Middle Rio Grande Endangered Species Collaborative Program

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Keywords: N/A

Abstract: We surveyed for Southwestern Willow Flycatchers (*Empidonax traillii extim*us; flycatcher) at five survey areas within the City of Carlsbad Preserve, Carlsbad, California, in 2022. Three flycatcher surveys were completed between May 18 and June 29, 2022. Territorial or transient flycatchers were not observed at the City of Carlsbad Preserve in 2022.

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Alhajeri, B. H. 2023. Cranial Geometric Morphometrics of Jumping Mice (Genera: *Eozapus, Napaeozapus,* and *Zapus*; Zapodinae, Rodentia): Implications for Subspecies Conservation. Journal of Mammalian Evolution 30(3): 713-734. doi: 10.1007/s10914-023-09666-4.

Keywords: *Eozapus*, *Napaeozapus*, North America, *Sicista, Zapus, Zapus hudsonius preblei*

Abstract: Jumping mice (subfamily Zapodinae) occur across most of North America (*Zapus* and *Napaeozapus*) and in confined regions in China (*Eozapus*). Recent molecular phylogenies have revised their taxonomy, raising some subspecies to full species and synonymizing others. This taxonomic revision has implications for subspecies conservation and management, since *Z. hudsonius preblei* and *Z. h. luteus* are legally protected by the United States federal Endangered Species Act (ESA), while *Z. h. campestris* and *Z. trinotatus orarius* are conserved in parts of their range. Several molecular studies have either synonymized *Z. h. preblei* with *Z. h. campestris* (and *Z. h. intermedius*) or grouped it with *Z. h. alascensis* and *Z. h. tenellus* as a widely distributed "Northern" lineage, arguing against its continued legal protection. However, genetic differentiation is a proxy for historical but not always adaptive distinctiveness, and the ESA considers both for conservation (i.e., Evolutionarily Significant Units). This study uses geometric morphometrics to compare adaptive distinctiveness of jumping mice subspecies. This compares scaled cranial shape, leading to insights that differ from linear measurements. For broader insights, cranial morphology was compared within jumping mice and with the closely related birch mice. Subspecies pairs within the three traditionally accepted *Zapus* species were ranked in order morphometric distinctiveness. The most distinct pair was found to be *Z. h. preblei* vs. *Z. h. alascensis*, members of the same genetic lineage. Other morphometrically distinct subspecies pairs were parts of the same or different genetic lineages, some having been elevated to full species. Other members of especially distinct pairs include *Z. princeps oregonus*, *Z. p. saltator*, *Z. p. cinereus*, *Z. p. minor*, *Z. p. pacificus*, and *Z. p. idahoensis*. Other aspects of adaptive distinctiveness should be examined in these subspecies for validation and to prioritize conservation efforts.

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Ansley, R. J., V. H. Rivera-Monroy, K. Griffis-Kyle, B. Hoagland, A. Emert, T. Fagin, S. R. Loss, H. R. McCarthy, N. G. Smith, and E. F. Waring. 2023. Assessing Impacts of Climate Change on Selected Foundation Species and Ecosystem Services in the South-Central USA. Ecosphere 14(2): e4412. doi: 10.1002/ecs2.4412.

Keywords: climate adaptation, grasslands, habitat fragmentation, invasive species, species distribution, wetlands, wildlife habitat, woody plant encroachment

Abstract: Climate change, interacting with and exacerbating anthropogenic modifications to the landscape, is altering ecosystem structure and function, biodiversity, and species distributions. Among the most visible short-term impacts are the altered ecological roles of foundation species—those species, native or non-native—that create locally stable environmental conditions and strongly influence ecosystem services. Understanding the future of these species is crucial for projecting impacts on ecosystem services at both local and regional scales. Here we present foundation species by ecoregion study cases across the US South-Central Region (Louisiana, New Mexico, Oklahoma, and Texas), including C_4 grasses, mesquite, and northern bobwhite in the Southern Great Plains, mangroves and nutria in coastal Louisiana wetlands, tiger salamanders and sandhill cranes in wetlands of the Southern Great Plains, and post and blackjack oaks and eastern redcedar in the Cross Timbers ecoregion. These case studies explore the impacts of climate change on foundation species and the consequences for ecosystem services, the outlook for climate adaptation efforts, and the sustainability of restoration in these systems. We underscore risks and vulnerabilities that stakeholders should consider when managing or restoring natural resources and conserving ecosystem services in an increasingly extreme and variable climate. We show that past management, through a lack of understanding or implementation of actions, has exacerbated shifts in invasive species, resulting in significant changes in ecosystem structure and function. These changes, interacting with landscape fragmentation and shifting land use and exacerbated by climate change, can result in critical losses of biodiversity. Unfortunately, lack of public understanding may hinder political support for restoration efforts and climate adaptation strategies crucial for the continued supply of traditional ecosystem services. Furthermore, the resulting invaded systems may provide opportunities for income via new ecosystem services valued by society that may reduce support for restoration to historical baselines, thus further shifting management priorities. These priorities should be informed by an understanding of past and ongoing ecological trends in region-specific situations, such as those we present, to highlight the immediacy of climate change impacts on the environment and society and provide evidence for the critical nature of informed management decisions.

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Archdeacon, T. P., R. K. Dudley, W. J. Remshardt, W. Knight, M. Ulibarri, and E. J. Gonzales. 2023. Hatchery Supplementation Increases Potential Spawning Stock of Rio Grande Silvery Minnow after Population Bottlenecks. Transactions of the American Fisheries Society 152(2): 187-200. doi: 10.1002/tafs.10398.

Keywords: conservation hatchery, demographics, resilience, resistance, threatened and endangered species

Abstract: Supplementation of imperiled wild fish stocks with captively raised fish is a commonly used conservation tool. Programs designed to maintain or improve fish populations through supplementation should be evaluated to determine whether they are meeting conservation objectives. The Rio Grande Silvery Minnow *Hybognathus amarus* is a small-bodied, endangered minnow endemic to the Rio Grande basin of the southwestern United States. The wild population of Rio Grande Silvery Minnow has been supplemented with captive-reared fish since 2002. Our objective was to determine whether supplementation measurably increases the number of spawning fish after years of population bottlenecks; this objective was simplified because nearly all hatchery-released fish have been given identifying markings.

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Archdeacon, T. P., E. J. Gonzales, J. K. Reale, E. B. Henry, and J. D. Grant. 2023. Effects of Seining Effort on Estimates of Fish Diversity in a Sand-Bed River. Environmental Monitoring and Assessment 195(5): 538. doi: 10.1007/s10661-023-11166-0.

Keywords: alpha, beta, gamma, community, assemblage, stream

Abstract: Changes in species diversity can be an indicator of ecosystem disturbance, impairment, or recovery. Estimating sampling effort needed to adequately represent stream fish assemblages is necessary for informing conservation actions. Increased sampling intensity can increase species detection, affecting the accuracy and precision of biodiversity indices. Seining is commonly used in fish surveys in sand-bottomed streams of the western USA. Here, we sampled 20, 200-m long stream sites each with 40 consecutive seine hauls to determine how increased within-site effort affected measures of species diversity. An average of 10 seine hauls were required to collect 75% of species present at sites in 40 seine hauls, while 18 seine hauls were required to collect 100% of species observed at a site sampled with 40 hauls. Simpson's diversity index was highly variable when fewer than 7 seine hauls were performed at each site but stabilized when effort was > 15 seine hauls per site. Total dissimilarity and *β*-diversity components were variable under low sampling effort and also stabilized when effort reached 15 seine hauls per site. However, sampling with more than 18–20 seine hauls per site yielded few additional species. In shallow, sand-bed streams, we suggest sampling with < 5 seine hauls per 200 m of stream can result in unreliable estimates of α-diversity and variation in β-diversity. Increased effort of 15–20 seine hauls per 200 m of stream captured nearly all species present in 40 hauls per 200 m and stabilized species evenness and *β*-diversity indices.

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Baird, D. C., J. Sperry, A. Schied, A. Posner, N. Holste, and P. Y. Julien. 2023. Changing Middle Rio Grande Channel Morphology: Bosque Del Apache National Wildlife Refuge to Elephant Butte Reservoir. Available online: https://www.sedhyd.org/2023Program/1/142.pdf

Keywords: N/A

Abstract: The Elephant Butte Reach (EBR) of the Middle Rio Grande (MRG) spans about 39 miles from the southern boundary of Bosque Del Apache National Wildlife Refuge to Elephant Butte Reservoir in New Mexico. Analyses of spatial and temporal trends in channel geometry and morphology are reported. Hydrology, hydraulics, and water surface elevation (WSE) changes in Elephant Butte Reservoir caused significant morphological changes of the Middle Rio Grande over the past century. This reach was divided into six sub-reaches based on channel width and geomorphic controls. It is shown, for the period from 1962 to 2012, reservoir WSE has the most influence on channel bed elevation and width. We propose a reservoir delta geomorphic evolution model that describes channel processes in the delta and the backwater-affected upstream sub reaches. This geomorphic evolution model applies to relatively constant reservoir WSE, and for rising and falling reservoir levels. The proposed geomorphic model includes the position of the pivot point (point between the topset and foreset delta slope).

URL: https://www.sedhyd.org/2023Program/1/142.pdf

Bates, J. M., M. Fidino, L. Nowak-Boyd, B. M. Strausberger, K. A. Schmidt, and C. J. Whelan. 2023. Climate Change Affects Bird Nesting Phenology: Comparing Contemporary Field and Historical Museum Nesting Records. Journal of Animal Ecology 92(2): 263-272. doi: 10.1111/1365-2656.13683.

Keywords: birds, climate change, CO_2, museum collections, nest records, nesting phenology

Abstract: 1. Global climate change impacts species and ecosystems in potentially harmful ways. For migratory bird species, earlier spring warm-up could lead to a mismatch between nesting activities and food availability. CO_2 provides a useful proxy for temperature and an environmental indicator of climate change when temperature data are not available for an entire time series. 2. Our objectives were to (a) examine nesting phenology over time; (b) determine how nesting phenology relates to changes in atmospheric CO_2 concentration; and (c) demonstrate the usefulness of historical museum collections combined with modern observations for trend analyses. 3. We assessed changes in nesting dates of 72 bird species in the Upper Midwest of the United States by comparing contemporary lay dates with those obtained from archived, historical museum nest records over a 143-year period (1872–2015). 4. Species-specific changes in lay date per one unit change in the CO_2 residual ranged from −0.75 (95% CI: −1.57 to −0.10) to 0.45 (95% CI: −0.29 to 1.43). Overall, lay dates advanced ~10 days over the 143-year period. Resident, short-distance migrants and long-distance migrants lay dates advanced by ~15, 18 and 16 days on average respectively. Twenty-four species (33.3%) significantly advanced, one (1.4%) significantly delayed and we failed to detect an advance or delay in lay date for 47 species (65.3%). Overall mean advance in first lay date (for the species that have significantly advanced laying date) was 25.1 days (min: 10.7, max: 49.9). 5. Our study highlights the scientific importance of both data gathering and archiving through time to understand phenological change. The detailed archived information reported by egg collectors provide the early data of our study. As with studies of egg-shell thinning and pesticide exposure, our use of these data illustrates another scientific utility of egg collections that these pioneer naturalists never imagined. As museums archive historical data, these locations are also ideal candidates to store contemporary field data as it is collected. Together, such information will provide the ability to track, understand and perhaps predict responses to human-driven environmental change.

DOI: 10.1111/1365-2656.13683

Caeiro-Dias, G., M. J. Osborne, H. M. Waterman, T. J. Krabbenhoft, and T. F. Turner. 2023. Limited Evidence for Extensive Genetic Differentiation between X and Y Chromosomes in *Hybognathus amarus* (Cypriniformes: Leuciscidae). Journal of Heredity 114(5): 470-487. doi: 10.1093/jhered/esad039.

Keywords: NextRAD, whole-genome sequencing, sex determination system, sex-linked genetic markers, Rio Grande silvery minnow

Abstract: Sex determination systems and genetic sex differentiation across fishes are highly diverse but are unknown for most Cypriniformes, including Rio Grande silvery minnow (*Hybognathus amarus*). In this study, we aimed to detect and validate sex-linked markers to infer sex determination system and to demonstrate the utility of combining several methods for sex-linked marker detection in nonmodel organisms. To identify potential sex-linked markers, Nextera-tagmented reductively amplified DNA (nextRAD) libraries were generated from 66 females, 64 males, and 60 larvae of unknown sex. These data were combined with female and male de novo genomes from Nanopore long-read sequences. We identified five potential unique male nextRAD-tags and one potential unique male contig, suggesting an XY sex determination system. We also identified two single-nucleotide polymorphisms (SNPs) in the same contig with values of F_{ST}, allele frequencies, and heterozygosity conforming with expectations of an XY system. Through PCR we validated the marker containing the sex-linked SNPs and a single nextRAD-tag sex-associated marker but it was not male specific. Instead, more copies of this locus in the male genome were suggested by enhanced amplification in males. Results are consistent with an XY system with low differentiation between sex-determining regions. Further research is needed to confirm the level of differentiation between the sex chromosomes. Nonetheless, this study highlighted the power of combining reduced representation and whole-genome sequencing for identifying sex-linked markers, especially when reduced representation sequencing does not include extensive variation between sexes, either because such variation is not present or not captured.

DOI: 10.1093/jhered/esad039

Cantu de Leija, A. and S. L. King. 2023. Relationships among Rare Plant Communities and Abiotic Conditions in Managed Spring-Fed Arid Wetlands Restoration Ecology: e14011. doi: 10.1111/rec.14011.

Keywords: N/A

Abstract: Spring-fed wetlands within arid and semiarid systems are hotspots for endemism and distribution of rare plants. Interactions among groundwater and the geomorphic and climatic features of the setting control the abiotic conditions, particularly soil salinity and moisture, that support these plants. However, water uncertainty and land use change challenge the persistence of conditions necessary to support rare plant communities. Wetland management can be implemented to sustain abiotic processes that support rare plant communities, but key information is needed to guide management practices. In this study, we evaluate the relationships of rare plants to abiotic conditions in a managed spring-fed arid wetland. Soil salinity and moisture conditions were monitored and related to the presence and abundance of rare plants within management units. Soil salinity and moisture variability were related to groundwater dynamics near springs, but wetland management influenced variability in seasonally flooded areas. Permanently saturated conditions and low soil salinities during the spring season supported higher plant diversity and the presence and greater abundance of rare plants. Rare plant presence and abundance were negatively related to low soil moisture, particularly in the summer. Results indicate that increases in soil salinity during the early establishment of plants may affect their distribution and abundance, an important management consideration in arid landscapes and hydrologically altered systems. Our findings inform the restoration and management of rare plant communities and contribute to the management of spring-fed arid wetlands.

DOI: 10.1111/rec.14011

Chaulagain, S., M.C. Stone, R. R. Morrison, L. Yang, J. Coonrod, and N. E. Villa. 2023. Determining the Response of Riparian Vegetation and River Morphology to Drought using Google Earth Engine and Machine Learning. Journal of Arid Environments 219: 105068. doi: 10.1016/j.jaridenv.2023.102068.

