Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Bibliography of Literature Published in 2021-2022

The enclosed list of references was compiled by searching recent (2021-2022) peer-reviewed literature on relevant keywords (i.e., MRG listed species) using the Google Scholar search engine. The document includes a list of citations in Harvard format, as well as the associated abstract and Digital Object Identifier (DOI) link for each publication. Related reports and other publicly available publications (i.e., grey literature) can be accessed via the Program Portal library.

While the purpose of this bibliography is to increase awareness about recently published literature pertaining to listed species in the Middle Rio Grande, the scope of the list is necessarily limited and should not be considered exhaustive. Its utility can be improved over time with input from users. Feedback regarding scope and search parameters can be emailed to the Program Support Team at cmurphy@west-inc.com.

Literature Cited

Archdeacon, T.P., Gonzales, E.J., Thomas, L.I., Rudolph, A.B. and Bachus, J.A., 2022. Effects of flow recession regime on stranding of Rio Grande silvery minnow suggests that conservation actions must overcome evolutionary traps. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 32(11), pp.1817-1829.

Baird, D.C., Yang, C.Y., Laforge, K., Julien, P.Y. and Doidge, S., Changing Middle Rio Grande Channel Conditions: Isleta to Rio Puerco. In *World Environmental and Water Resources Congress 2021* (pp. 208-221).

Brem, E.A. and Israelsen, W.J., 2021. Courtship behavior of the meadow jumping mouse (*Zapus hudsonius*). *Western North American Naturalist*, 81(2), p.267.

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de Leija, A.C., King, S.L. and Hawkins, T.S., 2022. Seed germination responses to salinity for three rare wetland plants of spring-fed arid systems. *Journal of Arid Environments*, 199, p.104705.

Friggens, M., 2021. Using Vulnerability Assessments to Strengthen Climate-Adaptive Conservation Response to Climate Change. *Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*, p.140.

Garrett, G., Roberson, A. and Bennett, J., 2021. Reintroduction of the Rio Grande Silvery Minnow in the Rio Grande Basin. *Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*, p.292.

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Johnson, C.A. and Benson, T.J., 2022. Dynamic occupancy models reveal Black-billed and Yellow-billed Cuckoos have high rates of turnover during the breeding season. *Ornithological Applications*, 124(3), p.duac021.

Londono-Gaviria, M., 2022. Low site-specific genomic variability is consistent with the history(s) of fragmentation of the riparian biota of the arid Southwest. (Masters Thesis, University of New Mexico)

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Mahoney, S.M., Pasch, B. and Theimer, T.C., 2021. Subspecies discrimination based on song structure by Willow Flycatchers. *Journal of Field Ornithology*, 92(2), pp.173-183.

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Owens, G.L., Todesco, M., Huang, K. and Rieseberg, L.H., 2022. Re-evaluating homoploid reticulate evolution in the annual sunflowers. *bioRxiv*, pp.2022-10.

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Samimi, M., Mirchi, A., Townsend, N., Gutzler, D., Daggubati, S., Ahn, S., Sheng, Z., Moriasi, D., Granados-Olivas, A., Alian, S. and Mayer, A., 2022. Climate change impacts on agricultural water availability in the Middle Rio Grande basin. *Journal of the American Water Resources Association*, 58(2), pp.164-184.

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Torell, G.L., Lee, K.D., Garnica, L.A., Mayer, A.S. and Ward, F.A., 2022. Least-Cost Provision of Ecosystem Services from Water: When, Where, and How Much? *Journal of Water Resources Planning and Management*, 148(2), p.04021100.

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Wohner, P.J., Laymon, S.A., Stanek, J.E., King, S.L. and Cooper, R.J., 2021. Early successional riparian vegetation is important for western Yellow-billed Cuckoo nesting habitat. *Restoration Ecology*, 29(5), p.e13376.

Yackulic, C.B., Archdeacon, T.P., Valdez, R.A., Hobbs, M., Porter, M.D., Lusk, J., Tanner, A., Gonzales, E.J., Lee, D.Y. and Haggerty, G.M., 2022. Quantifying flow and nonflow management impacts on an endangered fish by integrating data, research, and expert opinion. *Ecosphere*, 13(9), p.e4240.

Archdeacon, T.P., Gonzales, E.J., Thomas, L.I., Rudolph, A.B. and Bachus, J.A., 2022. Effects of flow recession regime on stranding of Rio Grande silvery minnow suggests that conservation actions must overcome evolutionary traps. ***Aquatic Conservation: Marine and Freshwater Ecosystems*****, 32(11), pp.1817-1829.**

Keywords: drought, drying, endangered species, fish, intermittence, isolated pools, mitigation, refuge

Abstract: 1. Flow intermittence is a major disturbance for riverine fishes. Many species of fishes that evolved in naturally intermittent streams have specialized adaptations to survive drought such as movement to refuge habitats. Conservation of fishes in river systems with highly altered flow regimes requires understanding of how individuals and populations respond to flow intermittence. 2. Here, flow was manipulated in two 16-km segments of the Rio Grande, New Mexico, to determine whether managed flow recession could reduce stranding imperilled Rio Grande silvery minnow in isolated pools. 3. Slower flow recessions did not decrease stranding in isolated pools over the range tested. Flow recession rate appeared to have an adverse impact on stranding; fewer fish were stranded under faster recession rates, but complex interactions were evident. Fish were stranded throughout both segments regardless of flow recession rate. 4. No evidence of a synchronized movement response was observed. Instead, many Rio Grande silvery minnows were probably trapped within proximal habitats, which dry completely and function as evolutionary traps, rather than moving to areas of perennial flow. Use of proximal habitats during streamflow intermittence has implications for management of the species and mitigation of mortality, including managed flow recession rates, and position and function of refuge habitats. 5. Effective mitigation for flow intermittence and stranding in streams with highly modified flow regimes will depend on the life history and behavioural response of the species. For Rio Grande silvery minnow, facilitating adaptive behaviour would require creating refuge areas that increase fish survival for weeks to months, as reducing the attractiveness of the traps is likely to be impossible given lack of a synchronized movement response to declining flows. Mismatching life-history strategies, behaviour, and scale of conservation actions may result in ineffective management and continued dependence on intensive management actions such as augmentation with hatchery fish.

