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**Allen, C., H. Birge, D. Angeler, C. Arnold, B. Chaffin, D. DeCaro, A. Garmestani, and L. Gunderson. 2018. Quantifying uncertainty and trade-offs in resilience assessments. *Ecology and Society* 23.**

**Key words:** coupled human-natural system; resilience assessment; social-ecological system; stressed watersheds

**Abstract:** Several frameworks have been developed to assess the resilience of social-ecological systems, but most require substantial data inputs, time, and technical expertise. Stakeholders and practitioners often lack the resources for such intensive efforts. Furthermore, most end with problem framing and fail to explicitly address trade-offs and uncertainty. To remedy this gap, we developed a rapid survey assessment that compares the relative resilience of social-ecological systems with respect to a number of resilience properties. This approach generates large amounts of information relative to stakeholder inputs. We targeted four stakeholder categories: government (policy, regulation, management), end users (farmers, ranchers, landowners, industry), agency/public science (research, university, extension), and NGOs (environmental, citizen, social justice) in four North American watersheds, to assess social-ecological resilience through surveys. Conceptually, social-ecological systems are comprised of components ranging from strictly human to strictly ecological, but that relate directly or indirectly to one another. They have soft boundaries and several important dimensions or axes that together describe the nature of social-ecological interactions, e.g., variability, diversity, modularity, slow variables, feedbacks, capital, innovation, redundancy, and ecosystem services. There is no absolute measure of resilience, so our design takes advantage of cross-watershed comparisons and therefore focuses on relative resilience. Our approach quantifies and compares the relative resilience across watershed systems and potential trade-offs among different aspects of the social-ecological system, e.g., between social, economic, and ecological contributions. This approach permits explicit assessment of several types of uncertainty (e.g., self-assigned uncertainty for stakeholders; uncertainty across respondents, watersheds, and subsystems), and subjectivity in perceptions of resilience among key actors and decision makers and provides an efficient way to develop the mental models that inform our stakeholders and stakeholder categories.

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**Allen, C. R., H. Birgé, D. G. Angeler, C. A. (Tony) Arnold, B. C. Chaffin, D. DeCaro, A. S. Garmestani, and L. H. Gunderson. 2018. Uncertainty and Trade-Offs in Resilience Assessments. Pages 243–268 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words:** coupled human-natural system, resilience assessment, social-ecological system, stressed watersheds, resilience metrics

**Abstract:** Several frameworks have been developed to assess the resilience of social-ecological systems, but most are time consuming and require substantial time and technical expertise. Stakeholders and practitioners often lack the resources for such intensive efforts. Furthermore, most resilience assessments end with problem framing and fail to explicitly address trade-offs and uncertainty inherent in any assessment of resilience. This chapter reports on a rapid assessment of survey responses to compare the relative resilience across four North American social-ecological watershed systems with respect to a number of proposed resilience properties. Responses were compared among four stakeholder categories: (1) government (policy, regulation, management), (2) end users (farmers, ranchers, landowners, industry), (3) agency/public science (research, university, extension), and (4) nongovernmental organizations (environmental, citizen, social justice) in each of the watersheds. Conceptually, social-ecological systems are comprised of components ranging from strictly human to strictly ecological, but that relate directly or indirectly to one another in complex ways. They have soft boundaries and several important dimensions or axes that together describe the nature of social-ecological interactions (e.g., variability, diversity, modularity, slow variables, feedbacks, capital, innovation, redundancy, and ecosystem services). There is no absolute measure of resilience, so our design takes advantage of comparisons across watersheds and therefore focuses on relative resilience. Our approach quantifies and compares the relative resilience across watershed systems and the potential trade-offs among different aspects of the social-ecological system (e.g., among social, economic, and ecological contributions). This approach permits explicit assessment of several types of uncertainty (e.g., self-assigned uncertainty for stakeholders; uncertainty across respondents, watersheds, and subsystems) and subjectivity in perceptions of resilience among key actors and decision-makers and provides an efficient way to develop the mental models that inform stakeholders and stakeholder categories.

**DOI:** 10.1007/978-3-319-72472-0\_15

**Allen, L. D., S. L. Howell, and B. E. Kus. 2018. Distribution and Abundance of Least Bell’s Vireos (*Vireo bellii pusillus*) and Southwestern Willow Flycatchers (*Empidonax traillii extimus*) on the Middle San Luis Rey River, San Diego County, Southern California - 2017 Data Summary. Data Series.**