Keywords: riparian vegetation, river morphology, remote sensing, random forest, Rio Grande, drought

Abstract: Riparian vegetation composition and channel morphology are susceptible to long-term alterations caused by external stressors, including climate-change-induced droughts and engineered infrastructures. The objectives of this study were to (1) quantify trends in riparian vegetation and channel/floodplain morphology over large spatial (~290 km) and temporal scales (~30 years) and (2) investigate the relationships between hydroclimatic drivers and changes in riparian vegetation and channel morphology. We implemented a random forest classifier via a machine learning technique in Google Earth Engine. The study area was a 290 km reach of the Rio Grande located in New Mexico, USA. We used the combination of remotely sensed data and products (e.g., Landsat imagery, Normalized Difference Vegetation Index (NDVI), and land cover) to characterize vegetation, vegetation cover changes, and river morphology shifts from 1984 to 2020. The trend analysis revealed increased vegetated areas and NDVI (0.0004/yr) during long-term drought. The channel experienced a reduction in width associated with vegetation encroachment and the formation of stable vegetated islands. The streamflow hydrograph characteristics were positively correlated with vegetation cover and channel morphology. Our study contributes novel insights into the long-term riparian ecosystem dynamics under drought stress, informing drought impact mitigation and ecosystem management in arid and semi-arid regions.

DOI: 10.1016/j.jaridenv.2023.102068

Chavez, M. J. 2023. Movement Patterns of a Federally Endangered Minnow in a Fragmented Desert River Thesis. Utah State University, Logan, Utah.

Keywords: N/A

Abstract: Fishes are unified in their need to move within the systems they occupy, and their movement patterns can be fundamental to their ecology and survival. Many large rivers in North America are fragmented by dams that modify natural flow regimes, compromise connectivity, and imperil freshwater fishes dependent on unrestricted movement in order to complete their life history. Coincident with widespread river fragmentation, are the declines of numerous endemic desert fishes in the American southwest. The Rio Grande Silvery Minnow (*Hybognathus amarus*, RGSM), has experienced a 95% reduction in its historical range and is now restricted to a highly fragmented stretch of river. Despite the important role of movement in riverine fishes, there are few studies describing the movement patterns of RGSM. The overall goal of this study is to document and better understand the movement ecology and patterns of RGSM. We used Passive Integrated Transponder (PIT) tags in hatchery-reared RGSM with stationary and mobile PIT-tag antenna systems to detect and track movement patterns across time and space. We released a total of 37,215 PIT-tagged RGSM between 2018 and 2022. Of those released, we detected 13,706 RGSM making at least one movement (e.g., detected at two different locations). We found RGSM to be highly mobile and documented individuals moving farther distances than ever previously recorded. Individuals moved a mean total distance of 12.2 river kilometers (rkm) over the course of one year, with a maximum total distance of 103.0 rkm. Overall, total distances moved by individuals was larger than linear home range sizes within one year of release, suggesting RGSM were moving at finer scales within the extent of the river they occupied. Although individuals moved large distances, movement patterns were leptokurtic, with a larger portion of RGSM remaining near their initial release location. We documented a total 198 unique upstream passages through a diversion dam. The documentation of these passages is particularly meaningful as passage through this diversion by RGSM has not been previously documented and the diversion is not equipped with a formal fish passage. As indicated by the high number of repeated detections over the study period, as well as our high redetection rate (36.8%), the efficacy of our study design to detect an imperiled small-bodied fish species has crucial conservation applications. Our study elucidates the movement patterns of RGSM and can be an important model for other fish species in fragmented desert systems.

URL: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1078&context=etd2023

Conkling, T. J., A. L. Fesnock, and T. E. Katzner. 2023. Numbers of Wildlife Fatalities at Renewable Energy Facilities in a Targeted Development Region. PLoS ONE 18(12): e0295552. doi: 10.1371/journal.pone.0295552

Keywords: alternative energy, birds, animal migration, wind power, deserts, wildlife, passerines, surveys

Abstract: Increased interest in renewable energy has fostered development of wind and solar energy facilities globally. However, energy development sometimes has negative environmental impacts, such as wildlife fatalities. Efforts by regional land managers to balance energy potential while minimizing fatality risk currently rely on datasets that are aggregated at continental, but not regional scales, that focus on single species, or that implement meta-analyses that inappropriately use inferential statistics. We compiled and summarized fatality data from 87 reports for solar and wind facilities in the Mojave and Sonoran Deserts region of southern California within the Desert Renewable Energy Conservation Plan area. Our goal was to evaluate potential temporal and guild-specific patterns in fatalities, especially for priority species of conservation concern. We also aimed to provide a perspective on approaches interpreting these types of data, given inherent limitations in how they were collected. Mourning doves (*Zenaida macroura*), Chukar (*Alectoris chukar*) and California Quail (*Callipepla californica*), and passerines (Passeriformes), accounted for the most commonly reported fatalities. However, our aggregated count data were derived from raw, uncorrected totals, and thus reflect an absolute minimum number of fatalities for the monitored period. Additionally, patterns in the raw data suggested that many species commonly documented as fatalities (e.g., waterbirds and other nocturnal migrants, bats) are rarely counted during typical pre-construction use surveys. This may explain the more commonly observed mismatch between pre-construction risk assessment and actual fatalities. Our work may serve to guide design of future scientific research to address temporal and spatial patterns in fatalities and to apply rigorous guild-specific survey methodologies to estimate populations at risk from renewable energy development.

DOI: 10.1371/journal.pone.0295552

Crouch, C. D., P. C. Rogers, M. M. Moore, and K. M. Waring. 2023. Building Ecosystem Resilience and Adaptive Capacity: A Systematic Review of Aspen Ecology and Management in the Southwest. Forest Science 69(3): 334-354. doi: 10.1093/forsci/fxad004.

Keywords: decline, ecological silviculture, exclosures, *Populus tremuloides*, Rocky Mountain elk, wildfire

Abstract: Quaking aspen (*Populus tremuloides* Michx.) has high conservation value on the southwestern edge of its range, which extends from the southwestern United States (i.e., Arizona, New Mexico, and Texas) to central Mexico. This value is driven by aspen's ecological importance, positive impact on local economies, and aesthetic and cultural values. Generally, the scant aspen populations that remain in the Southwest lack resilience and adaptive capacity, and managers are unsure how best to maintain the species in an uncertain future. This systematic review seeks to address that need by reviewing existing literature from the Southwest on which biotic and abiotic factors influence aspen forest dynamics and by synthesizing that literature with a discussion of how management can promote aspen ecosystem resilience and adaptive capacity. We found that fire and silvicultural treatments promote aspen regeneration, but chronic ungulate browse inhibits recruitment. Moreover, drought is a driver of overstory mortality and has a negative influence on recruitment. In the second half of this review, we propose three management objectives for increasing aspen resilience and adaptive capacity: (1) promote diversity in age structure, (2) mitigate ungulate impacts, and (3) enhance complexity. We consider how various management strategies could meet these objectives and highlight potential threats to aspen forest health and resilience.

DOI: 10.1093/forsci/fxad004

DellaSala, D. A., A. L. Kuchy, M. Koopman, K. Menke, T. L. Fleischner, and M. L. Floyd. 2023. An Ecoregional Conservation Assessment for Forests and Woodlands of the Mogollon Highlands Ecoregion, Northcentral Arizona and Southwestern New Mexico, USA. Land 12(12): 2112. doi; 10.3390/land12122112.

Keywords: ecoregion conservation, mature forests, Mexican wolf, Mogollon Highlands, grizzly bear, riparian, wildland urban interface

Abstract: The Mogollon Highlands, Arizona/New Mexico, USA, spans a large biogeographical region of 11 biotic communities, 63 land cover types, and 7 ecoregions. This 11.3 M ha region has high levels of beta diversity across topo-edaphic gradients that span deserts to mountain tops. The main stressors affecting the region's forests and woodlands include climate change, livestock grazing, and frequent mechanical removals of large amounts of forest biomass for fire concerns. We present an ecoregion conservation assessment for robust conservation area design that factors in appropriate wildfire response to protect communities from increasing threats of climate-induced wildfires spreading into urban areas. We focused mainly on maintaining connectivity for endangered focal species (grizzly bear (*Ursus arctos horribilis*) and Mexican wolf *(Canis lupus baileyi*)) along with protecting mature and old-growth (MOG) forests, Piñon (*Pinus* spp.)–Juniper (*Juniperus* spp.) Woodlands, and riparian areas. Over half the region is managed by federal agencies where new protected areas can be integrated with tribal co-management and prescribed burning, defensible space, and home hardening to protect communities from the growing threat of climate-induced wildfires. However, just 9% of the study area is currently protected, and even with the inclusion of proposed protected areas, only 24% would be protected, which is below 30 × 30 targets. The potential grizzly bear habitat, wolf habitat connectivity, and MOG forests (1.6 M ha (14.2%) of the study area; 18% protected) are concentrated mainly in the central and eastern portions of the MHE. There were 824 fires (2 to 228,065 ha) from 1984–2021, with 24% overlapping the wildland–urban interface. Regional temperatures have increased by 1.5 °C, with a 16% reduction in precipitation and stream flow since 1970 that under worst-case emission scenarios may increase temperatures another 3 to 8 °C by the century's end. The unique biodiversity of the MHE can be better maintained in a rapidly changing climate via at least a three-fold increase in protected areas, co-management of focal species with tribes, and strategic use of fuel treatments nearest communities.

DOI: 10.3390/land12122112

Keywords: conservation genomics, avian migration, population genetics

Abstract: Global biodiversity loss is one of the foremost concerns of conservation efforts in the 21st century. The maintenance of genetic diversity within species is a critical factor in a species' persistence and adaptive potential in the face of changing environmental conditions. Migratory species make up more than 12% of the global vertebrate biodiversity and pose distinct challenges to conservation efforts due to inhabiting different geographical regions at different times of the year. The field of conservation genomics provides a valuable toolkit to addressing and understanding global biodiversity loss but requires additional methodological developments to better address the conservation challenges posed by migratory species. In my dissertation, I demonstrate advancements in conservation genomics aimed toward better understanding migratory species. In my first study, I addressed the question of ecological and genomic vulnerability to climate change in the Brown-capped Rosy-Finch (*Leucosticte australis*), an elevational migratory songbird of conservation concern. Second, I addressed a methodological gap in population genomics and developed statistical genetics models for using genotype likelihood data from low-coverage whole genome sequencing data to implement population assignment. In my last study, I demonstrate the utility of low-coverage whole genome sequencing for population assignment with detailing migratory connectivity in the American Redstart (*Setophaga ruticilla*). Altogether, my doctoral research demonstrates how genomic tools can help unravel the complexities of migratory species conservation. Furthermore, the species-specific results are tied to knowledge gaps identified by wildlife managers and provide valuable information tied to conservation and management applications.

URL: https://hdl.handle.net/10217/237424

Edwards, P. J. 2023. Ecological Traits of Saliceae and the Species Replacing Them on the Active Floodplain. River Research and Applications: doi: 10.1002/rra.4229.

Keywords: invasive species, populus, riparian vegetation, Saliceae, vegetative propagation

Abstract: The dominant woody plants of active floodplains in the northern temperate zone are various species of *Salix* (willows) and *Populus* (poplars and cottonwoods) in the tribe Saliceae of the family Salicaceae. In this review, I consider the traits that enable these species to thrive in the dynamic floodplain environment and ask why they are now declining in the northern hemisphere, yet spreading rapidly in the southern hemisphere. I reach four main conclusions. First, floodplain Saliceae exhibit traits, notably huge numbers of minute, wind- and water-dispersed seeds and an exceptional capacity for vegetative propagation, that uniquely fit them for life on the active floodplain. Second, there are no functional equivalents to floodplain Salix and Populus in the southern hemisphere, which accounts for their remarkable success in invading riparian ecosystems. Third, the replacement of Saliceae by other species in the northern hemisphere has been caused mainly by changes in flow through dam construction, regulation and abstraction. The species that replace Saliceae vary according to site conditions: fertile sites in humid climates become occupied by various broadleaved trees (e.g., *Acer negundo*, *Fraxinus pennsylvanica*, *Ailanthus altissima*); nitrogen-fixing shrubs dominate in areas where nitrogen is limiting but phosphorus is adequate (*Amorpha fruticosa*, *Robinia pseudoacacia*, *Elaeagnus angustifolia*); sites in more arid regions are occupied by various *Tamarix* spp. The different ecological groups of woody species are associated with contrasting changes to the floodplain ecosystem.

DOI: 10.1002/rra.4229

Forester, B. R., C. C. Day, K. Ruegg, K., and E. L. Landguth. 2023. Evolutionary Potential Mitigates Extinction Risk Under Climate Change in the Endangered Southwestern Willow Flycatcher. Journal of Heredity 114(4): 341-353. doi: 10.1093/jhered/esac067.

Keywords: N/A

Abstract: The complexity of global anthropogenic change makes forecasting species responses and planning effective conservation actions challenging. Additionally, important components of a species' adaptive capacity, such as evolutionary potential, are often not included in quantitative risk assessments due to lack of data. While genomic proxies for evolutionary potential in at-risk species are increasingly available, they have not yet been included in extinction risk assessments at a species-wide scale. In this study, we used an individual-based, spatially explicit, dynamic eco-evolutionary simulation model to evaluate the extinction risk of an endangered desert songbird, the southwestern willow flycatcher (*Empidonax traillii extimus*), in response to climate change. Using data from long-term demographic and habitat studies in conjunction with genome-wide ecological genomics research, we parameterized simulations that include 418 sites across the breeding range, genomic data from 225 individuals, and climate change forecasts spanning 3 generalized circulation models and 3 emissions scenarios. We evaluated how evolutionary potential, and the lack of it, impacted population trajectories in response to climate change. We then investigated the compounding impact of drought and warming temperatures on extinction risk through the mechanism of increased nest failure. Finally, we evaluated how rapid action to reverse greenhouse gas emissions would influence population responses and species extinction risk. Our results illustrate the value of incorporating evolutionary, demographic, and dispersal processes in a spatially explicit framework to more comprehensively evaluate the extinction risk of threatened and endangered species and conservation actions to promote their recovery.

DOI: 10.1093/jhered/esac067

Forester, B. R. and T. M. Lama, T.M. 2023. The Role of Genomics in the Future of Endangered Species Act Decision-Making. Pp. 159-186. *In:* L. E. Baier, J. F. Organ, and C. E. Segal, eds. The Codex of the Endangered Species Act. Volume II: The Next 50 Years. Rowman & Littlefield, Lanham, Maryland.

Keywords: N/A

Abstract: The U.S. Endangered Species Act (ESA) provides a framework for the protection and recovery of threatened and endangered species and their habitats in the face of anthropogenic threats, including habitat modification (e.g., loss, fragmentation, degradation, transformation), overexploitation, disease, and climate change.[1] Genetic information has played a role in decision-making under the ESA for decades, most commonly informing taxonomy and the designation of distinct population segments (DPSs),[2] though detection of inbreeding also played an early role.[3] The transition to genomic technologies has improved the precision and resolution of important population genetic metrics for at-risk species, such as genetic diversity and population structure.[4] For other parameters, such as inbreeding, genomic data have transformed our ability to precisely measure individual level variation, as well as quantify downstream impacts on population viability.[5] Genomic data have also democratized access to other parameters, such as estimates of evolutionary potential, that were once limited to model organisms and species amenable to experimental manipulation.[6] We use “genetics” to refer to small sets (e.g., tens) of neutral molecular markers. Common genetic markers referenced in this chapter include mitochondrial DNA (mtDNA) markers, derived from the maternally inherited, haploid DNA molecule found in the mitochondria of eukaryotes, and microsatellites, short sequences of repeated nuclear DNA. By contrast, we use “genomics” to refer to the genotyping of large sets of molecular markers (e.g., thousands to millions). The most commonly used genomic-scale marker is the single nucleotide polymorphism (SNP), which represents a single base pair difference within and among populations and/or species. In contrast to genetic data, genomic data can be used to investigate both neutral microevolutionary processes, such as gene flow and genetic drift, as well as adaptive processes that contribute to evolutionary potential and adaptive capacity.[7]

In this chapter, we review how genetic data have informed decision-making under the ESA, and how the transition to genomics is improving the information that we can apply to both listing and recovery decisions. In some cases, genomic data are presenting new challenges to applied conservation under the ESA, providing an opportunity to evaluate and innovate existing practices. In all cases, falling costs and the increasing ease of genomic-scale data production in at-risk species are providing an unparalleled opportunity to improve applied conservation of threatened and endangered species and expand new frontiers for agency use of the “best available science” in ESA implementation.