DOI: 10.1002/aqc.3852

Baird, D.C., Yang, C.Y., Laforge, K., Julien, P.Y. and Doidge, S., Changing Middle Rio Grande Channel Conditions: Isleta to Rio Puerco. In *World Environmental and Water Resources Congress 2021* (pp. 208-221).

Keywords: N/A

Abstract: The Isleta Reach of the Middle Rio Grande spans about 42 miles from Isleta Diversion Dam to the confluence with the Rio Puerco. Analysis of spatial and temporal trends in channel geometry and morphology are reported. Hydrologic and hydraulics have been dynamic over the past century. The mean annual discharge has decreased since the 2000s, and the suspended sediment discharge has been declining since the 1970s, resulting in channel degradation. GIS analysis of aerial photographs and maps dates as far back as 1918 showing geomorphic changes; the current channel is less than one-fifth of what it was in 1918. There is also a slight increase in depth, velocity, median bed grain size, and sinuosity (channel length/valley length), while the slope decreased from 1972 to 2012.

DOI: 10.1061/9780784483466.019

Brem, E.A. and Israelsen, W.J., 2021. Courtship behavior of the meadow jumping mouse (*Zapus hudsonius*). *Western North American Naturalist*, 81(2), p.267.

Keywords: N/A

Abstract: We describe the first recorded observations of courtship behavior of the meadow jumping mouse (*Zapus hudsonius*) made in wild-caught and captive-reared animals. Male meadow jumping mice performed a series of courtship behaviors upon approach to the female, including rapid fanning of the muzzle with the forelimbs, self-grooming, muzzle fanning, retreat, and eventual mounting attempts. During courtship, female jumping mice may retreat, ignore the courting male, or bat at the male with forelimbs until the male retreats. Active rejection of courting males by the female is suggestive of female mate choice in this species.

DOI: 10.3398/064.081.0211

Caplan, T., 2021. Controlling Russian Olive (*Elaeagnus angustifolia*) in Riparian Floodplains: Lessons and Field Observations along the Middle Rio Grande, New Mexico. *Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*, p.252.

Keywords: N/A, book chapter

Abstract: N/A, book chapter

DOI: URL: https://uapress.arizona.edu/book/renewing-our-rivers

de Leija, A.C., 2021. Effects of wetland management and associated abiotic factors on rare plant communities of spring-fed arid wetlands (Masters Thesis, Louisiana State University).

Keywords: N/A

Abstract: Spring-fed arid wetlands support high biological productivity and are hotspots for endemism and distribution of rare plants, making them areas of high conservation value. These systems are driven by complex interactions among groundwater discharge and the geomorphic and climatic features of the setting, which provide gradients of edaphic conditions, particularly soil moisture and salinity that influence the presence and abundance of rare plant communities. However, spring-fed arid wetlands are at particular risk of increases in salinity and drier hydrological regimes due to anthropogenic activities. Such alterations to abiotic conditions may jeopardize the distribution and abundance of rare plants by exceeding their tolerances during their life cycle. In this study, I evaluate how wetland management practices and associated abiotic factors affect three poorly known rare plants of spring-fed arid wetlands in Bitter Lake National Wildlife Refuge, New Mexico: the annual Pecos sunflower (*Helianthus paradoxus*, federally Threatened), the biennial Wright's marsh thistle (*Cirsium wrightii*, proposed for listing as Threatened), and the annual Leoncita false-foxglove (*Agalinis calycina*, federal Species of Concern). In the lab, I used incubators to determine seed germination requirements and responses to field-derived salinities for the three species. Then, in the field, I established a series of monitoring plots equipped with groundwater wells to evaluate the hydrologic and soil factors influencing plant presence and abundance, with a particular focus on soil moisture and salinity. Pecos sunflower and Wright's marsh thistle showed high seed germination percentages at all salinity treatments, while Leoncita false-foxglove exhibited negative responses to increasing salinities. In the field, Pecos sunflower was the most abundant and widespread of the three and was positively associated to moist-soil management. Wright's marsh thistle and Leoncita false-foxglove occurred on permanently saturated soils associated to shallow groundwater. Reduced salinities during the spring were important for the three species. My results provide new plant life history information and insight on the abiotic processes needed to support their abundance. This information will guide management strategies to enhance their abundance and prevalence in the long term, as well as restoration efforts in areas where their populations are unstable or have been extirpated.

DOI: 10.31390/gradschool_theses.5407

de Leija, A.C., King, S.L. and Hawkins, T.S., 2022. Seed germination responses to salinity for three rare wetland plants of spring-fed arid systems. *Journal of Arid Environments*, 199, p.104705.

Keywords: arid wetlands, halophytes, salinity, seed germination, rare plants, ciénega

Abstract: Spring-fed wetlands within arid systems host unique species of plants, many of which are threatened due to the vulnerability of these ecosystems. Increased salinity and drier hydrologic regimes due to anthropogenic activities threaten these systems. Furthermore, limited knowledge regarding key life history traits of species jeopardize the restoration and management of their rare plants. Here, we evaluated key aspects of the seed ecophysiology of three rare plants of the Southwestern United States: *Helianthus paradoxus* (Pecos sunflower), *Cirsium wrightii* (Wright's marsh thistle), and *Agalinis calycina* (Leoncita false-foxglove). We examined seed dormancy break under controlled conditions and evaluated the effects of field-derived salinity gradients on seed dormancy break and germination. Seeds of *C. wrightii* were nondormant at dispersal, germination was high (>70%) under all treatments and was not affected by the tested salinities. Germination in *H. paradoxus* was high (>70%) following cold stratification, but increasing salinities reduced germination. *A. calycina* seeds required cold stratification, but germination was low (<50%) under all tested treatments and increasing salinities during incubation had the greatest negative effects in this species. Our findings contribute to the restoration of rare wetland plants within spring-fed arid marshes susceptible to groundwater declines and human-induced salinization.

