microsatellites fell within the range seen in the samples collected from the Rio Grande over the course of the study. Haplotype diversity (calculated from mtDNA) was lower in the broodstock from the Albuquerque BioPark compared to the those from Southwestern Native Aquatic Resources and Recovery Center. Genetic effective size estimated using the linkage disequilibrium method were high for broodstock from both facilities. This estimate pertains to the generation preceding the current sample. Genotyping of fish to be released to the middle Rio Grande in fall will allow us to conduct parentage analysis to better understand the reproductive contribution of the broodstock.

DOI: Report

Osborne, M. J., T. J. Pilger, J. D. Lusk, and T. F. Turner. 2017. Spatio-temporal variation in parasite communities maintains diversity at the major histocompatibility complex class IIβ in the endangered Rio Grande silvery minnow. Molecular Ecology 26:471–489.

Key words: adaption, community ecology, contemporary evolution, ecological genetics, host–parasite interactions, natural selection

Abstract: Climate change will strongly impact aquatic ecosystems particularly in arid and semi-arid regions. Fish–parasite interactions will also be affected by predicted altered flow and temperature regimes, and other environmental stressors. Hence, identifying environmental and genetic factors associated with maintaining diversity at immune genes is critical for understanding species' adaptive capacity. Here, we combine genetic (MHC class IIb and microsatellites), parasitological and ecological data to explore the relationship between these factors in the remnant wild Rio Grande silvery minnow (Hybognathus amarus) population, an endangered species found in the southwestern United States. Infections with multiple parasites on the gills were observed and there was spatiotemporal variation in parasite communities and patterns of infection among individuals. Despite its highly endangered status and chronically low genetic effective size, Rio Grande silvery minnow had high allelic diversity at MHC class IIb with more alleles recognized at the presumptive DAB1 locus compared to the DAB3 locus. We identified significant associations between specific parasites and MHC alleles against a backdrop of generalist parasite prevalence. We also found that individuals with higher individual neutral heterozygosity and higher amino acid divergence between MHC alleles had lower parasite abundance and diversity. Taken together, these results suggest a role for fluctuating selection imposed by spatiotemporal variation in pathogen communities and divergent allele advantage in maintenance of high MHC polymorphism. Understanding the complex interaction of habitat, pathogens and immunity in protected species will require integrated experimental, genetic and field studies.

DOI: 10.1111/MEC.13936

Pascolini-Campbell, M., R. Seager, A. Pinson, and B. I. Cook. 2017. Covariability of climate and streamflow in the Upper Rio Grande from interannual to interdecadal timescales. Journal of Hydrology: Regional Studies 13:58–71.

Key words: streamflow, hydroclimate, rivers, decadal variability

Abstract: We find that the interdecadal teleconnection between SST and streamflow is more clear than on interannual timescales. The highest ranked years tend to be clustered during positive phases of the Pacific Decadal Oscillation (PDO). During the periods of decadal high flow (1900–1920, and 1979–1995), Pacific SST resembles a positive PDO pattern and the Atlantic a negative Atlantic Multidecadal Oscillation (AMO) pattern; an interbasin pat- tern shown in prior studies to be conducive to high precipitation and streamflow. To account for the part of streamflow variance not explained by SST, we analyze atmospheric Reanalysis data for the months preceding the highest spring-summer streamflow events. A variety of atmospheric configurations are found to precede the highest flow years through anomalous moisture convergence. This lack of consistency suggests that, on interannual timescales, weather and not climate can dominate the generation of high streamflow events.

DOI: 10.1016/j.ejrh.2017.01.007

Peterson, D., R. B. Trantham, T. G. Trantham, and C. A. Caldwell. 2018. Tagging effects of passive integrated transponder and visual implant elastomer on the small-bodied white sands pupfish (Cyprinodon tularosa). Fisheries Research 198:203–208.