URL: https://ecoevorxiv.org/repository/object/3709/download/12430/?embed=True

Forrester, T. R., D. J. Green, R. McKibbin, T. C. Morgan, A. M. Bezener, and C. A. Bishop. 2023. Long-Term Decline in Brown-Headed Cowbird (*Molothrus ater*) Abundance Has Not Led to Less Brood Parasitism of Four Riparian Songbird Species. *Wilson Journal of Ornithology 135*(2): 154-171. doi: 10.1676/22-00074.

Keywords: N/A

Abstract: The abundance of a widespread brood parasite, the Brown-headed Cowbird (*Molothrus ater*), has decreased by ~30% in North America over the past 5 decades. Within a community, brood parasite abundance may be expected to positively correlate with host brood parasitism frequency and intensity, but evidence for this correlation is mixed. Few studies have examined if long-term changes in brood parasite abundance have resulted in changes to host parasitism frequency. We measured cowbird abundance, brood parasitism frequency and intensity of 4 riparian songbird species, and host abundance and richness in 2001–2004 and 2012–2014 in riparian vegetation of the south Okanagan Valley of British Columbia, Canada. We compared our data to historical data for the same parameters previously collected between ~1960 and the early 1990s in the same area. We found that cowbird abundance decreased by ~80% over 2 decades in the Okanagan Valley, mirroring or exceeding regional-scale trends. Host abundance and richness increased as cowbird abundance decreased. However, songbird brood parasitism frequency and intensity either increased or remained relatively high over more than 4 decades. We discuss possible explanations for this apparent disconnect between brood parasite abundance and host parasitism frequency and intensity, which offer opportunity for further study. Temporal changes in brood parasite abundance, such as the decline of Brown-headed Cowbirds in North America and the Common Cuckoo (*Cuculus canorus*) in Europe, should not be assumed to lead to correlated changes to host parasitism frequency and intensity.

DOI: 10.1676/22-00074

Gido, K .B., M. J. Osborne, D. L. Propst, T. F. Turner, and J. D. Olden. 2023. Megadroughts Pose Mega-Risk to Native Fishes of the American Southwest. Fisheries 48(5): .204-214. doi: 10.1002/fsh.10912.

Keywords: N/A

Abstract: Climate change and a host of other human stressors on aquatic systems in the American Southwest are rapidly exceeding our ability to conserve native fish diversity. The most severe megadrought in over a millennium has compromised current management plans by exacerbating the impacts of altered hydrology, poor water quality, invasive species, and habitat fragmentation. Drought legacies are of particular concern, and existing conservation actions may not be sufficient to maintain resilient native fish populations, particularly if this drought persists. We draw examples from current literature and empirical research to support our contention that more resources and novel approaches to prioritizing environmental flows, improving ecological connectivity of populations, preventing and controlling invasive species, and establishing refuge populations are necessary to stave off extinctions. Moreover, shifts in socio-political attitudes that better recognize environmental concerns must be integrated into water resource policy and management to achieve native fish conservation goals.

DOI: 10.1002/fsh.10912

Granados-Olivas, A., H. L. Hargrove, J. M. Heyman, A. Mayer, A. Mirchi, G. Ganjegunte, D. Gutzler, D. D. Pennington, F. A. Ward, L. A. Garnica Chavira, and S. Sheng. 2023. The Future of Water in a Desert River Basin Facing Climate Change and Competing Demands: A Holistic Approach to Water Sustainability in Arid and Semi-Arid Regions. Instituto de Ingeniería y Tecnología, Ciudad Juárez, Chihuahua, Mexico.

Keywords: N/A

Abstract: Study region: The Middle Rio Grande (MRG), defined by the portion of the basin from Elephant Butte Reservoir in New Mexico to the confluence with the Rio Conchos in Far West Texas, U.S.A. and Northern Chihuahua, Mexico. Study focus: The future of water for the MRG and many other arid and semi-arid regions of the world is challenged by a changing climate, agricultural intensification, growing urban populations, and a segmented governance system in a transboundary setting. The core question for such settings is: how can water be managed so that competing agricultural, urban, and environmental sectors can realize a sustainable future? We synthesize results from interdisciplinary research aimed at “water futures”, considering possible, probable, and preferable outcomes from the known drivers of change in the MRG in a stakeholder participatory mode. We accomplished this by developing and evaluating scenarios using a suite of scientifically rigorous computer models, melded with the input from diverse stakeholders. New hydrological insights for the region: Under likely scenarios without significant interventions, relatively cheap and easy to access water will be depleted in about 40 years. Interventions to mitigate this outcome will be very costly. A new approach is called for based on “adaptive cooperation” among sectors and across jurisdictions along four important themes: information sharing, water conservation, greater development and use of alternative water sources, and new limits to water allocation/withdrawals coupled with more flexibility in uses.

URL: http://cathi.uacj.mx/20.500.11961/25568

Gruppi, C., P. Sanzenbacher, K. Balekjian, R. Hagar, S. Hagen, C. Rayne, T. M. Schweizer, C. M. Bossu, D. Cooper, T. Dietsch, T. B. Smith, K. Ruegg,Ryan, and J. Harrigan. 2023. Genetic Identification of Avian Samples Recovered from Solar Energy Installations. PLoS ONE 18(9): e0289949. doi: 10.1371/journal.pone.0289949.

Keywords: bird genetics, birds, alternative energy, DNA barcoding, genetics, feathers

Abstract: Renewable energy production and development will drastically affect how we meet global energy demands, while simultaneously reducing the impact of climate change. Although the possible effects of renewable energy production (mainly from solar- and wind-energy facilities) on wildlife have been explored, knowledge gaps still exist, and collecting data from wildlife remains (when negative interactions occur) at energy installations can act as a first step regarding the study of species and communities interacting with facilities. In the case of avian species, samples can be collected relatively easily (as compared to other sampling methods), but may only be able to be identified when morphological characteristics are diagnostic for a species. Therefore, many samples that appear as partial remains, or “feather spots”—known to be of avian origin but not readily assignable to species via morphology—may remain unidentified, reducing the efficiency of sample collection and the accuracy of patterns observed. To obtain data from these samples and ensure their identification and inclusion in subsequent analyses, we applied, for the first time, a DNA barcoding approach that uses mitochondrial genetic data to identify unknown avian samples collected at solar facilities to species. We also verified and compared identifications obtained by our genetic method to traditional morphological identifications using a blind test, and discuss discrepancies observed. Our results suggest that this genetic tool can be used to verify, correct, and supplement identifications made in the field and can produce data that allow accurate comparisons of avian interactions across facilities, locations, or technology types. We recommend implementing this genetic approach to ensure that unknown samples collected are efficiently identified and contribute to a better understanding of wildlife impacts at renewable energy projects.

DOI: 10.1371/journal.pone.0289949

Hannah, M. 2023. The Role of Citizen Science in Ecosystem Management: A Case Study of the Middle Rio Grande Bosque Ecosystem Monitoring Program. Thesis. University of New Mexico, Albuquerque, New Mexico. Spring 2023.

Keywords: citizen science generated data, ecosystem management, water, middle Rio Grande, bosque, BEMP data

Abstract: Rapid advances in technology, especially smart phones, have changed citizen science around the world. Citizen science-generated data are growing exponentially, so there is increasing interest about what is happening with all this data. Some research suggests that governmental agencies are not using citizen science data to make ecosystem management decisions, although other studies contradict this finding. Regionally, the Middle Rio Grande bosque ecosystem extends for 162 miles along the Rio Grande in New Mexico. The Bosque Ecosystem Monitoring Program, or BEMP, was founded in 1996 following the efforts of the Bosque Initiative and the development of the Bosque Biological Management Plan in 1993. The objective of this research is to understand how BEMP data are incorporated into the ecosystem management framework. Interviews were conducted with known BEMP data users at local and federal agencies who are responsible for managing natural resources in the study area to learn more about how managers are applying BEMP data to their decision-making processes. A review of publicly available ecosystem management plans that cover the extent of the ecosystem supports this investigation. Interview findings suggest that BEMP data plays a strong role in ecosystem management decisions and is widely used across the ecosystem by various management agencies, specifically related to restoration projects. Recommendations are offered to the State and BEMP to improve MRG bosque ecosystem outcomes and citizen science program efficiency.

URL: https://digitalrepository.unm.edu/wr_sp/198/

Hargrove, W. L., J. M. Heyman, A. Mayer, A. Mirchi, A. Granados-Olivas, G. Ganjegunte, D. Gutzler, D. D. Pennington, F. A. Ward, L. G. Chavira, Z. Sheng, S. Kumar, N. Villanueva-Rosales, and W. S. Walker. 2023. The Future of Water in a Desert River Basin Facing Climate Change and Competing Demands: A Holistic Approach to Water Sustainability in Arid and Semi-Arid Regions. Journal of Hydrology: Regional Studies 46: 101336. doi: 10.1016/j.ejrh.2023.101336.

Keywords: water futures, drivers of change, agricultural intensification, urbanization, changing climate, adaptive cooperation, participatory modeling

Abstract: Study region: The Middle Rio Grande (MRG), defined by the portion of the basin from Elephant Butte Reservoir in New Mexico to the confluence with the Rio Conchos in Far West Texas, U.S.A. and Northern Chihuahua, Mexico. Study focus: The future of water for the MRG and many other arid and semi-arid regions of the world is challenged by a changing climate, agricultural intensification, growing urban populations, and a segmented governance system in a transboundary setting. The core question for such settings is: how can water be managed so that competing agricultural, urban, and environmental sectors can realize a sustainable future? We synthesize results from interdisciplinary research aimed at “water futures”, considering possible, probable, and preferable outcomes from the known drivers of change in the MRG in a stakeholder participatory mode. We accomplished this by developing and evaluating scenarios using a suite of scientifically rigorous computer models, melded with the input from diverse stakeholders. New hydrological insights for the region: Under likely scenarios without significant interventions, relatively cheap and easy to access water will be depleted in about 40 years. Interventions to mitigate this outcome will be very costly. A new approach is called for based on “adaptive cooperation” among sectors and across jurisdictions along four important themes: information sharing, water conservation, greater development and use of alternative water sources, and new limits to water allocation/withdrawals coupled with more flexibility in uses.

DOI: 10.1016/j.ejrh.2023.101336

Harju, S., S. Cambrin, and K. Jenkins. 2023. Mapping Low-Elevation Species Richness and Biodiversity in the Eastern Mojave Desert. Natural Areas Journal 43(1): 53-61. doi: 10.3375/22-25.

Keywords: biodiversity, Las Vegas, Mojave Desert, species distribution model, species richness

Abstract: Global loss of biodiversity is a well-known concern for conservationists and managers, but detailed spatial maps of local biodiversity for use by local managers are often lacking. We used a suite of existing species distribution models to calculate spatial variation in low-elevation species richness across Clark County, Nevada, USA, comprising much of the eastern Mojave Desert. We then used a macroecological model to estimate true latent low-elevation biodiversity across the county, correcting for potential taxonomic bias in the estimates of species richness. We found that species richness and biodiversity tended to be higher along the Muddy and Virgin Rivers and in the Las Vegas valley. Biodiversity was positively associated with flat, rocky landforms, low elevation, late seasonal greenup, and lower differences between winter and summer temperature. We present a brief example for local managers to apply the new publicly available low-elevation species richness and biodiversity spatial layers.

DOI: 10.3375/22-25

Harris, A., J. AuBuchon, M. Porter, and S. K. McKay. 2023. Retrospective: Transitioning River Geomorphology and its Impact on Habitat Management. US Army Corps of Engineers, Engineering Research and Development Center, Environmental Laboratory. Available online: https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/47642/1/ERDC-TN%20EMRRP-EM-11.pdf

Keywords: N/A

Abstract: Since the early 1900s, the US government and state-level agencies throughout the southwest have invested ambitiously and prolifically on large-scale engineering projects to mitigate risks due to alternating conditions of drought and flood. These approaches included construction-intensive methods, particularly building dams, levees, and river channelization. The combination of these structures met design goals to reduce flood risk by reducing inundated areas and improving river conveyance. However, the impacts to sediment supply and homogenization of water discharge have generated a geomorphic response that has impacted riparian ecosystems. Channel narrowing, floodplain disconnection, and streambed erosion have been common in these heavily engineered semi-arid river systems.

Due to increased prioritization of ecological function and cost of recurring maintenance challenges, government activities have shifted from hardened river infrastructure solutions to engineering with nature, habitat restoration, and channel maintenance. However, in contrast to hard-engineering projects, habitat management faces challenges in demonstrating longevity, engineering effectiveness, and quantifying habitat quality improvement.

The purpose of this paper is to characterize the geomorphic change that has occurred in one of these highly engineered river systems, the Rio Grande, and how observed trends impact assumptions about restoration effectiveness and project scales. Based on geomorphic trends on the Rio Grande near Albuquerque, NM, we discuss an alternative framework to assess long-term restoration efficacy within the context of geomorphic change. The intention is to increase project resilience and effectiveness. We discuss challenges to innovation in over-allocated and highly engineered river systems, while also demonstrating how such alternatives have economic potential and reduce liabilities by reducing recurring maintenance and improving ecological function.

URL: https://webapps.usgs.gov/mrgescp/documents/Harris-et-al_2023_Retrospective-Transitioning-River-Geomorphology-and-its-Impact-on-Habitat-Management.pdf

Harris, A. E., N. S. Richards, and S. K. McKay. 2023. Defining Levels of Effort for Ecological Models. ERDC/TN EMRRP-EM-11. US Army Corps of Engineers, Engineering Research and Development Center. September 2023. Available online: https://hdl.handle.net/11681/47642

Keywords: ecology, mathematical models, environmental management

Abstract: While models are useful tools for decision-making in environmental management, the question arises about the level of effort required to develop an effective model for a given application. In some cases, it is unclear whether more analysis would lead to choosing a better course of action. This technical note (TN) examines the role of ecological model complexity in ecosystem management. First, model complexity is examined through the lens of risk informed planning. Second, a framework is presented for categorizing five different levels of effort that range from conceptual models to detailed predictive tools. This framework is proposed to enhance communication and provide consistency in ecological modeling applications. Third, the level of effort framework is applied to a set of models in the Middle Rio Grande River system to demonstrate the framework's utility and application. Ultimately, this TN seeks to guide planners in determining an appropriate level of effort relative to risks associated with uncertainty and resource availability for a given application.

URL: https://hdl.handle.net/11681/47642

Hatch, M. D. and F. A. Ward. 2023. Management of Water Supply Shortages to Sustain an Endangered Fish Species. Journal of Water Resources Planning and Management 149(11): 04023058. doi: 10.1061/JWRMD5.WRENG-5927.

Keywords: N/A

Abstract: Arid and semi-arid landscapes globally represent significant challenges in developing and managing regional water resources for human uses while simultaneously sustaining aquatic ecosystems. Allocation of water resources between these divergent purposes requires careful analysis of the variable nature of the water supply and the plurality of demands on that supply if economic and ecological values of water are to be sustained. Where water resources are limiting, sustainability management of short-lived fish species may depend on adjusting the timing and quantity of out-of-channel diversions of water to reduce mortality-causing flow intermittence. Such management efforts can include strategies for improved water transport efficiency to increase the amount of water available for environmental flow. This work addresses gaps in the published literature by formulating and applying an analytic process that integrates demography of an endangered freshwater fish species, hydrology for a river segment with a high frequency of seasonal flow intermittence, and measures of cost-saving water management strategies to achieve environmental and economic objectives. This process provides a useful context for adaptive water resource planning that focuses on promising management actions needed to limit flow intermittence while serving to sustain socioecological systems.