DOI: 10.1016/j.jaridenv.2021.104705

Friggens, M., 2021. Using Vulnerability Assessments to Strengthen Climate-Adaptive Conservation Response to Climate Change. *Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*, p.140.

Keywords: N/A, book chapter

Abstract: N/A, book chapter

DOI: URL: https://uapress.arizona.edu/book/renewing-our-rivers

Garrett, G., Roberson, A. and Bennett, J., 2021. Reintroduction of the Rio Grande Silvery Minnow in the Rio Grande Basin. ***Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*****, p.292.**

Keywords: N/A, book chapter

Abstract: N/A, book chapter

DOI: URL: https://uapress.arizona.edu/book/renewing-our-rivers

Goetz, A., Moffit, I. and Sher, A.A., 2022. Recovery of a native tree following removal of an invasive competitor with implications for endangered bird habitat. *Biological Invasions*, 24(9), pp.2769-2793.

Keywords: *Empidonax traillii extimus*, *Salix*, *Tamarix*, birds, canopy, climate, ecological restoration, habitat conservation, habitats, indigenous species, invasive species, trees, vegetation, water stress, Southwestern United States

Abstract: Invasive species removal is a common focus in restoration ecology, but the ultimate goal of native plant species recovery and habitat recovery is often elusive. Control of invasive *Tamarix spp.* shrubs in the American Southwest has only sometimes led to increased native species cover; this is of particular concern for the protection of bird habitat, including the endangered Southwestern willow flycatcher (*Empidonax extimus traili*i, abbr. SWFL) that nests readily in *Tamarix* when native *Salix* canopy is absent. If we can identify the conditions that lead to more native trees as well as habitat protection for the SWFL, we can prioritize restoration efforts more effectively and reduce conflict between conservation goals. To determine whether reduction in the invasive *Tamarix* led to more *Salix* cover, we compiled data on vegetation, soils, and geographic conditions in 260 sites where *Tamarix* had been subject to control efforts and 132 positive and negative reference sites. We found that (1) reduction in *Tamarix* only increased *Salix* cover in wetter sites and was greater when a particular low-disturbance removal method was used; however, the increase did not typically compensate for the overall losses in canopy cover, and (2) *Salix* cover was generally highest in locations with low drought stress, as reflected by soil properties, distance to water, and climate. These results suggest that the presence and recovery of *Salix* is dependent on its relatively narrow environmental niche, in contrast with *Tamarix*'s broader one. Thus, although abundance of *Salix* and *Tamarix* was negatively correlated, this is likely because of *Salix*'s different niche, as much as or more than direct interspecific competition. Our findings demonstrate that removal of an invasive species does not necessarily lead to reestablishment of the native species they appeared to displace. We suggest that in the case of promoting habitat for SWFL and other birds, outcomes of restoration activity can be improved by focusing *Tamarix* removal efforts on sites more likely to promote *Salix* growth based on environmental characteristics.

DOI: 10.1007/s10530-022-02805-7

Holmes, R.N., Mayer, A., Gutzler, D.S. and Chavira, L.G., 2022. Assessing the effects of climate change on middle Rio Grande surface water supplies using a simple water balance reservoir model. *Earth Interactions*, 26(1), pp.168-179.

Keywords: Watersheds; Climate change; Water budget/balance; Hydrologic models

Abstract: The middle Rio Grande is a vital source of water for irrigation in the region. Climate change is impacting regional hydrology and is likely to put additional stress on a water supply that is already stretched thin. To gain insight on the hydrologic effects of climate change on reservoir storage, a simple water balance model was used to simulate the Elephant Butte–Caballo Reservoir system (southern New Mexico). The water balance model was forced by hydrologic inputs generated by 97 climate simulations derived from CMIP5 global climate models, coupled to a surface hydrologic model. Results suggest that the percentage of years that reservoir releases satisfy agricultural water rights allocations over the next 50 years (2021–70) will decrease relative to the past 50 years (1971–2020). The modeling also projects an increase in multiyear drought events that hinder reservoir management strategies to maintain high storage levels. In most cases, changes in reservoir inflows from distant upstream snowmelt is projected to have a greater influence on reservoir storage and water availability downstream of the reservoirs than will changes in local evaporation and precipitation from the reservoir surfaces.

DOI: 10.1175/EI-D-21-0025.1

Johnson, C.A. and Benson, T.J., 2022. Dynamic occupancy models reveal Black-billed and Yellow-billed Cuckoos have high rates of turnover during the breeding season. *Ornithological Applications*, 124(3), p.duac021.

Keywords: *Coccyzus americanus*, cryptic species, habitats, immigration, insects, probability, surveys, temperature, vocalization, Illinois

Abstract: Understanding the conservation needs of rare and hard-to-detect species becomes even more difficult when a species is highly mobile. Black-billed Cuckoos (*Coccyzus erythropthalmus*) and Yellow-billed Cuckoos (*Coccyzus americanus*) have experienced extensive range-wide population declines over the last several decades. Low detection probability has made it hard to determine causes of declines and resulted in poorly supported population and trend estimates. However, given evidence that cuckoos make wide-ranging movements during the breeding season, it may be necessary to address issues of both low vocalization rate and availability for detection to better understand these cryptic species. We performed passive and call-broadcast surveys for cuckoos at 41 sites across northern Illinois in 2019 and 2020. We examined the influence of call broadcast and temporal and environmental covariates on detection probability and how habitat covariates affected occupancy, immigration, and emigration both within and among sites. Individual detection probability increased substantially using call broadcasts (12 and 6 times for Black-billed and Yellow-billed Cuckoos, respectively) and detection increased with temperature. Black-billed Cuckoo detection probability also varied temporally, being lowest in the middle of the breeding season. We found strong support for turnover within sites during the breeding season, indicating maintenance of large home ranges, as well as among sites (average emigration probability of 86% and 47% for Black-billed and Yellow-billed Cuckoos, respectively). Black-billed Cuckoos were more likely to use open, shrubby sites and Yellow-billed Cuckoos to use sites with older successional habitat. While turnover rate was affected by habitat covariates, these species' reliance on ephemeral insect abundance may ultimately be driving occupancy dynamics. Our results suggest that broadcasts are essential for effectively monitoring these cuckoos, but also imply the need to move towards coordinating management at broader spatial scales for these highly mobile species.