Key words: pupfish, tagging effects, passive integrated transponder tag elastomeric tag

Abstract: One of the greatest limiting factors of studies designed to obtain growth, movement, and survival in small-bodied fishes is the selection of a viable tag. The tag must be relatively small with respect to body size as to impart minimal sub-lethal effects on growth and mobility, as well as be retained throughout the life of the fish or duration of the study. Thus, body size of the model species becomes a major limiting factor; yet few studies have obtained empirical evidence of the minimum fish size and related tagging effects. The probability of surviving a tagging event was quantified in White Sands pupfish (Cyprinodon tularosa) across a range of sizes (19–60 mm) to address the hypothesis that body size predicts tagging survival. We compared tagging related mortality, individual taggers, growth, and tag retention in White Sands pupfish implanted with 8-mm passive integrated transponder (PIT), visual implant elastomer (VIE), and control (handled similarly, but no tag implantation) over a 75 d period. Initial body weight was a good predictor of the probability of survival in PIT- and VIE-tagged fish. As weight increased by 1 g, the fish were 4.73 times more likely to survive PIT-tag implantation compared to the control fish with an estimated suitable tagging size at 1.1 g (TL: 39.29 ± 0.41 mm). Likewise, VIE-tagged animals were 2.27 times more likely to survive a tagging event compared to the control group for every additional 1 g with an estimated size suitable for tagging of 0.9 g (TL: 36.9 ± 0.36 mm) fish. Growth rates of PIT- and VIE- tagged White Sands pupfish were similar to the control groups. This research validated two popular tagging methodologies in the White Sands pupfish, thus providing a valuable tool for characterizing vital rates in other small-bodied fishes.

DOI: 10.1016/j.fishres.2017.08.019

Petrakis, R. E., W. J. D. van Leeuwen, M. L. Villarreal, P. Tashjian, R. Dello Russo, and C. A. Scott. 2017. Historical Analysis of Riparian Vegetation Change in Response to Shifting Management Objectives on the Middle Rio Grande. Land 6:29.

Key words: riparian ecosystems; remote sensing; climate fluctuation; land cover change; river management

Abstract: Riparian ecosystems are valuable to the ecological and human communities that depend on them. Over the past century, they have been subject to shifting management practices to maximize human use and ecosystem services, creating a complex relationship between water policy, management, and the natural ecosystem. This has necessitated research on the spatial and temporal dynamics of riparian vegetation change. The San Acacia Reach of the Middle Rio Grande has experienced multiple management and river flow fluctuations, resulting in threats to its riparian and aquatic ecosystems. This research uses remote sensing data, GIS, a review of management decisions, and an assessment of climate to both quantify how riparian vegetation has been altered over time and provide interpretations of the relationships between riparian change and shifting climate and management objectives. This research focused on four management phases from 1935 to 2014, each highlighting different management practices and climate-driven river patterns, providing unique opportunities to observe a direct relationship between river management, climate, and riparian response. Overall, we believe that management practices coupled with reduced surface river-flows with limited overbank flooding influenced the compositional and spatial patterns of vegetation, including possibly increasing non-native vegetation coverage. However, recent restoration efforts have begun to reduce non-native vegetation coverage.

DOI: 10.3390/land6020029

Powell, M. S., R. W. Hardy, A. M. Hutson, L. A. Toya, and D. Tave. 2017. Comparison of Body Composition and Fatty Acid Profiles between Wild and Cultured Rio Grande Silvery Minnows. Journal of Fish and Wildlife Management 8:487–496.