DOI: 10.1061/JWRMD5.WRENG-5927

Henry, A. L., E. González-Sargas, P. B. Shafroth, A. R. Goetz, and A. A. Sher. 2023. Functional Stability of Vegetation Following Biocontrol of an Invasive Riparian Shrub. Biological Invasions 25(4): 1133-1147. doi: 10.1007/s10530-022-02967-4.

Keywords: biological control, functional traits, riparian, functional diversity, species diversity, *Tamarix*

Abstract: Understanding plant community response to environmental change is a crucial aspect of biological conservation and restoration, but species-based approaches are limited in that they do not reveal the underlying mechanisms driving vegetation dynamics. An understanding of trait-environment relationships is particularly important in the case of invasive species which may alter abiotic conditions and available resources. This study is the first to measure the functional response of riparian plant communities to biocontrol of an invasive species. We focused on an invasive shrub, *Tamarix* (saltcedar), that is defoliated by a beetle that was released by the US Department of Agriculture along the Upper Colorado River (southwestern United States). We calculated community weighted means and functional dispersion of individual traits, multivariate functional dispersion and species diversity. We used linear mixed effect models (LME) to compare these metrics at paired vegetation patches dominated and not dominated by *Tamarix* during cycles of defoliation and refoliation over eight years. We found that community-weighted average trait values, species diversity and functional dispersion changed little in response to defoliation, and instead seemed to be responding to fluctuations in yearly precipitation. Average height and seed weight were greater in *Tamarix*-dominated patches relative to control patches. Functional dispersion followed a similar trajectory to species diversity, but was a more sensitive indicator of plant community change. We showed that riparian vegetation can be resilient to *Tamarix* biocontrol, and that defoliation might not necessarily always lead to substantial changes in ecosystem function.

DOI: 10.1007/s10530-022-02967-4

Houston, A., L. D. Allen, S. M. Mendia, and B. E. Kus. 2023. Least Bell's Vireos and Southwestern Willow Flycatchers at the San Luis Rey Flood Risk Management Project Area in San Diego County, California—Breeding Activities and Habitat Use—2022 Annual Report. Open File Report 2023-1040. US Geological Survey. 74 pp. doi: 10.3133/dr1177. Available online: https://pubs.usgs.gov/publication/ofr20231040

Keywords: N/A

Executive Summary: We completed four protocol surveys for Least Bell's Vireos (*Vireo bellii pusillus*; vireo) during the breeding season, supplemented by weekly territory monitoring visits. We identified a total of 133 territorial male vireos; 114 were confirmed as paired, and 3 were confirmed as single males. For the remaining 16 territories, we were unable to confirm breeding status. Two transient vireos were detected in 2022. The vireo population in the Project Area increased by 9 percent from 2021 to 2022. The vireo population at Marine Corps Base Camp Pendleton also increased (4 percent), whereas the population at Marine Corps Air Station remained relatively stable (decreased from 10 pairs to 9) and the Otay River population decreased by 10 percent (2 territories).

We used an index of treatment (Treatment Index) to evaluate the effect of on-going vegetation clearing on the Project Area vireo population. The Treatment Index measures the cumulative effect of vegetation treatment within a territory (since 2005) by using the percentage area treated weighted by the number of years since treatment. We determined that the Treatment Index for unoccupied habitat was more than four times that of occupied habitat, indicating that vireos selected habitat that was less treated in which to settle.

We monitored vireo nests at three general site types: (1) within the flood channel where exotic and native vegetation removal has occurred regularly (Channel), (2) three sites near the flood channel where limited exotic and native vegetation removal has occurred (Off-channel), and (3) three sites that have been actively restored by planting native vegetation (Restoration). Nesting activity was monitored in 80 territories, 3 of which were occupied by single males and 1 by a male whose breeding status could not be confirmed. Overall, 38 percent of completed nests were successful and nest success did not differ among the three sites. In 2022, there were no differences with regard to clutch size, hatching, or fledging success among Channel, Off-channel and Restoration sites. Overall breeding success and productivity were slightly higher in 2022 than in 2021, with 72 percent of pairs fledgling at least one young and pairs fledging an average of 2.2±1.7 young.

To investigate if the cumulative years of treatment had an effect on vireo reproductive effort, we looked at the effects of the Treatment Index on reproductive parameters. Results from generalized linear models indicated that treatment did not have an effect on vireo nesting effort or the number of vireo fledglings per pair produced in 2022. Similarly, we did not detect an effect of Treatment Index on daily survival rate (DSR) of nests.

Analysis of vegetation data collected at vireo nests from 2006 to 2022 did not reveal an effect of vegetation cover at the nest on DSR. We did find, however, that Channel nests were placed higher

in the host plant than Off-channel nests. In the Channel and Off-channel sites, successful nests were placed closer to the edge of the host plants than unsuccessful nests. Additionally, successful Off-channel nests were placed lower in the vegetation, in shorter host plants, and closer to the edge of the vegetation clump than unsuccessful nests.

Red/arroyo willow (*Salix laevigata* or *Salix lasiolepis*) were the species most commonly selected for nesting by vireos in all three site types. Black willow (*Salix gooddingii*) and mule fat (*Baccharis salicifolia*) also were commonly used. Vireos used a wider variety of species for nesting in Channel and Off-channel sites (eight and six species, respectively) compared to Restoration sites (two species), although there was limited nesting in Restoration sites in 2022.
There were 43 vireos banded before the 2022 breeding season that were resighted and identified at the Project Area in 2022, all of which were originally banded in the Project Area. Adult birds of known age ranged from 1 to 7 years old. A total of 146 vireos were newly banded in 2022. There were 8 adult vireos banded with a unique color combination, and 138 nestlings were banded with a single dark blue numbered federal band on the left leg. Between 2006 and 2022, survivorship of males (66±11 percent) was consistently higher than that of females (59±12 percent). First-year birds from 2006 to 2022 had an average annual survivorship of 15±6 percent.

First-year dispersal in 2022 averaged 6.7±7.4 kilometers (km), with the longest dispersal (15.3 km) by a male that was recaptured at Fallbrook Creek, Fallbrook Naval Weapons Station (FNWS). From 2007 to 2011, most returning first-year vireos returned to the Project Area, whereas from 2014 to 2016, the majority of returning birds dispersed to areas outside of the Project Area. From 2018 to 2021, the trend shifted, and more first-year vireos returned to the Project area. In 2022, only one first-year vireo returned to the project area and two dispersed to sites outside the Project Area (upstream to the middle San Luis Rey River and to Fallbrook Creek, FNWS). However, the total number of identified first-year vireos was low and the trend in 2022 will likely shift as additional returning first-year vireos are identified in subsequent years.

Most of the returning adult male vireos showed strong between-year site fidelity to their previous territories. Seventy-three percent of males (27/37) occupied a territory in 2022 that they had defended in 2021 (within 100 meters [m]). There were no females (0/4) detected in 2022 that returned to a territory they occupied in 2021; however, 50 percent of females (2/4) detected in 2022 returned to areas adjacent to their previous territories (within 300 m). The average between-year movement for returning adult vireos was 0.3±0.7 km. The amount of treatment at adults' 2021 territories did not affect the distance adults moved to their 2022 territories.

We completed four protocol surveys for the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher) at the Project Area between May 16 and July 25, 2022. Four transient Willow Flycatchers were detected in the Project Area in 2022. Two transients were detected in Reach 1, one in Reach 3a, and one in Pilgrim Pond. There were not any resident flycatchers documented in the Project Area in 2022.

A total of 46 vegetation transects (528 points) were sampled at the Project Area in 2022. Seventy-one percent (378/528) of points were located in the Channel, and 22 percent (115/528) were in

Upper Pond. The remaining 7 percent (35/528) of points were at the Whelan Restoration site. Foliage cover below 2 m was higher at the Channel points compared to Upper Pond and Whelan Restoration, which can be attributed to the dense herbaceous vegetation that grows after mowing. Above 2 m, foliage cover was similar at the Channel and Whelan Restoration sites and was higher than at Upper Pond. Average canopy height was higher in the Channel (5.6±3.4 m) compared to Upper Pond (4.7±2.9 m) and Whelan Restoration (4.6±1.9 m). From 2006 to 2022, total foliage cover declined above 2 m in the Channel, in contrast to Upper Pond and Whelan Restoration, where little directional change in vegetation cover has occurred and where vegetation cover has largely recovered to 2006 levels. Within the Channel, the steepest declines occurred between 2009 and 2013 and between 2014 and 2016. Since 2016, we observed an increase in foliage cover, largely herbaceous, between 0 and 2 m within the Channel. The percent cover remained below levels detected before 2009 for other height classes.

We sampled vegetation at 44 vireo nests and 44 random plots (“territory” plots) within territories in the Channel and Upper Pond after the 2022 breeding season. Vireos in the Channel established territories in areas with significantly more cover from 3 to 6 m but less cover below 2 m relative to the available habitat. Within territories, Channel vireos selected nest sites with significantly more foliage cover from 2 to 3 m. Vireos at Upper Pond established territories in areas with significantly more foliage cover from 5 to 6 m and below 1 m relative to available habitat. However, within territories, Upper Pond vireos selected nest sites with significantly less foliage cover from 5 to 6 m and below 1 m.

DOI: 10.3133/dr1177

Howell, S. L. and B. E. Kus. 2023. Distribution and Abundance of Southwestern Willow Flycatchers (*Empidonax traillii extimus*) on the Upper San Luis Rey River, San Diego County, California—2022 data summary (No. 1173). Data Report 1173. US Geological Survey. 12 pp. doi: 10.3133/dr1173. Available online: https://pubs.usgs.gov/publication/dr1173

Keywords: N/A

Abstract: We surveyed for Southwestern Willow Flycatchers (*Empidonax traillii extimus*; flycatcher) along the upper San Luis Rey River near Lake Henshaw in Santa Ysabel, California, in 2022. Surveys were completed at four locations: three downstream from Lake Henshaw, where surveys occurred from 2015 to 2021 (Rey River Ranch [RRR], Cleveland National Forest [CNF], Vista Irrigation District [VID]), and one at VID Lake Henshaw (VLH) that has been surveyed annually since 2018. There were 71 territorial flycatchers detected at 3 locations (RRR, CNF, VLH), and 6 transient flycatchers of unknown subspecies detected at VID and VLH. Downstream from Lake Henshaw, four territorial flycatchers, including two males and two females, were detected at RRR and CNF. In total, two territories were established consisting of two pairs at these locations. At VLH, we detected 67 territorial flycatchers, including 30 males, 34 females, and 3 flycatchers of unknown sex. In total, 40 territories were established, containing 35 pairs (24 monogamous pairings and 5 polygynous groups consisting of 4 males each pairing with 2 different females, and 1 male pairing with 3 different females), and 5 flycatchers of undetermined breeding status (3 males and 2 flycatchers of unknown sex). Brown-headed cowbirds (*Molothrus ater*; cowbird) were detected at all four survey locations.

Flycatchers used five habitat types in the survey area: (1) mixed willow riparian, (2) willow-cottonwood, (3) willow-oak, (4) willow-ash, and (5) oak-sycamore. Of the flycatcher locations, 83 percent were located in habitat characterized as mixed willow riparian, and 92 percent were in habitat with greater than 95-percent native plant cover. Exotic vegetation was not prevalent in the survey area.

There were 22 nests incidentally located during surveys: 5 were successful, 1 was seen with eggs on the last visit, 10 failed, and the outcome of the remaining 6 nests was unknown. Three of these nests were parasitized by cowbirds. There were 13 juveniles detected at VLH; no juveniles were detected at RRR or CNF.

Five banded flycatchers were detected during surveys, three of which were confirmed to be adults that held territories in previous years. In addition, two flycatchers with a single dark blue federal band, indicating that they were banded as nestlings in a previous demographic study downstream from Lake Henshaw (Howell and others, 2022), were resighted during surveys.

DOI: 10.3133/dr1173

LaFond, L. R., B. J. Darby, J. R. Boulanger, and K. A. Yurkonis. 2023. Small Mammals of a Northern Salt-Affected Grassland. Mammalia 87(5): 478-487. doi: 10.1515/mammalia-2023-0018.

Keywords: cover, litter depth, shrews, soil moisture, voles

Abstract: While many studies have characterized small mammals of the southern and central Great Plains (USA), far fewer have documented small mammals of the northern Great Plains which differ dramatically in plant structure and composition. We examined the presence and distribution of small mammals captured at a salinity-affected grassland in northeastern North Dakota (2018–2021). We captured 12 species from 8 genera including *Microtus pennsylvanicus* (n = 724), *Peromyscus* (*maniculatus*) *sonoriensis* (n = 114), *Sorex cinereus* (n = 54), and *Zapus hudsonius* (n = 43). We evaluated the extent to which these species varied with plant and environmental characteristics. *M. pennsylvanicus* was positively associated with plant cover and soil moisture and *P*. (*maniculatus*) *sonoriensis* was positively associated with forb cover and negatively associated with litter and elevation. *Z. hudsonius* was negatively associated with forb cover and soil moisture and *S. cinereus* was positively associated with cover and negatively associated with salinity. These species associated with their environments differently than their more southern counterparts and reinforce the notion that not all areas, even in relatively intact grasslands, are available to all species. Future studies are needed to further examine more infrequently captured species, including a *Sorex hoyi*, an *Onychomys leucogaster*, and eight *Myodes gapperi* in this region.

DOI: 10.1515/mammalia-2023-0018

Lynn, S. and B. E. Kus. 2023. Distribution and Abundance of Least Bell's Vireos (*Vireo bellii pusillus*), Southwestern Willow Flycatchers (*Empidonax traillii extimus*), and Coastal California Gnatcatchers (*Polioptila californica californica*) at the Santa Fe Dam, Los Angeles County, California—2022 Data Summary. Data Report 1171. US Geological Survey. 12 pp. doi: 10.3133/dr1171. Available online: https://pubs.usgs.gov/publication/dr1171

Keywords: N/A

Abstract: In 2022, we surveyed for Least Bell's Vireos (*Vireo bellii pusillus*; vireo), Southwestern Willow Flycatchers (*Empidonax traillii extimus*; flycatcher), and Coastal California Gnatcatchers (*Polioptila californica californica*; gnatcatcher) in the Santa Fe Dam detention basin and along the San Gabriel River upstream from the Santa Fe Dam near Irwindale, California. Four vireo surveys were completed between April 21 and July 13, 2022; three flycatcher surveys were completed between May 18 and July 13, 2022; and four gnatcatcher surveys were completed between April 21 and July 13, 2022. We detected seven territorial male vireos, including four that were paired and three with undetermined breeding status. We also detected one transient vireo. Two juvenile vireos were observed during surveys. Vireo territories were found in riparian scrub, willow (*Salix* spp.)-cottonwood (*Populus* spp.), and mixed willow habitat, with mixed willow the most commonly recorded habitat type. Black willow (*S. gooddingii*) was the dominant plant species in most vireo territories. We detected 10 transient flycatchers in riparian scrub (5 individuals), mixed willow (4 individuals), and non-native vegetation (1 individual). Black willow and mule fat (*Baccharis salicifolia*) were the predominant plant species in flycatcher locations. We detected four territorial male gnatcatchers, two of which were paired and two of undetermined breeding status. We also detected one territorial female gnatcatcher. One juvenile gnatcatcher was observed during surveys. All gnatcatchers were detected in coastal sage scrub. The dominant shrub species at gnatcatcher locations were California sagebrush (*Artemisia californica*) and scale broom (*Lepidospartum squamatum*).