DOI: 10.1093/ornithapp/duac021

Londono-Gaviria, M., 2022. Low site-specific genomic variability is consistent with the history(s) of fragmentation of the riparian biota of the arid Southwest (Masters Thesis, University of New Mexico).

Keywords: conservation genomics, genomic drift, genotype-environment associations, local adaptation, meadow jumping mouse, population divergence, *Zapus luteus*

Abstract: Persistently low population sizes, when coupled with reduced interpopulation connectivity, can impede the long-term viability of species in fragmented landscapes. Riparian-associated species in the arid American Southwest now face a series of threats due to fragmented populations and changing environmental conditions. During the last century, riparian habitats have deteriorated due to the synergistic effects of livestock grazing, increasing incidence of fire, and other anthropogenic impacts potentially have made local populations smaller, less demographically stable, and susceptible to the negative impacts of genetic drift and stochastic events. We evaluated genomic variation within and across geographic areas (i.e., mountain ranges and river systems) in the federally endangered New Mexico meadow jumping mouse (*Zapus luteus luteus*) using neutral and outlier loci to test whether observed genomic variation was influenced by 1) historical allopatric divergence, 2) recent anthropogenic fragmentation, or 3) both of these factors. We sampled 145 specimens from across the range of *Z. l. luteus* and 44 samples of co-distributed, closely related taxa and obtained over 8,800 single nucleotide polymorphisms. Combining insights from population genomics and phylogenomics, we found that eight geographic areas that are significantly differentiated from one another and have exceptionally low variability and low effective population sizes (fewer than 50 effective individuals in most cases). These lineages, however, reflect a biogeographic history that is mismatched with hypothesized riparian connectivity, but instead point to possible mitonuclear discordance. Additionally, each lineage has genomic variation consistent with expectations of adaptation to local conditions. Combined, these results suggest that there may be insufficient genomic variation in these distinctive jumping mice populations necessary to sustain viable populations without active management efforts. This improved understanding of how drift and selection have likely shaped the genomic structure of this endangered mammal provides a foundation to develop thoughtful management decisions.

DOI: URL: https://digitalrepository.unm.edu/biol_etds/360/

Lyman, J.A., Sanchez, D.E., Hershauer, S.N., Sobek, C.J., Chambers, C.L., Zahratka, J. and Walker, F.M., 2022. Mammalian eDNA on herbaceous vegetation? Validating a qPCR assay for detection of an endangered rodent. *Environmental DNA*, 4(5), pp.1187-1197.

Keywords: N/A

Abstract: Vegetation is an underutilized medium for environmental DNA (eDNA) sampling. eDNA methods leveraging water as a substrate exclude application to many terrestrial species. The use of eDNA to detect small mammals can complement current survey approaches (live capturing, track plating, and camera trapping) while reducing risks to the animals. The endangered New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is specialized to herbaceous riparian zones, making it an ideal candidate for developing a terrestrial eDNA detection method. We developed a species-specific assay for quantitative real-time PCR, then tested the long-term persistence of jumping mouse eDNA on plant material using four herbaceous day nests collected three to six months after occupancy. We conducted a field trial using sterile cotton swabs at six locations along two occupied streams to evaluate our assay's capability to detect present-day eDNA. Each of 60 swabs was used to swab a 0.50 m2 area along streamside transects that included vegetation such as forbs, grasses, and sedges. We also opportunistically swabbed plants (n = 9) following visual observation of jumping mice. We determined the limit of detection for both assays are fewer than eight copies per reaction. We detected eDNA in three of four nests. From field trial samples, we successfully detected the species from randomly swabbed vegetation (N = 3), and four of nine swabs from vegetation recently used by individuals. Further work is required to develop a robust survey method using this eDNA detection approach. Our study demonstrated that mammalian eDNA can persist on nest vegetation long after the animal was present, highlighting the promise of using eDNA from plants to detect rare or endangered terrestrial species.

DOI: 10.1002/edn3.331

Mahoney, S.M., Pasch, B. and Theimer, T.C., 2021. Subspecies discrimination based on song structure by Willow Flycatchers. *Journal of Field Ornithology*, 92(2), pp.173-183.

Keywords: behavioral isolation, *Empidonax traillii*, playback experiment, reproductive isolation, suboscine

Abstract: Animals use acoustic signals to repel competitors and attract mates, and signal divergence among populations can promote reproductive isolation. *Empidonax* flycatchers are insectivorous songbirds distributed across North and Central America that are conservative in plumage, but often exhibit differences in songs both among and within species. Four subspecies of Willow Flycatchers (*Empidonax traillii*) have been recognized and previous analyses have revealed differences in song structure among a subset of these subspecies. Using reciprocal playback experiments in the field, we tested for subspecific song discrimination among these four putative subspecies of Willow Flycatchers. We found that three subspecies (*E. t. adastus*, *E. t. brewsteri*, and *E. t. traillii*) responded similarly to their own songs and those of each other, but all three subspecies responded significantly less aggressively to songs of the southwestern subspecies (*E. t. extimus*). In contrast, the southwestern subspecies (*E. t. extimus*) responded significantly more aggressively to its own song than to those of the other three subspecies. Our results indicate that behavioral responses reflect differences in song structure among subspecies; subspecies responded more strongly to songs of subspecies with similar structures, less strongly to songs most different in structure, and the subspecies with the most distinctive song (*E. t. extimus*) responded less to songs of the other three subspecies. If responses of males to songs reflect relative reproductive compatibility within and among subspecies, songs may contribute to reproductive isolation of the four subspecies of Willow Flycatchers.