Key words: body composition, silvery minnows, hatchery

Abstract: Federally endangered Rio Grande Silvery Minnows (RGSM; Hybognathus amarus) were raised in one of three culture regimes: intensively, with only a hatchery diet; semi-intensively with access to natural food and hatchery diet supplementation; and with only natural food available at the Los Lunas Silvery Minnow Refugium (Los Lunas, New Mexico), a naturalized conservation refugium designed to mimic the natural environment of the RGSM in the Rio Grande. The project compared each culture regime and assessed differences and similarities in lipid and fatty acid content between feeding an artificial diet and consumption of natural food items in this species. After 117 d, whole- body lipid levels and fatty acid profiles were measured in each group and compared with values for wild RGSM. Fish fed the hatchery diet exclusively or as supplementary feed had significantly higher percent lipid (15.5% 6 0.5% and 10.6% 6 0.1%, respectively) than fish raised without access to the diet. Both groups had significantly higher percent lipid than fish raised in the refugium or wild fish (8.3% 6 0.1% and 7.8% 6 0.2%, respectively). Condition factor differed among groups and was highest in fish fed the hatchery diet (1.00) followed by fish supplemented with the hatchery diet (0.93), refugium fish (0.91), and wild fish (0.90). In this respect, refugium fish appeared more similar to wild fish than fish fed the hatchery diet or offered the diet as a supplement. Comparison of fatty acid profiles among groups showed marked differences among wild fish, refugium fish, and those fed the hatchery diet, either exclusively or as supplementary feed. Total omega-3 fatty acids, expressed as percentage of total fatty acids, were highest in wild fish but similar among other groups. Total omega-6 fatty acids showed an opposite trend, with five to nine times higher percentages of linoleic acid observed among fish from the three culture regimes compared with wild fish. Significant differences in lipid content and fatty acid composition between wild RGSM and cultured silvery minnows reflected their respective diets and culture regimes. Given similarities in fat content and condition factor with wild RGSM, we conclude that fish in the refugium do not require supplemental feeding with an artificial diet for this type of naturalized conservation management. Results from this study show that RGSM readily forage on natural food items present and also artificial feed when available, indicating dietary plasticity, which is advantageous for fish culture and future recovery.

DOI: 10.3996/072016-JFWM-055

Reynolds, M. G. 2017. Trial and Error: How Courts Have Shaped Prior Appropriation in New Mexico. Natural Resources Journal 57:263–318.

Key words: water lawsuits, water law, New Mexico

Abstract: This systematic review of New Mexico prior appropriation case law from 1883 to the present employs a thematic chronology in four parts spanning approximately three decades each, including the following topics. Part One covers the initial conflict between prior appropriation and riparian common law and early interpretations of the 1907 Water Act. In Part Two, courts contrast the 1907 Act with the old arid region doctrine and justify the integration of groundwater into prior appropriation. Diminishing supplies and increasing usage drive Part Three's concentration on proceedings to change places of use and points of diversion, at times deferring issues of priority or subordinating prior appropriation to other systems of allocation. Part Four explores progress of general stream adjudications, affirmation of prior appropriation against equitable apportionment and common use, and the expansion of power for priority enforcement subject to political barriers. The conclusion distinguishes between prior appropriation's vitality in principle and in practice, with a call to the New Mexico Legislature to enact statutes and provide adequate funding to meet New Mexico's present and future water needs.

DOI:

Sher, A. A., H. El Waer, E. González, R. Anderson, A. L. Henry, R. Biedron, and P. Yue. 2018. Native species recovery after reduction of an invasive tree by biological control with and without active removal. Ecological Engineering 111:167–175.

Key words: biological control, riparian restoration, Tamarix, diorhabda, invasive tree removal, plant community response, ecological restoration, integrated pest management, BACI design, RDA multivariate analysis, field of dreams hypothesis, disturbance ecology

Abstract: Removal of invasive species is often an important, if not central, component of many riparian restoration pro- jects, however little is known about the response of plant communities following this practice. In particular, active control of the exotic, dominant tree Tamarix spp is often a focus of riparian restoration, much of which occurring against a backdrop of biological control by a folivore beetle. Our research employed controls in both time and space to investigate the impact of active Tamarix removal methods in sites subjected to biological control in 40 sites sampled three times over a period of five years. We found that reduction in Tamarix cover was much greater over time with active means of removal, however the native understory increased both with and without active removal. Importantly, change in the relative cover of understory native species was significantly negatively correlated with change in Tamarix cover, with those sites that received a combination of low-disturbance-mechanical, chemical and bio-control showing greater increases in native understory dominance than those sites with biological control alone or high-disturbance mechanical control. Sites with only biocontrol still contained 10% live Tamarix cover > 7 yr since the beetle was released there. Taken together, these results suggest that the reduction of this exotic tree, even by biological control that leaves some canopy intact, can facilitate recovery of the native plant community. As such, this study supports the Field of Dreams hypothesis that states that once niches are restored, native plants should be able to recolonize.