DOI: 10.3133/dr1171

Macías-Duarte, A., E. Juárez, E. S. Murrieta, E. L. Perales-Hoeffer, and C. I. Ortega Rosas. 2023. Abundance and Occupancy of the Western Yellow-Billed Cuckoo (*Coccyzus americanus*) in Sonora, Mexico. Canadian Journal of Zoology. doi: 10.3133/dr1171

Keywords: N/A

Abstract: Unveiling factors that determine abundance and distribution of endangered wildlife species has important implications for their conservation across international boundaries. For instance, the Western Distinct Population (as defined by the U.S. Fish and Wildlife Service) of the yellow-billed cuckoo *Coccyzus americanus* (Linnaeus, 1758) has disappeared in most of the species' range across western United States and southwestern Canada but little is known about the conservation status at the southern edge of its breeding distribution in Mexico. To fill this information gap, we estimated abundance and occupancy rates of yellow-billed cuckoos using a standard broadcast call survey protocol. We used Bayesian spatial count models to estimate cuckoo population density at survey sites. We used Bayesian hierarchical models to estimate the effects of geography, climate, and vegetation on occupancy rates while accounting for imperfect detection. Mean cuckoo count per transect for all sites was $\bar{C}$ = 9.00 ± 0.45 cuckoos. Overall cuckoo density was $\bar{\bar{D}}$ = 13.18 cuckoos/km^2 (SD($\bar{D}$) = 5.61 cuckoos/km^2). Overall cuckoo occupancy in Sonora was $\bar{\psi}$ = 0.538 (95% credible interval (ψ) = 0.488–0.600), but showed strong geographic variation. Relatively high occupancy levels suggest yellow-billed cuckoo populations in Sonora may be robust, but they are largely reliant on declining high-tree cover.

DOI: 10.1139/cjz-2022-009

Malaney, J. L., C. R. Wilford, J. T. Woods, B. L. Christman, R. D. Jennings, C. L. Chambers, J. L. Zahratka, S. W. Liphardt, J. R. Demboski, and J. A Cook. 2023. Wagering with an Incomplete Deck—Refining Conservation Plans for the New Mexico Meadow Jumping Mouse (*Zapus luteus luteus*). Journal of Mammalogy 104(5): 1019-1035. doi: 10.1093/jmammal/gyad049.

Keywords: climate change, jumping mice, phylogeography, species distribution model, *Zapus luteus*

Abstract: Limited sampling for imperiled taxa inhibits effective management by obscuring windows into ecological and evolutionary processes and ultimately thwarting thoughtful conservation efforts. We report eight new locations for the endangered New Mexico Meadow Jumping Mouse (*Zapus luteus luteus*) detected across three states that expand their known distribution. When combined with existing curated museum records, we develop an ensemble species distribution model to evaluate persistence of populations over the next 50 years. Predicted distributions indicate complex future changes, including regional expansion and the likelihood that half of the designated critical habitat areas will be unsuitable by 2070. Three of the newly discovered populations occur where predicted climate conditions suggest extirpation is likely. Importantly, indices of historical sampling efforts show that recognized and potential distributions are mismatched, highlighting vast areas that have been insufficiently surveyed. Ongoing habitat degradation and climate disruption are projected to synergistically erode genetic diversity across four of the five divergent phylogroups. Considering these combined results, a holistic sampling strategy is needed to more completely document the distribution of jumping mice and facilitate genomic analyses aimed at establishing a roadmap for improving our understanding of geographic variation and adaptive potential. Current management efforts are not only costly, but they are lacking key biological insights, essentially wagering actions with an incomplete deck of cards.

DOI: 10.1093/jmammal/gyad049

Meek, M. H., E. A. Beever, S. Barbosa, S. W. Fitzpatrick, N. K. Fletcher, C. S. Mittan-Moreau, B. N. Reid, S. C. Campbell-Staton, N. F. Green, and J. J. Hellmann. 2023. Understanding Local Adaptation to Prepare Populations for Climate Change. BioScience 73(1): 36-47. doi: 10.1093/biosci/biac101.

Keywords: N/A

Abstract: Adaptation within species to local environments is widespread in nature. Better understanding this local adaptation is critical to conserving biodiversity. However, conservation practices can rely on species' trait averages or can broadly assume homogeneity across the range to inform management. Recent methodological advances for studying local adaptation provide the opportunity to fine-tune efforts for managing and conserving species. The implementation of these advances will allow us to better identify populations at greatest risk of decline because of climate change, as well as highlighting possible strategies for improving the likelihood of population persistence amid climate change. In the present article, we review recent advances in the study of local adaptation and highlight ways these tools can be applied in conservation efforts. Cutting-edge tools are available to help better identify and characterize local adaptation. Indeed, increased incorporation of local adaptation in management decisions may help meet the imminent demands of managing species amid a rapidly changing world.

DOI: 10.1093/biosci/biac101

Metcalfe, A. N., J. D. Muehlbauer, M. A. Ford, and T. A. Kennedy. 2023. Colorado River Basin. Pp. 462-509. *In*: M. D. Delong, T. D. Jardine, A. C. Benke and C. E. Cushing, eds. Rivers of North America. Academic Press, San Diego, California. doi: 10.1016/B978-0-12-818847-7.00001-X.

Keywords: N/A

Abstract: The Colorado River is often referred to as “the lifeblood of the west.” The basin supplies municipal water to nearly 40 million people and irrigates approximately 22,000 km2 of agricultural lands. Twenty-two major rivers converge with the Colorado after it begins its descent from the Rocky Mountains and winds through the plateaus of Colorado, Utah, and Arizona, onto the deserts of southwestern Arizona, and finally into the Gulf of California, where inflows from the Río Hardy and Río Sonoyta in Mexico complete the drainage. The mainstem Colorado, Green, Yampa, Little Colorado, and Yampa Rivers are described in further detail in the 2005 edition (Blinn and Poff, 2005) of this book. In this edition, we discuss seven other major tributaries in the Colorado River basin: the Gunnison, San Juan, Virgin, Bill Williams, Verde, Black, and Salt Rivers. The water quality and quantity, flora and fauna, and sediment and organic loads of each of these tributaries uniquely alter the mainstem Colorado River and the habitat it provides. Thus, understanding the hydrology, ecology, and human use of these tributaries is critical toward understanding both the complex history and present-day management of the Colorado River Basin as a whole.

DOI: 10.1016/B978-0-12-818847-7.00001-X

Morgan, M., A. Webster, M. Piccarello, K. Jones, J. Chermak, L. McCarthy, and J. Srinivasan. 2023. Adaptive Governance Strategies to Address Wildfire and Watershed Resilience in New Mexico's Upper Rio Grande Watershed. Frontiers in Climate 5: 1062320. doi: 10.3389/fclim.2023.1062320.

Keywords: N/A

Abstract: Global climate models project that New Mexico's Upper Rio Grande watershed is expected to become more arid and experience greater climatic and hydrological extremes in the next 50 years. The resulting transitions will have dramatic implications for downstream water users. The Upper Rio Grande and its tributaries provide water to about half of New Mexico's population, including the downstream communities of Albuquerque and Santa Fe, and surrounding agricultural areas. In the absence of formal climate adaptation strategies, informal governance arrangements are emerging to facilitate watershed climate adaptation strategies, including fuel treatments and stream remediation. One example is the Rio Grande Water Fund (RGWF), a collaborative effort coordinating work to protect storage, delivery, and quality of Rio Grande water through landscape-scale forest restoration treatments in tributary forested watersheds. This article examines the RGWF as one example of an emerging adaptation strategy that is working within—and beyond—existing legal and policy frameworks to accomplish more collaborative efforts across jurisdictional lines and administrative barriers. We identified ten (10) key characteristics of adaptive governance from the relevant literature and then applied them to the RGWF's experience in the watershed to date. Key findings include: (1) the RGWF's approach as a collaborative network created the right level of formality while also keeping flexibility in its design, (2) a scalar fit to the environmental challenge built social capital and investment in its work, (3) leadership from key stakeholders leveraged opportunities in the watershed to create and maintain stability, and (4) use of adaptive management and peer review processes built capacity by creating the feedback loops necessary to inform future work.

DOI: 10.3389/fclim.2023.1062320

Nguyen, E., K. B. Mayes, R. Smith, J. Trungale, and J. S. Perkin. 2023. The Duality of Drought: Pelagic-and Benthic-Spawning Stream Fishes Show Opposing Responses to Drought in the Southern Great Plains. North American Journal of Fisheries Management 43(5): 1276-1293. doi: 10.1002/nafm.10874.

Keywords: distribution, hydrology, in-stream flow, management theory, riparian and ecology, risk assessment, threatened and endangered species

Abstract: Objective: Streamflow is a primary determinant of fish assemblage structure in riverine systems, but alteration of natural flow regimes can result in fish assemblage shifts through the process of environmental filtering. Because natural drought conditions reduce and homogenize streamflow in a manner comparable to projections for climate change in some regions, drought could serve as a proxy for expected future flow conditions.

Methods: We investigated the effects of drought as a temporally dynamic environmental filter of the occurrence of two guilds of fishes, benthic spawners that deposit adhesive ova along the benthic zone of rivers and pelagic spawners that release semibuoyant, nonadhesive ova into the pelagic zone of rivers. We developed species-specific random forest models to estimate annual probability of occurrence for three benthic-spawning and four pelagic-spawning minnow species at three sites in the upper Brazos River, Texas, for the period 1950–2018. We then used a generalized additive mixed-effects model to assess the relationship between drought intensity and likelihood of occurrence to test whether reproductive modes differed in response to drought (hypothesis 1) and whether response to drought was spatially (hypothesis 2) or temporally (hypothesis 3) variable.

Result: We found support for hypothesis 1 as two of four pelagic-spawning species (Shoal Chub *Macrhybopsis hyostoma*, Smalleye Shiner *Notropis buccula*) declined and two of three benthic-spawning species increased as drought intensified, support for hypothesis 2 as responses to drought varied by gauge location, and no support for hypothesis 3 as drought response was consistent for periods 1950–1979 and 1980–2018.

Conclusion: These findings offer insight into the future of riverine fish assemblages as climate change is expected to exacerbate regional drought conditions. Management of pelagic-spawning fishes during extreme drought in the southern Great Plains may require strategies such as (1) rescues of fish from drying reaches, (2) captive holding and propagation, and (3) assisted recolonization following subsidence of drought conditions.

DOI: 10.1002/nafm.10874

Ormsbee, H. A., 2023. Hydraulic Habitat Suitability for the Rio Grande Silvery Minnow at the Los Chavez Irrigation Outfall, New Mexico. Thesis. University of New Mexico, Albuquerque, New Mexico. August 2023.

Keywords: Rio Grande Silvery Minnow, hydraulic habitat suitability, irrigation outfalls, MRGCD, habitat refuge, habitat suitability indices, hydraulic modeling

Abstract: It is essential to manage the Middle Rio Grande for aquatic species to preserve the native biodiversity of the river. During periods of low flow, endangered species such as the Rio Grande Silvery Minnow (RGSM) may get trapped in a drying reach without the ability to escape from isolated pools. Very little is known about how areas of refuge, such as irrigational outfall channels, buffer RGSM from stream flow intermittency. Hence, there is a crucial need to quantify available habitat for RGSM in areas of refuge.

This study aims to make connections between flow regimes and physical-habitat conditions to help inform the operation of the Los Chavez outfall, specifically for the benefit of the RGSM. Two-dimensional hydraulic simulations were performed to characterize inundated areas and areas of suitable hydraulics for a range of discharges. Eco-value curves were created to delineate a discharge/habitat relationship for larval and adult life stages.

Results from this study indicate that available areas increased for larval and adult RGSM as more water was released from the outfall, however there was a diminishing return in available habitat with outfall flows above 15 cfs. The Rio Grande did not contribute to floodplain habitat until flows reached 1000 cfs. The outfall itself provided little suitable v habitat for larval RGSM, but the channel provided suitable habitat for adult RGSM once the outfall converged with the sandbar. Larval RGSM had suitable habitat in the floodplain at each Rio Grande and Los Chavez discharge. Adult RGSM had suitable areas in the outfall and surrounding floodplain at each Rio Grande and Los Chavez discharge.

URL: https://digitalrepository.unm.edu/ce_etds/302/

Osborne, M. J., G. Caeiro-Dias, and T. F. Turner. 2023. Transitioning from Microsatellites to SNP-Based Microhaplotypes in genetic monitoring Programmes: Lessons from Paired Data Spanning 20 Years. Molecular Ecology 32(2): 316-334. doi: 10.1111/mec.16760

Keywords: RAD-seq, demography, genetic effective population size, inbreeding, long-term monitoring, multilocus heterozygosity, rapid evolution

Abstract: Many long-term genetic monitoring programmes began before next-generation sequencing became widely available. Older programmes can now transition to new marker systems usually consisting of 1000s of SNP loci, but there are still important questions about comparability, precision, and accuracy of key metrics estimated using SNPs. Ideally, transitioned programmes should capitalize on new information without sacrificing continuity of inference across the time series. We combined existing microsatellite-based genetic monitoring information with SNP-based microhaplotypes obtained from archived samples of Rio Grande silvery minnow (*Hybognathus amarus*) across a 20-year time series to evaluate point estimates and trajectories of key genetic metrics. Demographic and genetic monitoring bracketed multiple collapses of the wild population and included cases where captive-born repatriates comprised the majority of spawners in the wild. Even with smaller sample sizes, microhaplotypes yielded comparable and in some cases more precise estimates of variance genetic effective population size, multilocus heterozygosity and inbreeding compared to microsatellites because many more microhaplotype loci were available. Microhaplotypes also recorded shifts in allele frequencies associated with population bottlenecks. Trends in microhaplotype-based inbreeding metrics were associated with the fraction of hatchery-reared repatriates to the wild and should be incorporated into future genomic monitoring. Although differences in accuracy and precision of some metrics were observed between marker types, biological inferences and management recommendations were consistent.

DOI: 10.1111/mec.16760

Phillips, L. 2023. Fantastic Birds and Where to Find Them. Dissertation. University of Nevada, Reno, Nevada. August 2023.

Keywords: N/A

Abstract: I investigated avian-habitat relationships in three related study systems. In my first chapter I characterize the nonbreeding habitat of the western subspecies of Willow Flycatchers (*Empidonax traillii subspp*.), including the federally endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*), with a range-wide species distribution model. The three western subspecies of Willow Flycatchers migrate between the riparian landscapes in the western and southwestern United States to the riparian areas in tropical dry forests along the Pacific coast of Central America. The predictive model of potential habitat suitability will be corroborated on the ground by conservation collaborators and used to locate new long-term monitoring sites, and acquire new protected areas. Unlike the migratory western Willow Flycatchers, The Nicaraguan Grackle is a residential (non-migratory) bird that occupies more open wetlands and riparian areas around the Nicaraguan great lakes and the Caño Negro wetland complex of Costa Rica. In my second chapter, I create urgently-needed baseline maps of habitat suitability with varied levels of freshwater recurrence for the Nicaraguan Grackle (*Quiscalus nicaraguensis*). This map of predicted habitat suitability will be used as evidence to garner elevated protection status for this understudied, declining species. Finally, in my third chapter, I use unmanned aerial systems (UAS or drones) to explore methods to improve habitat variables used in nest-site selection modeling for Mojave Desert riparian songbirds, including the endangered Least Bell's Vireo (*Vireo bellii pusillus*). I compared UAS and satellite image products of vegetation structure within first and second order resource selection functions for breeding and nesting habitat in Amargosa Canyon. The ultimate goal with this research was to determine key features of vegetation structure that influence nest-site selection to inform habitat restoration upstream on the Amargosa River.