DOI: 10.1111/jofo.12366

McDaniel, K.C. and Bunting, D.P., 2021. Controlling Tamarisk Monocultures at the Bosque Del Apache National Wildlife Ref-uge: Lessons Along the Middle Rio Grande, New Mexico. *Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*, p.244.

Keywords: N/A, book chapter

Abstract: N/A, book chapter

DOI: URL: https://uapress.arizona.edu/book/renewing-our-rivers

McLain, K., 2022. Hydrological Controls on Flow Conveyance Losses on the Middle Rio Grande (Doctoral dissertation, New Mexico Institute of Mining and Technology).

Keywords: Middle Rio Grande, conveyance, seepage, aquifer, drying, San Acacia

Abstract: The San Acacia reach of the Middle Rio Grande experiences high conveyance losses throughout the year that vary greatly based on local features, seasonal flow variability, and regional influences. Variability in loss rates are driven by hydrogeological differences, topographical differences, and vegetative differences throughout the region, with some sub-reaches occasionally gaining flow and some sub reaches frequently losing 100% of flow. Manual water table measurements of wells in the riparian corridor at seven transects were conducted for a full year, and pressure transducer data from the same wells from 2016-2021 were used to continuously monitor the groundwater table. Three USGS discharge gauges (San Acacia, Highway 380, and San Marical) were used to calculate ”virtual seepage runs”, allowing for differentiation of loss rates between these sub-regions. Summer drying events provide insight into the most critical reaches, and close analysis of water table trends within these areas can provide further indications of the controlling local features. Summer drying typically spanned from just north of the Brown Arroyo area to an location between San Marcial and South Fort Craig. This region is the ”critical” section of the reach. Inside of this zone, variations in water table gradients and other local features affect loss rate strongly. From north to south, the region from San Acacia to Escondida was the least critical, with a transitional zone below it from Escondida to Brown Arroyo. Between the previous stretch and the one below, from Brown Arroyo to Highway 380, the intensity of water table gradients increased, particularly between the Rio Grande and the Low Flow Conveyance Channel (LFCC). Then from the Highway 380 area to the southern end of the Bosque del Apache, the most extreme losses in the reach were seen. This is also the area with the steepest gradient between the Rio Grande and the LFCC and the steepest gradient between the Rio Grande and eastern bosque. Losses likely decreased from South Bosque Boundary to San Marcial, associated in decreases in water table gradients. From the South Bosque Boundary, the gradient between the Rio Grande and the LFCC gradually decreases until the LFCC becomes higher than the Rio Grande at river mile 64.4, the end of the summer drying extent.

DOI: URL: https://www.proquest.com/openview/4d163ea8af28f0e2767528838bc3f20b/1?pq-origsite=gscholar&cbl=18750&diss=y

Owens, G.L., Todesco, M., Huang, K. and Rieseberg, L.H., 2022. Re-evaluating homoploid reticulate evolution in the annual sunflowers. *bioRxiv*, pp.2022-10.

Keywords: N/A

Abstract: Sunflowers of the genus *Helianthus* are models for hybridization research and contain three of the best studied examples of homoploid hybrid speciation. To understand the broader picture of hybridization within the annual sunflowers, we used whole genome resequencing to conduct a phylogenomic analysis and test for gene flow between lineages. We find that all annual sunflower species tested have evidence of admixture, suggesting hybridization was common during the radiation of the genus. Support for the major species tree decreases with recombination rate, consistent with hybridization and introgression contributing to discordant topologies. Admixture graphs found hybridization to be associated with the origins of the three putative hybrid species (*H. anomalus*, *H. deserticola*, and *H. paradoxus*). However, the hybridization events are more ancient than suggested by previous work. Furthermore, *H. anomalus* and *H. deserticola* appear to have arisen from a single hybridization event involving an unexpected donor, rather than through multiple independent events as previously proposed. Using a broader data set that covers the whole *Helianthus* genus, including perennial species, we find that signals of introgression span the genus and beyond, suggesting highly divergent introgression and/or the sorting of ancient haplotypes. Thus, *Helianthus* can be viewed as a syngameon in which largely reproductively isolated species are linked together by occasional or frequent gene flow.

DOI: 10.1101/2022.10.14.512273

Rodriguez, G., 2021. Impact of Riverside Drains on Surface-Water and Ground Water Interactions in the Middle Rio Grande, New Mexico: Implications to the Sustainability of Native Cottonwoods (*Populus deltoides ssp. wislizenii*) and Native Species.

Keywords: Rio Grande, bosque, cottonwood, riparian

Abstract: The Middle Rio Grande riparian zone, named the Bosque, provides cultural, aesthetic, environmental, recreational, and historical value to the residents of the Middle Rio Grande valley. Most of the Bosque has not experienced successful native cottonwood (*Populus deltoides ssp. wislizenii*) recruitment since the completion of the Cochiti reservoir and most of the Bosque cottonwood forest is senescing. This decline of the native species in the Bosque can be attributed to highly managed hydrology of the riparian zone. The levees and agricultural drains managed by the Middle Rio Grande Conservancy District (MRGCD), that borders both sides of the river, also affect the integrity of the Bosque. While the relationship between river stage and ground water level is well understood, the effects of the riverside drains on ground water level and bank storage are less understood. This study uses shallow monitoring well data and river stage data to evaluate the impact of the riverside drains on bank storage, ground water elevation, and the decline of bank storage. These factors affect cottonwood recruitment and native riparian integrity. The study compares the riverside drain on the east side of the San Juan Chama Drinking Water Project diversion dam to the riverside drain on the west, which is shallower, using time series analyses to evaluate the influence the riverside drain has on the native cottonwoods . Comparison of ground water depth measurement from monitoring wells on the west side of the river to those on the east side of the river, installed and monitored by the Bosque Ecosystem Monitoring Program (BEMP), indicate that the agricultural drain and, its induced artificial hydraulic gradient sloping away from the river, is causing the water table to drop below the 3 m at one site, ground water depth where the physiological condition of native cottonwood (decline, resulting in mortality in some individual trees. The agricultural drain has also increased the bank storage decline from a level that promotes optimal growth of cottonwood seedlings of 3 cm/day to a high of 20 cm/day occurring during a high water event in 2017 (Heller 2018).