DOI: 10.1016/j.ecoleng.2017.11.018

Smith, D. M., and D. M. Finch. 2017. Climate change and wildfire effects in aridland riparian ecosystems: An examination of current and future conditions. Gen. Tech. Rep. RMRS-GTR-364. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 65 p. 364. <https://www.fs.usda.gov/treesearch/pubs/54331>. Accessed 4 Jan 2018.

Key words: breeding birds, climate change, Middle Rio Grande, riparian, woody vegetation, wildfire

Abstract: Aridland riparian ecosystems are limited, the climate is changing, and further hydrological change is likely in the American Southwest. To protect riparian ecosystems and organisms, we need to understand how they are affected by disturbance processes and stressors such as fire, drought, and non-native plant invasions. Riparian vegetation is critically important as foraging, resting, migrating, and breeding habitat to birds and other animal species in the southwestern United States. Fremont cottonwood (Populus fremontii), Arizona sycamore (Platanus wrightii), and other woody species provide birds with nesting sites and foraging opportunities, some of which are absent or rare in adjacent plant communities. The structurally diverse, species-rich vegetation along many southwestern streams supports high densities of territories and nest sites for a variety of birds including several species of high conservation priority. Survival and reproduction of woody riparian plants is largely determined by periodic floods and droughts. As in other regions, rivers and streams of the American Southwest have been heavily altered by human activity, resulting in significant changes to disturbance regimes. Hydrological models, incorporating greenhouse gas emission scenarios, project that these changes will be exacerbated by climate change. In this report, we review the ecohydrology of southwestern streams and share results from our study sites along the Middle Rio Grande to describe effects of hydrological changes, wildfire, and invasions on plant communities and riparian-nesting birds. We also examine climate change projections and output from population models to gauge the future of aridland riparian ecosystems in an increasingly arid Southwest.

DOI: Report

Steele, C., J. Dialesandro, D. James, E. Elias, A. Rango, and M. Bleiweiss. 2017. Evaluating MODIS snow products for modelling snowmelt runoff: Case study of the Rio Grande headwaters. International Journal of Applied Earth Observation and Geoinformation 63:234–243.

Key words: MODIS snow products, MOD10A1, MODSCAG, snow covered area, Snowmelt Runoff Model

Abstract: Snow-covered area (SCA) is a key variable in the Snowmelt-Runoff Model (SRM) and in other models for simulating discharge from snowmelt. Landsat Thematic Mapper (TM), Enhanced Thematic Mapper (ETM +) or Operational Land Imager (OLI) provide remotely sensed data at an appropriate spatial resolution for mapping SCA in small headwater basins, but the temporal resolution of the data is low and may not always provide sufficient cloud-free dates. The coarser spatial resolution Moderate Resolution Imaging Spectroradiometer (MODIS) offers better temporal resolution and in cloudy years, MODIS data offer the best alternative for mapping snow cover when finer spatial resolution data are unavailable. However, MODIS' coarse spatial re- solution (500 m) can obscure fine spatial patterning in snow cover and some MODIS products are not sensitive to end-of-season snow cover. In this study, we aimed to test MODIS snow products for use in simulating snowmelt runoff from smaller headwater basins by a) comparing maps of TM and MODIS-based SCA and b) determining how SRM streamflow simulations are changed by the different estimates of seasonal snow depletion. We com- pared gridded MODIS snow products (Collection 5 MOD10A1 fractional and binary SCA; SCA derived from Collection 6 MOD10A1 Normalised Difference Snow Index (NDSI) Snow Cover), and the MODIS Snow Covered- Area and Grain size retrieval (MODSCAG) canopy-corrected fractional SCA (SCAMG), with reference SCA maps (SCAREF) generated from binary classification of TM imagery. SCAMG showed strong agreement with SCAREF; excluding true negatives (where both methods agreed no snow was present) the median percent difference between SCAREF and SCAMG ranged between − 2.4% and 4.7%. We simulated runoff for each of the four study years using SRM populated with and calibrated for snow depletion curves derived from SCAREF. We then substituted in each of the MODIS-derived depletion curves. With efficiency coefficients ranging between 0.73 and 0.93, SRM simulation results from the SCAMG runs yielded the best results of all the MODIS products and only slightly underestimated discharge volume (between 7 and 11% of measured annual discharge). SRM simulations that used SCA derived from Collection 6 NDSI Snow Cover also yielded promising results, with efficiency coefficients ranging between 0.73 and 0.91. We recommend that when simulating snowmelt runoff from small basins (< 4000 km^2) with SRM, we recommend that users select either canopy-corrected MODSCAG or create their own site-specific products from the Collection 6 MOD10A1 NDSI.