URL: https://www.proquest.com/openview/895e1d8b3f748be96c769242c817721e/1?pq-origsite=gscholar&cbl=18750&diss=y

Pottinger, R. E. and B. E. Kus. 2023. Least Bell's Vireo (*Vireo bellii pusillus*) and Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Surveys in the Sepulveda Dam Basin, Los Angeles County, California—2022 Data Summary. Data Report 1177. 8 pp. US Geological Survey. doi: 10.3133/dr1177. Available online: https://pubs.usgs.gov/publication/dr1177

Keywords: N/A

Abstract: We surveyed for Least Bell's Vireos (*Vireo bellii pusillus; vireo*) and Southwestern Willow Flycatchers (*Empidonax traillii extimus*; flycatcher) along Bull Creek, Haskell Creek, and the Los Angeles River (Sepulveda Dam project area) in Los Angeles County, California, in 2022. Four vireo surveys were completed from April 26 to July 14, and three flycatcher surveys were completed from May 19 to July 14. We detected 10 territorial male vireos, 5 of which were confirmed as paired, and 2 transient vireos. Of the 10 territorial vireos, 70 percent were detected along the Los Angeles River, 20 percent along Bull Creek, and 10 percent along Haskell Creek. Of the vireos detected, 80 percent were in habitats characterized as mixed willow, and most vireos were detected in habitats with greater than 50-percent native plant cover. One transient flycatcher was observed in the survey area in 2022.

DOI: 10.3133/dr1177

Ramsey-Wiegmann, L.D. 2023. Accidental and Restored Wetlands of the Lower Salt River: A Portrait of Biodiversity and Community Composition Over a Decade of Urbanization. Thesis. Arizona State University, Tempe, Arizona. May 2023.

Keywords: N/A

Abstract: Urban wetland ecosystems provide myriad ecosystem services and are shaped by diverse social and ecological factors. In rapidly urbanizing parts of the desert Southwest, wetlands are especially vital. Across less than 60 km as it enters the Phoenix area, the Salt River is dammed, diverted, re-filled, clear-cut, restored, and ignored. This study documents how animal and plant communities in three perennially inundated reaches of the river changed over a decade under different social-ecological pressures. One wetland in the urban core is restored, another formed accidentally by human infrastructure, and the last is managed on the urban periphery. Surveys conducted since 2012 used point count surveys to assess bird communities and visual encounter surveys to assess reptiles and amphibians. Plant communities were surveyed in 2012 and 2022 using cover classes. Between 2012 and 2022, accidental and restored wetlands close to the urban core displayed an increase in plant abundance, largely consisting of introduced species. While all sites saw an increase in plant species considered invasive by land management groups, both urban wetlands saw an increase in regionally native species, including plants that are culturally significant to local Indigenous groups. Reptile communities declined in richness and abundance in both urban sites, but birds grew in abundance and richness at the urban restored site while not changing at the urban accidental wetland. The non-urban site saw stable populations of both birds and herpetofauna. These trends in biotic communities reveal ecological tradeoffs under different management strategies for urban wetlands. These findings also create a portrait of wetland communities along a rapidly urbanizing arid river. As the Salt River watershed becomes more urbanized, it is important to establish a more empathetic and informed relationship between its plant and ii animal—including human—residents. To this end, these data were incorporated in a series of handmade paper artworks, crafted from the most abundant wetland plant species found at the study sites, harvested alongside local land management efforts. These artworks examine the potential of four common cosmopolitan wetland plants for papermaking, revealing the potential to align ecosystem management efforts with both materials production and fine arts. By using relief printmaking to visualize long-term ecological data, I explored an alternative, more creative and embodied way to engage with and visualize urban wetland communities. This alternate mode of engagement can complement ecological management and research to diversify disciplines and participants engaged with understanding and living alongside urban wetlands.

URL: https://keep.lib.asu.edu/system/files/c7/RamseyWiegmann_asu_0010N_22917.pdf

Ritchie, A. B., S. B. Chavarria, A. E. Galanter, A. K. Flickinger, A. J. Robertson, and D. S. Sweetkind. 2023. Development of an Integrated Hydrologic Flow Model of the Rio San Jose Basin and Surrounding Areas, New Mexico. Scientific Investigations Report 2023–5028. US Geological Survey. 76 pp. doi: 10.3133/sir20235028. Available online: https://pubs.usgs.gov/publication/sir20235028

Keywords: N/A

Abstract: The Rio San Jose Integrated Hydrologic Model (RSJIHM) was developed to provide a tool for analyzing the hydrologic system response to historical water use and potential changes in water supplies and demands in the Rio San Jose Basin. The study area encompasses about 6,300 square miles in west-central New Mexico and includes the communities of Grants, Bluewater, and San Rafael and three Native American Tribal lands: the Acoma and Laguna Pueblos and the Navajo Nation. Perennial surface water features are sparse in the study area and most water resources consist of groundwater pumped from sedimentary and basalt aquifers.

Calibration of the RSJIHM was performed using PEST++ (version 4.3.20) and BeoPEST (version 13.6). Model parameter values were adjusted during calibration to fit model simulated values to the measured or estimated values for several observation groups: (1) solar radiation, (2) potential evapotranspiration, (3) actual evapotranspiration, (4) precipitation and minimum and maximum air temperature, (5) snow water equivalent, (6) snow-covered area, (7) streamflow, (8) hydraulic head, (9) springflow at Ojo del Gallo, (10) springflow at Horace Springs, (11) surface-water releases from Bluewater Lake, and (12) surface-water diversions for irrigation within the Bluewater-Toltec Irrigation District.

The simulated average annual hydrologic budget from 1950 through 2018 indicated that the majority (greater than 98 percent) of precipitation within the basin was consumed by evapotranspiration, leaving 1.2 percent to recharge the groundwater system, 0.47 percent to direct runoff to streams, and 0.20 percent to infiltrate the soil zone and interflow to streams. The average annual recharge to the groundwater system and runoff to streams simulated by the RSJIHM was about 28,000 and 11,000 acre-feet, respectively. The RSJIHM simulated about 590,000 acre-feet of cumulative aquifer storage depletion from 1950 through 2018.

Additional work that could improve the simulation capability of the RSJIHM includes (1) further data collection (streamflow, head, springflow) in the southwestern subbasin that includes the El Malpais National Monument, (2) incorporating temporally variable vegetation parameters, (3) spatial downscaling of the hydrometeorological input datasets, (4) incorporating additional spatial variability to hydraulic property parameters on the basis of new data collection, and (5) using environmental tracers to verify and calibrate model parameters.

DOI: 10.3133/sir20235028

Ryan, A., 2023. Comparative Habitat Assessment to Investigate Feasibility of Habitat Restoration for the Dunes Sagebrush Lizard. Thesis. Texas Tech University, Lubbock, Texas. December 2023.

Keywords: Sand, dunes, lizard, restoration, conservation

Abstract: The Dunes-sagebrush lizard is a habitat specialist species endemic to the Mescalero-Monahans sand dune system in Texas and New Mexico. Sand mining, fracking, and other oil industry activities have contributed to the naturally patchy and rolling dune system to become fragmented and flatten out in many areas, decreasing dunes-sagebrush lizard populations. Although there seems to be a necessity to federally list the dune-sagebrush lizard, instead, USFWS and some stakeholders decided to attempt and develop a Candidate Conservation Agreement. With populations decreasing due to habitat loss and fragmentation, the question of habitat restoration arose. In order to investigate restoration requirements, a comparative habitat analysis was conducted including habitat surveys, GIS analysis of elevation models, and a literature review. Habitat surveys were conducted for fifteen “suitable” and “unsuitable” one acre squared plots. Statistical analysis, including ANOVA and a Principal Component Analysis, was conducted to discern and visualize differences in habitat suitability levels. ANOVA results showed the most significant differences in regards to honey mesquite (p=0.01), sand shinoak (p=0.01), tall dropseed (p=0.01), alkali sacaton (p=0.01), slope (p=0.01), bare ground (p=0.01), and litter (p=0.01). These differences were made even more clear by the results of the Principal Component Analysis. Additionally, germination studies were conducted on gilia beardtongue, a plant species found in dune sagebrush lizard habitat. Room temperature water and darkness led to more germinations versus cold water and light and dark cycles. Habitat restoration would aid in the recovery of dunes sagebrush lizards. In addition to being expensive, habitat restoration would need to ensure a continuous system and require extensive monitoring and management to ensure restoration is successful.

URL: https://ttu-ir.tdl.org/server/api/core/bitstreams/27b84dc4-6f89-4d5d-92be-49f066be55d5/content

Salas, K. 2023. Interdisciplinary Approach to Understanding Stakeholder Reasoning and Decision-Making for Wate. Dissertation. University of Texas at El Paso. August 2023.

Keywords: N/A

Abstract: On a global scale, humanity is compelled to address complex or 'wicked' resource-related issues in the face of accelerating environmental change. In our work, we use the term wicked problem to refer to an issue that has multiple potential solutions and involves various stakeholders. The paths to reach resource sustainability under environmental uncertainty are difficult to identify, plausible outcomes remain uncertain, and tradeoffs required by any path chosen are challenging to understand. Environmental sustainability issues may involve perspectives from multiple stakeholders (i.e., scientists, policymakers, community members, and industry), often leading to conflicting interests and cultural misalignments that trigger the need for a more integrated approach. Participatory modeling (PM) has been identified as an emerging strategy to address these problems. PM aims to generate a shared understanding of the challenges confronting a given resource system through social learning and collaborative thought experiments that explore potential societal responses supported by computational tools. This approach has many examples, but our understanding of how social learning, knowledge shifts, and decision-making occurs in this context remains limited. In this study, we focus on how people understand and collaborate through PM using freshwater supply models of the Middle Rio Grande River Basin. We conducted online workshops with activities targeting key competencies and collaboration, exposing participants to online scientific data and models. Through these workshops, participants identified conflicts, co-created knowledge, and developed potential solutions informed using scientific models. Results of the study allowed us to determine what mechanisms facilitated social learning and the effectiveness of various tools used to present scientific data and models to non-scientists. In this study, we extensively explore stakeholder engagement, participatory modeling, and scenario analysis in the Paso del Norte region's water challenges, utilizing SWIM 2.0. Our research underscores the significance of collaborative processes, knowledge co-creation, and diverse perspectives. The findings highlight participatory methodologies' potential in addressing complex water issues and fostering stakeholder trust. Furthermore, we emphasize the role of group dynamics and negotiations during the collective construction of a group concept map, shedding light on its impact on collaborative success, scenario analysis, and trust-building.

URL: https://scholarworks.utep.edu/open_etd/3938/

Samimi, M., A. Mirchi, D. Moriasi, Z. Sheng, D. Gutzler, S. Taghvaeian, S. Alian, K. Wagner, and W. Hargrove. 2023. Adapting Irrigated Agriculture in the Middle Rio Grande to a Warm-Dry Future. Journal of Hydrology: Regional Studies 45: 101307. doi: 10.1016/j.ejrh.2022.101307.

Keywords: climate change, water security, irrigation interventions, Soil and Water Assessment Tool (SWAT), alternative crops, groundwater depletion

Abstract: Study region: Middle Section of the Rio Grande Basin (MRG), U.S.

Study focus: Long-term tradeoffs of technologically possible land and water management interventions were analyzed to adapt irrigated agriculture to growing water scarcity in a desert environment under a projected warm-dry future. Nineteen different intervention scenarios were investigated to evaluate potential watershed-scale agricultural water savings and associated water budget impacts in the MRG. The interventions are based on (i) management innovations of growers in implementing deficit irrigation and changing cropping patterns using existing crops, (ii) changing cropping patterns by introducing new alternative drought- and salt-tolerant crops, and (iii) limitations of the soil and water assessment tool (SWAT) model to perform scenario simulations.

New hydrological insights for the region: (1) status quo irrigation management cannot sustain the current crop mix in the face of dwindling river water and likely fresh groundwater depletion within the 21st century; (2) existing cropping and irrigation interventions create limited water savings; and (3) deficit irrigation of alfalfa or removing it from the crop mix allows moderate water savings to sustain high-value perennial pecan crops but the region will remain vulnerable to intensive, prolonged droughts. Strategies for future agricultural water sustainability in the study area could include transitioning to relatively drought- and salt-tolerant crops, desalinating brackish groundwater for irrigation, and developing water markets to increase flexibility in water use.

DOI: 10.1016/j.ejrh.2022.101307

Schad, A. N., D. Allen, L. L. Dodd, R. Luna, J. Kelly, K. Hellinghausen, N. E. Harms, G. O. Dick, and Y. Charo. 2023. Aquatic Ecosystem Restoration in the Texas Western Gulf Coast Plain/Lower Rio Grande Alluvial Floodplain Ecoregion: Resaca Boulevard Resaca Section 206—Vegetation Community Adaptive Management. ERDC/EL TR-23-6. US Army Corps of Engineers, Engineering Research and Development Center. August 2023. Available online: https://erdc-library.erdc.dren.mil/jspui/handle/11681/47559

Keywords: restoration ecology, Lower Rio Grande Valley, environmental protection, aquatic ecology, Brownsville, environmental management, Texas

Abstract: As part of the US Army Corps of Engineers (USACE) Continuing Authorities Program (CAP), Section 206 projects focus on restoring aquatic habitats for the benefit of fish and other wildlife. From 2017–2021, USACE Engineer Research and Development Center–Environmental Laboratory researchers in the Aquatic Ecology and Invasive Species Branch (ERDC-EL EEA) at the Lewisville Aquatic Ecosystem Research Facility (LAERF) collaborated with USACE Galveston District, The Nature Conservancy, US Fish and Wildlife Service, National Park Service, and local nonfederal sponsors—Brownsville (Texas) Public Utility Board and the City of Brownsville—to study restoration methods on former, naturally cut-off, channels of the Lower Rio Grande River. These aquatic ecosystems, locally termed “resacas,” are home to endemic plants and animals and are thus an important natural resource of national interest. This technical report documents the planning, design, construction, monitoring, and adaptive management activities throughout the Resaca Boulevard Resaca Section 206 Aquatic Ecosystem Restoration project. Methods and results for invasive species management—primarily Brazilian peppertree (*Schinus terebinthfolia*)—and aquatic and riparian vegetation establishment in endemic Texas ebony resaca forest, subtropical Texas palmetto woodland, and Texas ebony/snake-eyes shrubland habitats are discussed.

URL: https://hdl.handle.net/11681/47559

Schneider, K. E., A. Rust, and T. Hogue. 2023. Modeling Compound Hydrologic Disturbances in the Rio Grande Headwaters. Journal of the American Water Resources Association 60(1): 95-109. doi: 10.1111/1752-1688.13162

Keywords: post-fire hydrology, forest disturbance, disturbance hydrology modeling, climate change

Abstract: In recent decades, the western United States (U.S.) has experienced increasing magnitudes and frequencies of natural land cover disturbances that impact water budget partitioning. Post-disturbance hydrologic response is often variable at the stream outlet and is difficult to detect and quantify with traditional before–after control–impact studies. This study uses a modified version of the U.S. Geological Survey's Monthly Water Balance Model (MWBM) to simulate and separate the hydrologic response to several forest disturbances, including (1) wildfire, (2) forest conversion (subalpine to mid-elevation forest) and (3) a climate that is hotter and drier than present in the Rio Grande Headwaters (RGH) in Colorado, U.S. (this climate scenario was derived from an ensemble of climate scenarios from the Coupled Model Intercomparison Project phases 3 and 5, which were selected based on water stress potential in the state of Colorado). We leverage historic post-disturbance vegetation data in the RGH to add quantitative vegetation representation to the MWBM, then modeled synthetic future (2021–2050) streamflow scenarios as both single and compound disturbances. Relative to a baseline scenario, modeled scenarios predict several changes to average annual water trends over the final simulation decade (2041–2050); (1) decreases in average annual water yield under a hot and dry climate (−14%), except during the rising limb of annual snowmelt; (2) increases in average annual water yield (+32%) and peak runoff under a fire simulation; and (3) increases in average annual water yield (+24%) along with earlier and higher peak runoff under compound (fire + hot/dry) conditions. These findings show the strengths of hydrologic models in separating compound disturbance signals at the stream outlet and a need for quantitative vegetation representation within models to adequately represent dynamic disturbance conditions.