DOI: URL: https://digitalrepository.unm.edu/wr_sp/196/

Rozanski, C.A., 2021. The importance of fluvial geomorphology and watershed restoration for the New Mexico jumping mouse (Doctoral dissertation, Northern Arizona University).

Keywords: endangered species management, fluvial geomorphology, riparian, watershed restoration, wildlife ecology, *Zapus hudsonius luteus*, New Mexico Jumping Mouse, White Mountains (Ariz.), Habitat

Abstract: The New Mexico jumping mouse (*Zapus luteus luteus*, formerly New Mexico meadow jumping mouse, *Zapus hudsonius luteus*) is a federally endangered small mammal that persists in isolated populations in Arizona, New Mexico, and Colorado. This riparian obligate requires dense, structurally diverse riparian vegetation and perennial flowing water. Alterations to the natural fluvial conditions of a watershed can directly affect the quality of riparian habitat available. Stream geomorphic data is used to describe the condition of fluvial processes, riparian habitat, and floodplain creation and maintenance. The purpose of this study was to determine the effects of local fluvial geomorphology on use of streams by the New Mexico jumping mouse in the southwest United States. In 2020, we collected geomorphic data from 58 stream reaches in montane meadows and forests in the White Mountains of eastern Arizona. Stream reaches that supported the presence of jumping mice (n = 31), compared to those that did not (n = 27), had a greater median bed material size (D50), greater sinuosity, lower bank-height ratio, channel evolution stage I, IV, or V, lower width-depth ratio and slope, and a greater width flood prone area, meander-width ratio, and entrenchment ratio. D50, sinuosity, and bank-height ratio were strong predictors of presence. Channel evolution stage, width flood prone area, and entrenchment ratio were of moderate predictive importance. Width-depth ratio, stream type, meander-width ratio, and slope were weak predictors. As bank-height ratio increased, the probability of presence of jumping mice at a site decreased. In contrast, as median bed material size and sinuosity increased, the likelihood of use by jumping mice increased. Streams that are actively degrading due to bank erosion can exhibit an increasing bank-height ratio and may also see a decrease in sinuosity and bed particle size (D50) over time. Channel incision can contribute to a drop in the water table, disconnection of the channel from the historic floodplain, and shift the plant community from riparian to upland associated species. Riparian areas are an important resource, especially in the arid Southwest. Changes in habitat management should incorporate watershed restoration actions that improve long-term channel stability, eliminate sources of degradation, and support geomorphic and hydrologic conditions that are foundational to the creation and maintenance of riparian habitat.

DOI: URL: https://openknowledge.nau.edu/id/eprint/5657/

Ruegg, K., Anderson, E.C., Somveille, M., Bay, R.A., Whitfield, M., Paxton, E.H. and Smith, T.B., 2021. Linking climate niches across seasons to assess population vulnerability in a migratory bird. *Global Change Biology*, 27(15), pp.3519-3531.

Keywords: N/A

Abstract: Global loss of biodiversity has placed new urgency on the need to understand factors regulating species response to rapid environmental change. While specialists are often less resilient to rapid environmental change than generalists, species-level analyses may obscure the extent of specialization when locally adapted populations vary in climate tolerances. Until recently, quantification of the degree of climate specialization in migratory birds below the species level was hindered by a lack of genomic and tracking information, but recent technological advances have helped to overcome these barriers. Here we take a genome-wide genetic approach to mapping population-specific migratory routes and quantifying niche breadth within genetically distinct populations of a migratory bird, the willow flycatcher (*Empidonax traillii*), which exhibits variation in the severity of population declines across its breeding range. While our sample size is restricted to the number of genetically distinct populations within the species, our results support the idea that locally adapted populations of the willow flycatcher with narrow climatic niches across seasons are already federally listed as endangered or in steep decline, while populations with broader climatic niches have remained stable in recent decades. Overall, this work highlights the value of quantifying niche breadth within genetically distinct groups across time and space when attempting to understand the factors that facilitate or constrain the response of locally adapted populations to rapid environmental change.

DOI: 10.1111/gcb.15639

Samimi, M., Mirchi, A., Townsend, N., Gutzler, D., Daggubati, S., Ahn, S., Sheng, Z., Moriasi, D., Granados-Olivas, A., Alian, S. and Mayer, A., 2022. Climate change impacts on agricultural water availability in the Middle Rio Grande basin. ***Journal of the American Water Resources Association*****, 58(2), pp.164-184.**

Keywords: climate change, Soil and Water Assessment Tool, Rio Grande; irrigated agriculture, groundwater depletion, water sustainability

Abstract: We present a comprehensive analysis of water availability under plausible future climate conditions in a heavily irrigated agricultural watershed located in the middle section of the Rio Grande Basin in the United States Desert Southwest. Future managed streamflow scenarios (through year 2099) were selected from among 97 scenarios developed based on downscaled, bias-corrected global climate model outputs to evaluate future inflows to the principal surface water storage reservoirs, possible future reservoir releases, and groundwater pumping to sustain irrigated agriculture. The streamflow projections describe a wide range of dry and wet conditions compared to the average historical flows in the river, indicating significant uncertainty in future water availability in the Rio Grande Basin. We applied the Soil and Water Assessment Tool to illustrate the impact of climate futures on different components of the water budget at a watershed scale. Results indicate declining reliability of reservoir storage to meet the water demand of irrigated agriculture. The impact of declining surface water can be offset by increasing the pressure on the already-strained groundwater resources. However, the region should be prepared to use slightly saline (total dissolved solids [TDS] > 1,000 mg/L) and moderately saline groundwater (TDS > 3,000 mg/L) as fresh groundwater in the regional aquifer is depleted within the 21st Century under hotter and drier conditions and status quo agricultural land and water management practices.