DOI: 10.1016/j.jag.2017.08.007

Stone, M. C., C. F. Byrne, and R. R. Morrison. 2017. Evaluating the impacts of hydrologic and geomorphic alterations on floodplain connectivity. Ecohydrology 10.1002/eco.1833.

Key words: environmental flows, floodplain connectivity, hydrodynamic models, restoration

Abstract: The dynamic interaction between a river and its floodplain is important for a variety of hydrologic, ecological, and geomorphic processes. However, water management activities have widely disrupted the natural flow regime and in many cases reduced floodplain connectivity. Recent environmental flow research has called for techniques that incorporate hydrogeomorphic processes, which are important for ecological and riverscape health. The objective of this study was to evaluate the impacts of hydrologic alterations on floodplain dynamics and connectivity. Changes in floodplain inundation dynamics and interface dynamics were investigated for 2 hydrologic scenarios on 2 distinct rivers - the Gila River and the Rio Grande, both in New Mexico, USA. The objective was achieved using a combination of 2-D hydrodynamic models and analysis tech- niques to evaluate large spatial and temporal datasets. The results improved understanding of inundation patterns and water flux between the channel and floodplain under baseline and altered hydrologic scenarios. Due to the distinct qualities of the study sites, unique insights were gleaned. In the Gila River, discernible changes in floodplain dynamics were observed in spite of the relatively minor alterations from the baseline hydrologic conditions. In contrast, the Rio Grande results revealed the importance of not only hydrologic alterations but also channel incision on reduced floodplain connectivity. The proposed techniques can be adapted to a wide range of river systems depending on the nature of hydrologic or geomorphic alterations under consideration. As a result, the degree of alteration of floodplain connectivity can be better under- stood, leading to improved river management.

DOI: 10.1002/eco.1833

Stone, M. C., Z. Afrin, and A. Gregory. 2017. An Investigation into the Potential Impacts of Watershed Restoration and Wildfire on Water Yields and Water Supply Resilience in the Rio Grande Water Fund Project Area. Prepared by the University of New Mefxico for the Middle Rio Grande Conservancy District. <http://riograndewaterfund.org/wp-content/uploads/2017/01/rgwf_stone_etal_2017.pdf>. Accessed 3 Jan 2018.