DOI: 10.1111/1752-1688.13162

Seiler, G., T. Gulya, and L. F. Marek. 2023. Fifty Years of Collecting Wild *Helianthus* Species for Cultivated Sunflower Improvement. Helia 46(78): doi: 10.1515/helia-2023-0003.

Keywords: crop wild relatives, exploration, genebank, genetic resources, germplasm

Abstract: Wild *Helianthus* species have been undeniably beneficial in sustaining the sunflower crop by providing plant breeders with a diverse genetic pool of potentially useful traits. Exploration to collect populations of wild sunflowers is one of the more difficult and challenging activities in the conservation and utilization of these valuable genetic resources. The logistics of collecting requires careful planning, locating the target species, obtaining permission to access and collect, and timing the exploration to ensure the availability of mature seed. The US Department of Agriculture, Agricultural Research Service (USDA-ARS) established the wild Helianthus seed collection in 1976 at Bushland, Texas with the goal of collecting and conserving the broadest representative genetic diversity possible and serving as a central repository of germplasm and related information. In 1985 this collection was transferred to UDSA-ARS, North Central Regional Plant Introduction Station, Ames, Iowa. Over the last half century, 37 explorations were undertaken covering 175,000 km to collect the 53 *Helianthus* species from their distributional ranges in the forty-eight conterminous states in the US, three Canadian Providences (Manitoba, Saskatchewan, and Alberta), Argentina and Australia. The many explorations have created a global crop wild relatives (CWR) genebank collection. The current wild CWR sunflower genebank contains 2562 accessions of 53 species with 1065 wild *Helianthus annuus* accessions (42 %), 617 accessions representing populations of the 13 other wild annual species (24 %), and 880 accessions representing 39 perennial species (34 %). This collection is the largest and most genetically diverse ex situ sunflower collection in the world and is vital to the conservation of wild sunflower species for the global sunflower community.

DOI: 10.1515/helia-2023-0003

Sharma, P. 2023. Dryland Vegetation Mapping Using High Spatial-Temporal Resolution Satellite Imagery in New Mexico: A Comparison of Phenological Time-Series Transformation Methods. Thesis. University of New Mexico, Albuquerque, New Mexico. December 2023.

Keywords: N/A

Abstract: New Mexico's drylands are undergoing notable vegetation changes due to rising aridity, higher temperatures, and shifts in precipitation with changing climate. Mapping drylands through remote sensing is challenging compared to mesic systems due to the irregular patterns of rainfall-driven phenology and weaker vegetation absorption signals. This study aims to enhance vegetation mapping in New Mexico, utilizing a high-resolution, frequently revisited PlanetScope dataset with multispectral capabilities, specifically chosen for its suitability for time-series analysis. The challenge with high spatial and temporal data lies in the overwhelming volume, leading to issues like the curse of dimensionality, overfitting, data redundancy, collinearity, and visualization problems. This study assesses the effectiveness of dimensionality reduction techniques such as Principal Component Analysis (PCA), Minimum Noise Fraction (MNF), Fourier Transform (FT), and Independent Component Analysis (ICA) in transforming phenological time series data for vegetation classification. A null model, without phenological data, serves as a comparison baseline. The classification model related known field plots to a series of variables using a random forest (RF) algorithm in an object-based image analysis (OBIA) v framework to map vegetation at the Sevilleta National Wildlife Refuge and East Jemez Area in New Mexico, USA. The study highlighted the importance of using phenological data, where the PCA method had the highest overall accuracy at 53.52%, whereas the null model had 46.71%. PCA might be more appropriate for supervised classification than other methods because it reduces the influence of noise in the data. However, the MNF model performed better in the discrimination of vegetation classes.

URL: https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1073&context=geog_etds

Shaw, C .K. and S. R. Wiest. 2023. Increasing Accessibility of Riparian Assessment Tools through Web Applications. ASCE Inspire 2023: 199-207. doi: 10.1061/9780784485163.024.

Keywords: N/A

Abstract: Riparian zones are important transitional areas between upland and stream ecosystems that improve water quality, provide ecological habitat and corridors, maintain natural hydrologic processes, and provide other important ecosystem goods and services. Riparian management has grown in prominence, as these systems have become important foci of stream restoration efforts, stormwater best management practices, greenspace corridors, and nature-based solutions for climate mitigation. Restoration practitioners, regulators, designers, and researchers require models for assessing the ecological outcomes of different riparian management actions. While many models exist, they often are challenging to find in grey literature and may not have analytical tools and calculators available for other users. In this study, we compile nine riparian assessment procedures and models, construct a web application for accessing these tools, and demonstrate the utility of this application for informing stream restoration. Our project embodies the principles of Open Science by increasing the accessibility and practicality of existing scientific models. For instance, our web interface helps practitioners locate hard-to-find models, select among models for a particular application, and execute the models with error-checked calculators. The application also increases the long-term shareability of these riparian models through platforming that publicly shares computational code (e.g., through online repositories), reduces barriers to entry for analysts (e.g., programming literacy), and increases ease of use, all of which save time and money for stakeholders.

DOI: 10.1061/9780784485163.024

Smith, C. I., L. C. Sweet, J. Yoder, M. R. McKain, K. Heyduk, and C. Barrows. 2023. Dust Storms ahead: Climate Change, Green Energy Development and Endangered Species in the Mojave Desert. Biological Conservation 277:109819. doi: 10.1016/j.biocon.2022.109819.

Keywords: N/A

Abstract: The Mojave Desert contains the hottest, driest regions in North America and is also one of the most ecologically intact regions in the contiguous United States. However, a confluence of factors including urbanization, climate change, and energy development are rapidly transforming this ecoregion. As a result of these growing threats, even common, widespread Mojave Desert endemics are at risk of being driven to extinction by the end of the 21st century. Ironically, renewable energy development that could delay or even reverse the effects of climate change in the region is also a potentially significant source of habitat loss for these same organisms. Protecting the Mojave therefore presents difficult choices about how to select among different conservation priorities. We argue that these choices will necessarily involve compromises in which protections for some habitats will have to be prioritized while allowing development in other areas. We review the state of conservation in the Mojave and use the Mojave Desert's iconic Joshua trees (*Yucca brevifolia* and *Y. jaegeriana*) as a case study to describe a framework for identifying habitats that should be given the highest levels of protection to ensure climate change resilience. Finally, using existing spatial data, we evaluate land use and conservation status in the Mojave. The result identifies considerable scope for compromise between conservation and renewable energy development. Although our examples are specific to the Mojave, we argue that these recommendations apply broadly to many biological communities threatened by climate change.

DOI: 10.1016/j.biocon.2022.109819

Soliz, L. E. 2023. Assessing the Effects of Biological Invasions and Reduced Flows on a Spring-Fed Stream Food Web in San Felipe Creek (Del Rio, Texas, USA). Thesis. Texas Tech University, Lubbock, Texas.

Keywords: invasive riparian vegetation, food web, federally threatened species

Abstract: Invasive riparian vegetation can greatly alter the structure and function of ecological communities by changing habitat and resource availability. I conducted a field study in San Felipe Creek, a spring-fed tributary of the Rio Grande, to examine the effects of an invasive riparian plant, Giant Reed (*Arundo donax*), on the stream food web. I hypothesized that shading by Giant Reed alters the structure of the food web via bottom-up pathways. I also hypothesized that invasive Suckermouth Catfish would benefit from the invasion of Giant Reed via inputs of detritus. Alternatively, I hypothesized that the invasion of Giant Reed would lead to a reduction in benthic periphyton, an important food resource for Suckermouth Catfish, having negative effects on their overall population. To test these hypotheses, I sampled periphyton, benthic macroinvertebrates, and fishes at reaches with (invaded; n = 3 reaches) Giant Reed and without (control; n = 3 reaches) during the summer, fall, and winter of 2021 and 2022. I also sampled diets of 4 abundant species within San Felipe Creek to determine if diets differed between control and invaded reaches. At the base of the food web, I found that periphyton biomass was 46% lower in invaded reaches, when compared to control reaches. Total macroinvertebrate densities were similar between control and invaded reaches. However, a subset of Families and functional feeding guilds were lower in invaded reaches. Fish relative abundance was 75% lower in invaded reaches, when compared to control reaches. This pattern was driven by Lepomis spp. and functional feeding guilds (invertivores and omnivores). Overall diet composition was similar across all species in both invaded and control reaches. Overall, my findings support my hypothesis and indicate that invasive Giant Reed does have bottom-up effects that extend to multiple trophic levels. I found no evidence of a facilitative relationship between Suckermouth Catfish and Giant Reed. I did find that Suckermouth Catfish fed primarily on benthic periphyton (70%) which may be negatively affected by the invasion of Giant Reed. Based on my findings, the removal of Giant Reed should help improve the stream food web by increasing productivity from the bottom up.

URL: https://hdl.handle.net/2346/97299

Srinivasan, J. and M. Schoon. 2023. Recovery or Continued Resuscitation? A Clinical Diagnosis of Colorado River Sub-Basin Recovery Programs. Ecology and Society 28(1): 5. doi: 10.5751/ES-13749-280105.

Keywords: N/A

Abstract: With a particular emphasis on the Upper Colorado River Endangered Fish Recovery Program (UCR-EFRP) and Lower Colorado River Multi-Species Conservation Program (LCR-MSCP), we analyze, for each program, four system properties that contribute to resilience: system architecture, which includes (1) connectivity and distribution and (2) assemblage of system elements; and system dynamics, which includes (3) social and natural capital flows and (4) system renewal and continuation. Each of these system properties is analyzed based on specific social and corresponding biophysical indicators. The system properties were ranked on a carefully constructed scale based on gradations of each system property (derived from the literature) on both social and biophysical indicator standing. Our results indicate that the UCR-EFRP has relatively better social architecture and dynamics with relatively less impact on the ecological architecture and dynamics compared to the LCR-MSCP, though this result may be a function of the greater amount of infrastructural constriction and path dependence in the lower basin compared to the upper basin. We conclude by suggesting that a transformative pathway forward needs greater adaptability and flexibility incorporated into the social architecture and dynamics to move toward better ecological health of the river.

DOI: 10.5751/ES-13749-280105

Stumpf, K. and C. Muise. 2023. Increasing Capture Rates of Grassland Birds Over Thirteen Years Indicates Successful Restoration. Georgia Journal of Science 81(2):1.

Keywords: grasslands, grassland restoration, mist netting, conservation, avian ecology, Passerellidae, Emberizidae, Passeriformes, Common Yellowthroat, Field Sparrow, sparrow.

Abstract: Grassland bird populations are being lost at an alarming rate due to human modifications to grassland ecosystems. Grassland restoration has been shown to mitigate population declines for many species that use these habitats at some point in their annual cycles. We examined capture rates of adult, breeding, and hatch-year birds at a restored grassland site in the piedmont of central Georgia to determine whether colonization, breeding success, hatching success, and recruitment processes were impacting populations of grassland birds. We banded birds approximately twice per month from January 2009 through December 2021 at Panola Mountain State Park. Restoration efforts started in 2001, and include annual prescribed burns, control of invasives, and revegetation with native grassland plants. We documented an increase in total capture rates when all grassland species were combined ($p=0.03$, $r^2=0.37$) and for several grassland species, including Chipping Sparrows ($p=0.01$, $r^2=0.44$) and Marsh Wrens ($p=0.004$, $r^2=0.55$). Capture rates of grassland birds in breeding condition increased as well, including when grassland species were combined ($p=0.01$, $r^2=0.45$), Common Yellowthroats ($p=0.05$, $r^2=0.30$), Indigo Buntings ($p=0.04$, $r^2=0.34$), and Field Sparrows ($p=0.002$, $r^2=0.59$). Capture rates of hatch-year birds increased for Chipping Sparrows ($p=0.02$, $r^2=0.39$). Species-specific responses to restoration occur at different rates depending on habitat preferences, yet the only species that significantly declined was the Red-winged Blackbird, a bird more associated with water than grasslands. We attribute these increases and, importantly, the lack of significant declines, to successful ongoing restoration, which is providing adequate and appropriate resources for grassland birds. If managers identify target species, we recommend that restoration efforts include activities that are aimed at species-specific habitat requirements and habitat-level threats of those target species.

URL: https://digitalcommons.gaacademy.org/gjs/vol81/iss2/1/

Supplee, T. and M. K. Briggs. 2023. Horseshoe Reservoir Habitat Restoration Study. Final Report to the Salt River Project and The Nature Conservancy. Prepared by National Audubon Society and New River/New World Consulting. January 6, 2023. Available online: https://media.audubon.org/2023-09/Horseshoe%20Reservoir%20Habitat%20Study.pdf

Keywords: N/A

Abstract: During the summer and fall of 2021 the US Bureau of Reclamation in partnership with SRP conducted the Verde Reservoirs Sediment Mitigation Study (VRSMS). The objective of the study was to evaluate alternatives to restore capacity lost at Horseshoe Reservoir to protect water supply resiliency and adapt facilities and operations for expected future conditions resulting from climate change (VRSMS 2021). The modification of Verde River storage options under the two alternatives that raise the height of Bartlett Dam offer operational flexibility at Horseshoe Reservoir not currently available. Under the Bartlett Modification 1 and 2 alternatives, Horseshoe Reservoir would be operated in a run-of-river operational regime that does not use Horseshoe Reservoir as a conservation pool but matches inflows to outflows when possible.

This operational change offers opportunities for ecological enhancements within the current footprint of Horseshoe Reservoir. The central objective of this study and report is to provide SRP input on location and type of native plant habitat that potentially can be established in the Horseshoe Dam reservoir study area above and beyond any compensatory mitigation requirements if Horseshoe Reservoir is managed under a run-of-river operational regime. In support of realizing the central objective, supporting study objectives include a review of literature and anecdotal experiences of past reservoir and river bottomland restoration, restoration tactics, and methods for controlling non-native species.

URL: https://media.audubon.org/2023-09/Horseshoe%20Reservoir%20Habitat%20Study.pdf

Turbek, S. P., C. Bossu, C. Rayne, C. Gruppi, B.E. Kus, B. E., M. Whitfield, Thomas B. Smith, Eben H. Paxton, R. A. Bay, K. C. Ruegg. 2023. Historical DNA Reveals Climate Adaptation in an Endangered Songbird. Nature Climate Change (13) 735-741. doi: 10.1038/s41558-023-01696-3.

Keywords: N/A

Abstract: To cope with climate change, species may shift their distributions or adapt in situ to changing environmental conditions. However, clear examples of genetic changes via adaptation are limited. We explore evolutionary responses to climate change in the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) through whole-genome comparisons between historical specimens, collected from 1888 to 1909 near San Diego, California, United States, and contemporary individuals from across the breeding range. Genomic analyses revealed that introgression into San Diego increased adaptive potential over time and shifted genome-wide population structure towards that of neighbouring populations. In contrast, loci linked to climate (dew point temperature and precipitation) shifted away from neighbouring populations and in a direction consistent with adaptation to climate change in southern California. This research highlights the role of admixture in facilitating adaptive shifts through its impact on genome-wide genetic variation and represents one of the few studies to document climate adaptation in a wild population.