DOI: 10.1111/1752-1688.12988

Stanek, J.E., Mcneil, S.E., Tracy, D., Stanek, J.R., Manning, J.A. and Halterman, M.D., 2021. Western Yellow-Billed Cuckoo Nest-Site Selection and Success in Restored and Natural Riparian Forests. ***The Journal of Wildlife Management*****, 85(4), pp.782-793.**

Keywords: N/A

Abstract: The western distinct population segment of yellow-billed cuckoo (*Coccyzus americanus*; western cuckoo) has been extirpated from most of its former breeding range in the United States because of widespread loss and degradation of riparian cottonwood (*Populus spp.*)-willow (*Salix spp.*) forests. Restoration and management of breeding habitat is important to the recovery of this federally threatened species, and identification of high-quality breeding habitat can help improve the success of recovery. In 2005, the Lower Colorado River Multi-Species Conservation Program, a long-term, multi-agency effort, was initiated to maintain and create wildlife habitat within the historical floodplain of the lower Colorado River (LCR) for federally endangered and threatened species, including western cuckoos. We conducted an empirical, multi-scale field investigation from 2008–2012 to identify habitat characteristics selected by nesting western cuckoos along the LCR. Multiple logistic regression models revealed that western cuckoos selected nest sites characterized by increased densities of small, native, early successional trees measuring 8–23 cm diameter at breast height, and lower diurnal temperature compared to available habitat in restoration and natural forests. Nesting cuckoos selected sites with increased percent canopy closure, which was also important for nest success in restoration sites along the LCR. Our results show habitat components selected by nesting western cuckoos in restoration and natural riparian forests and can help guide the creation, enhancement, and management of riparian forests with habitat conditions necessary to promote nesting of western cuckoos.

DOI: 10.1002/jwmg.22020

Tashjian, P., 2021. The Partnerships. ***Renewing Our Rivers: Stream Corridor Restoration in Dryland Regions*****, p.205.**

Keywords: N/A, book chapter

Abstract: N/A, book chapter

DOI: URL: https://uapress.arizona.edu/book/renewing-our-rivers

Torell, G.L., Lee, K.D., Garnica, L.A., Mayer, A.S. and Ward, F.A., 2022. Least-Cost Provision of Ecosystem Services from Water: When, Where, and How Much? ***Journal of Water Resources Planning and Management,*** **148(2), p.04021100.**

Keywords: N/A

Abstract: Changes in surface or groundwater management influence water use patterns as well as the economic value and sustainability of all water uses. In water-scarce regions, programs that establish environmental flows usually involve reallocating water from another productive use. Few peer-reviewed papers to date have investigated impacts on system-wide economic performance resulting from environmental flow regimes. This work presents an original approach to address that gap by developing and applying a basin-scale hydroeconomic optimization model of North America's Middle Rio Grande Basin to explore impacts of environmental pulse flows on the region's economy and water stocks. The model accounts for surface and groundwater storage, irrigation, urban, recreational, and environmental demands; surface water inflows under various climate scenarios; groundwater pumping and recharge; substitute water prices; crop water use; evaporation; as well as institutional constraints governing water use. Results show that climate change, in the form of highly variable inflows, has an impact on the total and marginal cost of implementing environmental pulse flows, amplified by the conjunctive nature of the system.

DOI: 10.1061/(ASCE)WR.1943-5452.0001511

Van Horn, D.J., Reale, J.K. and Archdeacon, T.P., 2022. Water quality in three potential drought refuges in an arid-land river: assessing habitat suitability for at-risk fish species. ***Knowledge & Management of Aquatic Ecosystems*****, (423), p.7.**

Keywords: N/A

Abstract: Drought is a common disturbance in arid-land streams and rivers. The survival of aquatic species depends on access to refuge habitats where water quality remains high. Over the past century, modified flow regimes and altered watershed and instream characteristics have led to the extinction and endangerment of numerous fish species endemic to the southwestern United States. We assessed the water quality of potential drought refuges in the Middle Rio Grande (MRG), with an emphasis on suitability for the endangered Rio Grande Silvery Minnow (RGSM). We examined three types of potential drought refuges: three agricultural return drain outfalls; three isolated pools that remained during streamflow intermittency; and a reach with perennial flow below an agricultural diversion dam. All potential refuges are known to contain RGSM and other fishes. Two out of three drain outfalls, one out of three isolated pools, and three out of ten kilometers of perennially wetted stream below a dam met basic water quality criteria necessary to support RGSM populations. These findings suggest that refuge habitability is context dependent, that generalizations regarding the suitability of a specific refuge type should be avoided, and that careful assessment is required to determine if a specific location will support fish assemblages. Although some areas may contain water, they may represent ecological traps if fish are exposed to poor water quality conditions compared to other potential refuge habitats.

DOI: doi.org/10.1051/kmae/2022002

Walsworth, T.E. and Budy, P., 2021. An empirically based simulation model to inform flow management for endangered species conservation. ***Canadian Journal of Fisheries and Aquatic Sciences*****, 78(12), pp.1770-1781.**

Keywords: N/A

Abstract: Increasing water demand, water development, and ongoing climate change have driven extensive changes to the hydrology, geomorphology and biology of arid-land rivers globally, driving an increasing need to understand how annual hydrologic conditions affect the distribution and abundance of imperiled desert fish populations. We analyzed the relationship between annual hydrologic conditions and the endangered Rio Grande silvery minnow (*Hybognathus amarus*) in the Middle Rio Grande, New Mexico, USA, using hurdle models to predict both presence and density as a function of integrated annual hydrologic metrics. Both presence and density were positively related to spring high flow magnitude and duration and negatively related to summer drying, as indicated by an integrated flow metric. Simulations suggest hydrologic conditions near the wettest observed in the data set would be required to meet recovery goals in a single year in all reaches. We demonstrate how the models developed herein can be used to examine alternative water management strategies, including strategies that may currently be socially and logistically infeasible to implement, to identify strategies minimizing trade-offs between conservation and other management goals.