Key words: watershed restoration, water yields, snowpack

Abstract: The purpose of the study was to investigate the potential changes in water yields and water supply resilience in tributary watersheds of the upper Rio Grande as a result of forest restoration and wildfires with a focus on high-elevation mixed conifer areas. This study focused on the portion of the upper Rio Grande which lies within New Mexico – henceforth referred to as the NM-URG. The focus watersheds included the Rio Chama, Upper Rio Grande, Santa Fe, and Jemez basins (Figure 5 and Table 2). This report contains a review of existing literature, data, and models to help guide the Middle Rio Grande Conservancy District (MRGCD) board, The Nature Conservancy (TNC), and Rio Grande Water Fund (RGWF) partners regarding the potential benefits associated with forest restoration in these high-elevation watersheds. Key findings from this study include:

1. Although there is a rich body of research on the topics of wildfire and watershed restoration affects on hydrologic process, very little research has been conducted in high-elevation southwestern forests. Research priorities include improved quantification of forest stand characteristics on snowpack dynamics and water yield and improved predictions for post- wildfire peak flows and debris flows.
2. By extrapolating research findings and practical experience from other parts of the American West, we can conclude the following with a high degree of confidence:
    a. Catastrophic (stand replacing) wildfires will continue to increase in severity, frequency, and area in the NM-URG in the absence of intervention (e.g. watershed restoration);
    b. Water supply reliability is reduced after catastrophic wildfires. The most dramatic impact of wildfires on water supply is associated with severe flooding, sediment loading, and debris flows. Further, water yields are reduced from snowpack following severe wildfires. This is of great concern in the NM-URG where water supply is largely derived from snowpack.
    c. Conversely, watershed restoration will increase water supply reliability - primarily by reducing the risk of catastrophic wildfires, with the additional benefit of a potential increase in water yields.
3. Existing databases describing hydrology, land use/land cover, and meteorology are available at large spatial scales; However, data is sparse at the local scale and especially so in high elevation headwaters – with the notable exception of the Valles Caldera.
4. Historical hydrologic data illustrate substantial annual to decadal variability in precipitation patterns (especially in snowpack) along with tremendous spatial variability across elevation bands. Strong spatial correlations are observed between elevation, precipitation, and land cover type. A remarkably strong temporal correlation was observed between seasonal snowpack conditions and downstream water supply.
5. Although mixed conifer forests cover only 17% of the NM-URG watershed, approximately 25% of the precipitation volume falls in these areas. Although insufficient

data exists to quantify the percentage of water supply derived from mixed conifer forests, the figure is likely much greater than 25% due to the high water yield associated with the snowpack dominated hydrology in these regions.

6. Existing models are not capable of optimizing watershed restoration efforts with respect to source-water protection and hydrologic response. However, such tools can be developed through close collaboration between watershed partners including federal and non-federal agencies, water management organizations, non-governmental organizations, university researchers, and stakeholders. A framework for such an approach is included in Part 4 of this report including strategies for incorporating existing models.

DOI: Report

Thibault, J. R., J. R. Cleverly, and C. N. Dahm. 2017. Long-term Water Table Monitoring of Rio Grande Riparian Ecosystems for Restoration Potential Amid Hydroclimatic Challenges. Environmental Management 60:1101–1115.

Key words: groundwater, surface flow, flood, drought, cottonwood, salt cedar

Abstract: Hydrological processes drive the ecological functioning and sustainability of cottonwood-dominated riparian ecosystems in the arid southwestern USA. Snow- melt runoff elevates groundwater levels and inundates floodplains, which promotes cottonwood germination. Once established, these phreatophytes rely on accessible water tables (WTs). In New Mexico's Middle Rio Grande corridor diminished flooding and deepening WTs threaten native riparian communities. We monitored surface flows and riparian WTs for up to 14 years, which revealed that WTs and surface flows, including peak snowmelt discharge, respond to basin climate conditions and resource management. WT hydrographs influence the composition of riparian communities and can be used to assess if potential restoration sites meet native vegetation tolerances for WT depths, rates of recession, and variability throughout their life stages. WTs were highly variable in some sites, which can preclude native vegetation less adapted to deep drawdowns during extended droughts. Rates of WT recession varied between sites and should be assessed in regard to recruitment potential. Locations with relatively shallow WTs and limited variability are likely to be more viable for successful restoration. Suitable sites have diminished greatly as the once meandering Rio Grande has been con- strained and depleted. Increasing demands on water and the presence of invasive vegetation better adapted to the altered hydrologic regime further impact native riparian communities. Long-term monitoring over a range of sites and hydroclimatic extremes reveals attributes that can be evaluated for restoration potential.