DOI: 10.1038/s41558-023-01696-3

Valdez, R. A., C. Cunningham, A. Effati, and D. L. Freeman. 2023. The Need for Constructing Endangered Fish Habitats that Conform to Climate-Driven Flow Changes in a Western U.S. River. Journal of the American Water Resources Association 59(5): 1084-1098. doi: 10.1111/1752-1688.13114.

Keywords: climate change, Colorado Pikeminnow, constructed habitats, drought, flow recommendations nursery habitat, Razorback Sucker, San Juan River

Abstract: Warmwater fish habitat in the San Juan River of the southwestern United States has been reduced by over 30% as a result of water depletion, reservoir inundation, and cold-water dam releases combined with drought-related changes in hydrology. This reduction and a suite of other factors have contributed to declines in native fish populations including the federally endangered Colorado Pikeminnow (*Ptychocheilus lucius*) and Razorback Sucker (*Xyrauchen texanus*). Conservation efforts for these species include determining flow needs; protecting, managing, and augmenting habitats; and stocking hatchery fish. But the young of stocked fish have low survival due largely to a paucity of nursery habitat not being reformed and maintained under current conditions. Flow recommendations for Navajo Dam releases designed to mimic the river's natural hydrograph have not been met due to water shortages, and the desired outcomes of increased channel complexity and enhanced fish habitat have not been observed. Forecasted hydrology that includes ongoing drought shows that achieving the flow targets through further dam reoperations is unlikely. Mechanical construction of early life-stage habitats is a highly recommended complement to flow management for offsetting the effects of flow reduction and habitat loss. Habitats with features that are effective and resilient under a range of flows are important in counterbalancing the effects of climate change.

DOI: 10.1111/1752-1688.13114

Veihl, A. 2023. Securing Environmental Flows for the Rio Grande Silvery Minnow. Thesis. University of New Mexico, Albuquerque, New Mexico.

Keywords: Bureau of Reclamation, Rio Grande, silvery minnow, water leasing

Abstract: Since 1997, the Bureau of Reclamation (Bureau) has been leasing water to provide habitat for the now-endangered Rio Grande silvery minnow (Minnow). The majority of leased water comes from the San-Juan Chama project, a trans-basin water delivery system that was originally implemented to secure flows to the Rio Grande for municipal and agricultural use. Limitations on water storage within reservoirs incentivize contractors that are allocated more surface water than they can use to lease the extra quantity. It is through this water leasing market that the Bureau has established the largest environmental flow program in the state of New Mexico. This paper explores the specifics of the Bureau's supplemental water leasing program, including the sources of the leased water, the frequency at which supplemental water is needed, and the quantities and prices of water being applied to the river; the latter of which will be used to analyze the program from an economic viewpoint. Using hydrologic data from the U.S. Geological Survey [USGS], the supplemental project water can be compared to the overall streamflow of the river, demonstrating its efficiency in relation to the goal of keeping the river sufficiently continuous. This paper also attempts to understand how the supplemental water could be used downstream of its application. Because the Minnow's water use is largely non-consumptive, leased water flowing out of the Middle Rio Grande is available for use. If the water is actively used (i.e. not lost via conveyance), it is likely that it will generate commercial and public benefits as well as non-market economic benefits (Ward and Booker, 2006; Berrens et. al., 1996). Reviewing studies that estimate these benefits may be useful in garnering support for either the Bureau's program or a similar one that may be done by another organization in the future.

URL: https://digitalrepository.unm.edu/wr_sp/201/

Wagner, R. 2023. Multi-Factor Disturbance Regimes Drive Soil Fungal Community Composition Across a Southwestern US Riparian Cottonwood Landscape. Thesis. University of New Mexico, Albuquerque, New Mexico. August 2023.

Keywords: Middle Rio Grande, *Populus deltoides*, *Mallocybe*, disturbance gradient, fungal inoculation, differential abundance

Abstract: In southwestern US riparian cottonwood forests, anthropogenic changes have replaced the structuring force of seasonal flooding with novel multi-factor disturbance regimes, driving these ecosystems to new states. While the impetus for restoration is high, little attention has been paid to understanding belowground feedbacks from these new drivers. Using high-throughput sequencing of environmental DNA, we compared the impacts of fires, exotic plants, restoration practices and lower levels of disturbance on soil fungal community composition and diversity across a riparian cottonwood landscape in New Mexico. We focused on mycorrhizal fungi for the benefits they may confer upon cottonwoods. We found that along a scale of increasing disturbance, relative abundances of pathotrophs and saprotrophs increased while those of ectomycorrhizal fungi decreased. Surprisingly, the impact from exotic clearing was similar to that of fire. Mature and young cottonwood stands were also similar, suggesting that across an historic landscape of diverse cottonwood age classes, soil fungal community structure may have varied little. Our methods will help resource managers identify supportive soils for cottonwood reforestation and monitor the responses of vital belowground communities to restoration or new disturbances.

URL: https://digitalrepository.unm.edu/biol_etds/467/

Wagnon, C. J. 2023. Dryland State Transitions, Trophic Interactions, and the Restoration of a Keystone Species. Dissertation. University of Illinois at Urbana-Champaign, Urbana, Illinois.

Keywords: N/A

Abstract: Shrub encroachment is a global driver of ecosystem change impacting grass-dominated drylands, with consequences for trophic interactions. Such state transitions have prompted shrub removal efforts in attempts to reverse the process and restore encroached grasslands. However, we lack adequate understanding of how trophic food webs respond to shrub encroachment or how habitat restoration actions impact animal behavior, including shrub removal. My research examined how shrub encroachment and grassland restoration efforts in the Chihuahuan Desert of New Mexico shapes the trophic and behavioral ecology of mammals. I first evaluated how shrub encroachment affects trophic interactions and the landscape of fear in a canid-lagomorph system. Lagomorph prey responded strongly to bottom-up pulses during years of high summer precipitation but only on sites with moderate to high shrub cover. This outcome is inconsistent with the hypothesis that bottom-up effects should be strongest in grasslands because of greater herbaceous food resources. Instead, this pattern is consistent with changes in the landscape of fear because perceived predation risk in lagomorphs is reduced in shrub-dominated habitats. I then examined the behavioral response of a keystone rodent of grasslands, *Dipodomys spectabilis*, to extensive shrub removal efforts by comparing personality traits and movement behavior between restoration and remnant habitats. Personality traits were present in *D. spectabilis* but did not strongly differ between environments. Notably, *D. spectabilis* exhibited personality-dependent movement through artificial shrubs in a movement experiment, suggesting a mechanistic pathway affecting colonization dynamics of shrub removal sites. My research reveals the varied and complex ways that wildlife populations may respond to ecosystem change in drylands. Future research should consider the landscape of fear and animal personality when evaluating wildlife responses to global change drivers and habitat restoration.

URL: https://www.ideals.illinois.edu/items/127436

Wescoat, J. L., Jr. 2023. Institutional Levels of Water Management in the Colorado River Basin Region: A Macro-Historical Geographic Review. Frontiers in Water 4: 1024055. doi: 10.3389/frwa.2022.1024055.

Keywords: N/A

Abstract: Complex water-stressed basins like the Colorado River in North America have multiple institutional levels of water management. Each institutional level is characterized by rules, organizations, and spatial jurisdictions that developed over decades to centuries to shape a dynamic multi-level system. After introducing the concept of institutional levels, and its relationship to geographic scales, this paper employs systematic bibliographic search methods to review their development in the Colorado River basin region. Results begin with the community level of water management from prehistoric Indian water cultures to early Hispanic water communities, 19th century water communities, and 20th century water organizations. Conflict among water communities shaped the state level of constitutional authority over water rights administration during the 19th century. Competition among states led in the 20th century to the interstate level of apportionment that often paralleled federal and tribal level water development policies, eventually leading to the international level of treaty relations between the U.S. and Mexico. This macro-historical geographic progression from institutions that were relatively small in size and early in time to those at higher levels and more recent in time offers insights into the multi-level institutional logic of the “law of the river” in the Colorado River basin region.

DOI: 10.3389/frwa.2022.1024055

West, N. M., D. H. Branson, J. M. Muscha, and J. W. Campbell. 2023. Early Impacts of Invasive Shrub Removal on Riparian Arthropod Communities. Ecological Restoration 41(4): 189-198. doi: 10.3368/er.41.4.189.

Keywords: arthropod communities, *Elaeagnus angustifolia*, invasion management, plant invasion, Russian olive

Abstract: Plant invasions can change native communities in complex ways. Restoring invasion-altered habitats starts with invader removal, and imposes significant physical and compositional changes. Restoration facilitates desirable plant community development, but arthropod community responses to removal and the timelines required for native vegetation establishment are difficult to predict. We examined initial effects of Elaeagnus angustifolia (Russian olive) removal on arthropod communities during a long-term experiment evaluating the combined consequences of invasive shrub removal and plant community restoration. We sampled E. angustifolia-invaded areas pre-removal (2010) and post-removal (2013) using sweep netting, and identified arthropods to family level. We found greater variation in the arthropod community composition within removal blocks than within invaded blocks after two years. These shifts resulted from changes in the relative abundance of community members (e.g., Dictynidae (Araneae), Culicidae (Diptera), and Cicadellidae (Hemiptera)), rather than overall richness or diversity. This response is likely due to increased plant diversity in *E. angustifolia* removal sites but also structural differences in vegetation cover after removal. Removing a dominant structural element like *E. angustifolia* instantly changes the successional stage of the ecosystem. Thus, restoration managers should consider methods that maintain structural continuity during restoration implementation. Arthropods provide important ecosystem services such as nutrient cycling and pollination and serve as a prey base for higher trophic levels. Thus, understanding how arthropod communities change after plant restoration events is vital to assessing future management decisions to limit ecosystem impacts of invasive plants and their management.

DOI: 10.3368/er.41.4.189

Wiest, S. R., D. D. Hernandez-Abrams, and S. K. McKay. 2023. Review of Riparian Models for Assessing Ecological Impacts and Benefits. ERDC/TN EMRRP-ER-26. US Army Corps of Engineers, Engineering Research and Development Center, Environmental Laboratory. Available online: https://erdc-library.erdc.dren.mil/jspui/handle/11681/47706

Keywords: riparian ecology, ecology, mathematical models, environmental management

Abstract: Riparian zones are key transitional ecosystems between upland and aquatic zones, and these systems are often degraded due to both land use change and stream processes (e.g., deforestation and water impoundments and/or diversions). These important ecosystems require restoration because of the many benefits they provide ranging from providing habitat for diverse species to promoting water quality. Restoration practitioners, regulators, and researchers require riparian assessment methods and models to efficiently guide mitigation and restoration planning. This technical note (TN) compiles a subset of existing riparian tools and evaluates them relative to model objectives, modeling approach, and input variables. Findings are synthesized into a gap analysis of these models to inform future riparian model development and improve riparian assessment.

URL: https://hdl.handle.net/11681/47706

Zahratka, J. L. 2023. Hibernacula and Hormones of an Endangered Jumping Mouse. Dissertation, Northern Arizona University, Flagstaff, University. December 2023.

Keywords: N/A

Abstract: In seasonal environments, animals must adjust their behavior and physiology to balance energetic demands. The strategies animals use to balance energy demands and adapt to seasonally changing environments determines their survival and fitness. Among these strategies, hibernation is an evolutionary adaption to cope with seasonally available resources that is marked by dramatic physiological and behavioral adjustments affecting fitness, reproduction, and phenology of life histories. Hormones serve as chemical messengers to translate perceived environmental signals into behavioral and physiological adjustments. In my dissertation, I provide insight into the hibernation strategy among one of the smallest, nonvolant terrestrial hibernators, the New Mexico meadow jumping mouse (*Zapus luteus*, formerly *Zapus hudsonius luteus*) and the role of hormones in making seasonal adjustments, specifically during reproduction and the onset of hibernation. The lack of data on this federally Endangered species limits our understanding of how it adjusts to fluctuating environmental conditions. To address this, I first sought to describe hibernacula (unconfirmed for this species) and developed methods and criteria to identify them. Once a hibernaculum was confirmed, I measured soil temperatures at 3 depths within 3 m of each hibernaculum as an approximation of temperatures in the hibernaculum. I compared these soil temperatures to those to collected at randomly selected sites located within 500 m of the hibernaculum in potential habitat. I also collected aspect, slope, horizontal and canopy cover, elevation, and depth of the underground burrow to describe each hibernaculum. I found New Mexico meadow jumping mice favored sites for hibernacula with iii north-facing aspects and some vegetation cover. Proximity to water varied but averaged 59.6 m ± 19.6 (standard error; SE). New Mexico meadow jumping mice dug hibernation burrows at an average depth of 29.5 cm ± 2.4. Soil temperatures at this depth were cold in winter ($\bar{x}$= 1.0°C ± 0.01 from December through February) and relatively consistent (CV = 118% at 30 cm depth) compared to other depths (CV = 163% at 10 cm and 37% at 50 cm). Soil temperatures near hibernacula were colder and warmed later in spring than randomly selected comparison sites. Females selected hibernacula where soil temperatures were colder ($\bar{x}$= 2.1 °C ± 0.03) than hibernacula of males ($\bar{x}$= 2.5 ± 0.02; W = 230944353, p < 0.0). New Mexico meadow jumping mice presumably constructed hibernacula at sites cold enough to reduce body temperature and maximize metabolic savings, but not so cold that they catabolized all their fat reserves to maintain their set body temperature. We assume females selected colder hibernacula than males because it conferred an energetic advantage that females needed compared to males. In my second study, I addressed the capacity for New Mexico meadow jumping mice to reproduce more than once during an active season. Reproduction is an energetically demanding annual life cycle event so that animals must balance energetic demands with the tradeoffs between survival and reproduction. Further, the timing of reproduction and potential number of young produced during the active season by this species is unknown. The fecundity of this Endangered species is important to its recovery. Using enzyme immunoassays on fecal samples collected from captured females (n = 75), I quantified progesterone levels, the pregnancy hormone, coupled with physical condition of captured females, to determine pregnancy. We found fecal progesterone metabolite (FPM) levels from

pregnant animals were highest in July ($\bar{x}$= 1000.1 pg/mg ± 142.7). We used the range of mean FPM levels when jumping mice are not known to reproduce in September (224.0 pg/mg ± 86.2) and October (122.4 pg/mg ± 74.0) as our baseline. We used both months iv because no animals were captured in Arizona in October due to the onset of hibernation. Based on these fecal progesterone metabolite levels, I found New Mexico jumping mice reproduced only once, most commonly in July. I also found differences in fecal progesterone metabolites between states (i.e., study areas) suggesting more females were pregnant in Arizona than Colorado. Finally, I used glucocorticoids (cortisol) and thyroid hormones (T3) coupled with body mass and the predictable timing of life events as tools to identify energetically demanding periods during the active season. Glucocorticoids and thyroid hormones are primarily responsible for mediating the trade-offs in energy modulation between predictable annual life events. Reproduction and the pre-hibernation period, specifically, are characterized by changing energetic demands. I found New Mexico meadow jumping mice showed variations in cortisol and T3 metabolite levels consistent with the onset of hibernation in fall, but not reproduction. These data suggest the pre-hibernation period was the most energetically demanding period during the active season. I also found lower levels of fecal T3 metabolites in Colorado than Arizona and higher cortisol in Colorado than Arizona, suggesting phenotypic plasticity to environmental conditions (e.g., elevation, moisture regimes, vegetation, latitude). These data will facilitate informed conservation measures for recovery of this species and provide a platform for future research on hibernation physiology.

URL: https://www.proquest.com/openview/006f307abe65ce1bccb19fb06b24ad99/1?pq-origsite=gscholar&cbl=18750&diss=y