DOI: doi.org/10.1139/cjfas-2020-0353

Wohner, P.J., Laymon, S.A., Stanek, J.E., King, S.L. and Cooper, R.J., 2021. Challenging our understanding of western Yellow-billed Cuckoo habitat needs and accepted management practices. *Restoration Ecology*, 29(3), p.e13331.

Keywords: California, natural regeneration, restoration, South Fork Kern River Valley, spot mapping, successional dynamics, vertical structure

Abstract: Riparian restoration in the southwestern United States frequently involves planting cottonwood (*Populus spp.*) and willow (*Salix spp.*). In the absence of flooding and gap-forming disturbance, planted forests often senesce without further young tree recruitment. This has largely been the case in California riparian systems that historically supported state-endangered western Yellow-billed Cuckoo (*Coccyzus americanus*; Cuckoo). A decline in Cuckoo population numbers in the past 30 years has been associated with forest maturation. Other riparian species of concern show a concomitant decline, indicating the problem is not specific to Cuckoos. Although varying hypotheses exist for recent decline, alternative management practices have not been sufficiently explored to rule out breeding ground habitat quality as a major contributing factor. Few intensive Cuckoo datasets exist to test hypotheses about breeding habitat quality due to extremely low populations in the remaining occupied sites. We used a historical (1986–1996) spot mapping dataset from the South Fork Kern River Valley, CA to identify vegetation characteristics related to Cuckoo and five other sensitive riparian bird territory densities. We found Cuckoo densities were positively associated with increased vertical vegetative structure 1–5 m above ground with a threshold for mean tree height. Sensitive species densities were also related to vertical structure and started to decline with stand height greater than 6–8 m. Naturally regenerated sites had higher densities of most sensitive bird species than planted sites. We provide ideas for restoring mature forest with little vertical structure.

DOI: doi.org/10.1111/rec.13331

Wohner, P.J., Laymon, S.A., Stanek, J.E., King, S.L. and Cooper, R.J., 2021. Early successional riparian vegetation is important for western Yellow-billed Cuckoo nesting habitat. *Restoration Ecology*, 29(5), p.e13376.

Keywords: canopy cover, dbh, forbs, large insect prey, riparian forest, South Fork Kern River Valley, willow

Abstract: Western Yellow-billed Cuckoo (Cuckoo; *Coccyzus americanus*) populations continue to decline in the western United States despite efforts to increase availability of riparian forest. Cuckoos have unique breeding habitat requirements such as large contiguous tracts of riparian forest (>80 ha), large estimated home ranges (20–90 ha), and dense vertical structure around the nest. However, local habitat-scale features may be missing in landscapes of predominantly mature riparian forest that may need to be specifically managed for nesting. We used historical nest data (n= 95) from the South Fork Kern River Valley, California, from 1985 to 1996 to identify important nest site features that may be missing in current riparian forests. We found that increased canopy cover and vertical structure at all levels in the canopy greatly increased the probability of Cuckoo nesting. With smaller estimated effect sizes, the probability of Cuckoo nesting increased with increasing willows and forbs and smaller mean tree dbh. Cuckoos selected plots with disproportionately high percent willow cover relative to availability plots regardless of whether sites had low or high percent willow available. Counts of fledged young were positively related to willow percentage. No vegetation variable influenced daily survival rate which was 0.991 (LCI = 0.980, UCI = 0.996). Overall 17-day nest success was likely high (0.86, LCI = 0.71, UCI = 0.93). In the absence of natural processes that create early successional stage forest, specific management for early successional stage forest is needed to increase the probability of Cuckoo nesting and nest productivity.

DOI: doi.org/10.1111/rec.13376

Yackulic, C.B., Archdeacon, T.P., Valdez, R.A., Hobbs, M., Porter, M.D., Lusk, J., Tanner, A., Gonzales, E.J., Lee, D.Y. and Haggerty, G.M., 2022. Quantifying flow and nonflow management impacts on an endangered fish by integrating data, research, and expert opinion. *Ecosphere*, 13(9), p.e4240.

Keywords: adaptive management, Bayesian model selection, Beverton–Holt, condition-dependent management, Delphi method, designer flows, floodplain restoration, forecasting, intermittency, natural flow paradigm, out-of-sample prediction, stock assessment, stocking

Abstract: Managers charged with recovering endangered species in regulated river segments often have limited flexibility to alter flow regimes and want estimates of the expected population benefits associated with both flow and nonflow management actions. Disentangling impacts on different life stages from concurrently applied actions is essential for determining the effectiveness of each action, but difficult without models that integrate multiple information sources. Here, we develop and fit an integrated population model for endangered Rio Grande Silvery Minnow (*Hybognathus amarus*) in the Middle Rio Grande, New Mexico. We integrate catch per unit effort monitoring data collected during 2002–2018 with population estimates, data collected during rescue of minnow from drying pools, habitat availability estimates, laboratory results, releases of hatchery reared minnow, and expert opinion. We use expert elicitation to develop a larval carrying capacity index as an informed proxy for the complex interactions among flow, habitat, and life history in this species. We evaluate the model using out-of-sample forecasts of 2019 and 2020, develop an algorithm to identify supplemental water releases that maximize benefits to the minnow, and quantify the effectiveness of various actions. Experts generally agreed on the duration and timing of flow requirements and disagreed regarding the importance of different magnitudes. The integrated model with the larval carrying capacity index outperformed two alternative models in forecasting catch in 2019 and 2020. The model estimates that minnow abundance varied by more than three orders of magnitude between 2002 and 2018 and that in a few years recruitment was limited by spawner abundance. Evaluation of the expected benefits of flow and nonflow management actions to fall population abundance across different years suggests that efficient addition of water to the base hydrograph is the most effective action in most, but not all years. Many actions are effective only under certain hydrologic and population conditions and the effectiveness of different actions varies in different sections of the study area. Widespread water extraction and river regulation combined with periodic drought and ongoing climate change may necessitate creative management of federally listed fish species in arid systems informed by thorough analyses of management effectiveness.

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