DOI:10.1007/s00267-017-0945-x

Webb, A. D. 2017. Fire Effects and Management in Riparian Ecosystems of the Southwestern United States and Mexico. The University of Arizona, Tuscon, AZ. <http://arizona.openrepository.com/arizona/bitstream/10150/626146/1/azu_etd_15790_sip1_m.pdf>. Accessed 4 Jan 2018.

Key words: lowland riparian, fire management, riparian ecosystems

Abstract: Lowland riparian ecosystems constitute a tiny fraction of total land area in the southwestern United States and northern Mexico, yet they are extremely important to human livelihoods and biotic communities. Facing ongoing projected climate change toward hotter and drier conditions, riparian ecosystems are both vulnerable to changes in climate and increasingly critical to the well-being of humans and wildlife. Due to the dynamic nature of these ecosystems and their abundance of resources, riparian areas have been modified in various ways and to a large extent through human endeavor. These alterations often interfere with multiple and complex ecological processes, making riparian areas more vulnerable to disturbance and change. Few naturally functioning riparian areas remain, and those that do are imperiled by climate change, groundwater pumping, land use, and other factors. A small but growing body of literature suggests that wildfires may be increasing in frequency and severity in southwestern riparian zones. This literature review summarizes and synthesizes the state of the knowledge of wildfire and prescribed fire effects on abiotic processes and vegetation, and post-fire rehabilitation. Results suggest that in lowland riparian ecosystems, fire regimes and fire effects are influenced primarily by streamflow and groundwater regimes. Thus, increasing fire frequency and severity may be attributed to drought, land use, water use, and their subsequent effects on the spread of non-native plant species, as well as a history of fire suppression and increasing anthropogenic ignitions in areas with a growing human presence. Changing fire regimes are likely to have drastic and potentially irreversible effects on regional biodiversity and ecosystem function. However, there are options for managing riparian ecosystems that will be more resilient to fire and climate change, such as implementing environmental flows, prescribed fire, fuel reduction treatments, floodplain restoration, and promoting gene flow. This study is intended to inform management decisions, and identify gaps in systematically reviewed literature.

DOI: Thesis

Worthington, T. A., A. A. Echelle, J. S. Perkin, R. Mollenhauer, N. Farless, J. J. Dyer, D. Logue, and S. K. Brewer. 2017. The emblematic minnows of the North American Great Plains: A synthesis of threats and conservation opportunities. Fish and Fisheries. 19:271-307.

Key words: conservation, flow alteration, fragmentation, Great Plains, habitat complexity, non-native species

Abstract: Anthropogenic changes to the Great Plains rivers of North America have had a large, negative effect on a reproductive guild of pelagic-broadcast spawning (PBS) cyprinid fishes. The group is phylogenetically diverse, with multiple origins of the PBS mode. However, because of incomplete life-history information, PBS designation often relies only on habitat and egg characteristics. We identified 17 known or candidate PBS fishes and systematically synthesized the literature on their biology and ecology in relation to major threats to persistence. Research output on an individual species was unrelated to conservation status, but positively correlated with breadth of distribution. The PBS species have opportunistic life-history strategies and are typically short-lived (generally 1–3 years) fishes. Many PBS species have truncated ranges showing declines in both distribution and abundance, especially those endemic to the Rio Grande catchment. Fundamental habitat associations are unknown for many species, particularly regarding seasonal shifts and early life stages. Critical thermal tolerances have been quantified for five PBS species and are generally >35°C. Turbidity and salinity changes are linked to responses at multiple life stages, but information is lacking on interactions between water quality and quantity. Hydrologic alteration appears to be a primary threat to PBS species, through complex interactions with landscape fragmentation, and habitat change. We highlight areas where scientific and management communities are lacking information and underline areas of potential conservation gain.

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