**Key words:** Least Bell’s Vireos, Southwestern Willow Flycatchers, San Luis Rey River

**Summary:** We surveyed for Least Bell’s Vireos (LBVI) (*Vireo bellii pusillus*) and Southwestern Willow Flycatchers (SWFL) (*Empidonax traillii extimus*) along the San Luis Rey River, between College Boulevard in Oceanside and Interstate 15 in Fallbrook, California (middle San Luis Rey River), in 2017. Surveys were conducted from April 13 to July 11 (LBVI) and from May 16 to July 28 (SWFL). We found 146 LBVI territories, at least 107 of which were occupied by pairs. Five additional transient LBVIs were detected. LBVIs used five different habitat types in the survey area: mixed willow, willow-cottonwood, willow-sycamore, riparian scrub, and upland scrub. Forty-four percent of the LBVIs occurred in habitat characterized as mixed willow and 89 percent of the LBVI territories occurred in areas with greater than 50 percent native plant cover. Of 16 banded LBVIs detected in the survey area, 8 had been given full color-band combinations prior to 2017. Four other LBVIs with single (natal) federal bands were recaptured and banded in 2017. Three LBVIs with single dark blue federal bands indicating that they were banded as nestlings on the lower San Luis Rey River and one LBVI with a single gold federal band indicating that it was banded as a nestling on Marine Corps Base Camp Pendleton (MCBCP) could not be recaptured for identification. One banded LBVI emigrated from the middle San Luis Rey River to the lower San Luis Rey River in 2017.

One resident SWFL territory and one transient Willow Flycatcher of unknown subspecies (WIFL) were observed in the survey area in 2017. The resident SWFL territory, which was comprised of mixed willow habitat (5–50 percent native plant cover), was occupied by a single male from May 22 to June 21, 2017. No evidence of pairing or nesting activity was observed. The SWFL male was banded with a full color-combination indicating that he was originally banded as a nestling on the middle San Luis Rey River in 2014 and successfully bred in the survey area in 2016. The male SWFL left the middle San Luis Rey River after June 21, 2017 and subsequently was detected on the San Dieguito River on June 26, 2017, by USGS biologists. The transient WIFL was detected on May 30, 2017, in mixed willow habitat comprised of 50–95 percent of native plant cover.

**DOI:** 10.3133/ds1082

**Archdeacon, T. P., S. R. Davenport, J. D. Grant, and E. B. Henry. 2018. Mass Upstream Dispersal of Pelagic-Broadcast Spawning Cyprinids in the Rio Grande and Pecos River, New Mexico. *Western North American Naturalist* 78:100–106.**

**Key words:** spawning, Rio Grande Silvery Minnow, Cyprinidae, dispersal, recovery, fragmentation, channelization

**Abstract:** Pelagic-broadcast spawning minnows are a reproductive guild of fishes, of which several species occur in the American Great Plains and Southwest. The eggs and larvae of these species drift laterally and downstream, with drift distances varying depending on channel conditions and flow. Persistence or recolonization of these species in upstream reaches must depend on retention of eggs and larvae or upstream dispersal of later life stages, otherwise net downstream displacement of eggs and larvae would result in upstream extirpations. However, only a few individuals of several species have been observed dispersing. Here, we describe 2 direct visual observations of the young-of-year of 4 species of pelagic-broadcast spawning minnows dispersing upstream en masse. In August 2009, we observed Plains Minnow (*Hybognathus placitus*), Speckled Chub (*Macrhybopsis aestivalis*), and Rio Grande Shiner (*Notropis jemezanus*) dispersing upstream. The continuous shoal of fish was >200 m in length and was dispersing upstream at a rate of >1000 fish/min. In July 2017, we observed a continuous shoal of Rio Grande Silvery Minnow (*Hybognathus amarus*) approximately 1.9 km in length dispersing upstream at a rate between 350 and 1500 fish/min. While such dispersal events are rarely observed, they may be important for maintenance of populations in upstream areas.

**DOI:** Report

**Arnold, C. A. (Tony), H. Gosnell, M. H. Benson, and R. K. Craig. 2018*a*. Cross-Basin Patterns of Systemic-Change Drivers and Adaptive Governance Features. Pages 205–227 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words:** adaptive governance, interdisciplinary qualitative textual analysis, resilience,

 systemic-change drivers

**Abstract:** Features of adaptive governance and drivers of systemic change were derived using qualitative textual analysis of six North American basin resilience assessments. This meta-analysis sought new knowledge that transcends each study concerning two categories of variables: (1) drivers of change in complex social-ecological-institutional water systems that affect systemic resilience and (2) features of adaptive governance. Pervasive themes, concepts, and variables from these six interdisciplinary texts were identified through inductive textual analysis and then analyzed for cross-basin patterns. Synthesis frameworks, as well as comprehensive lists of the variables that these studies uniformly or nearly uniformly addressed, are presented. These results are cross-interdisciplinary in that they identify patterns and knowledge that transcend several diverse interdisciplinary studies. The relevant and potentially generalizable insights into complex system change and adaptive governance, as well as a set of methods for synthesizing diverse interdisciplinary studies, form a foundation for future research on the dynamics of complex social-ecological-institutional systems and how they could be governed adaptively for resilience.

**DOI:** 10.1007/978-3-319-72472-0\_13

**Arnold, C. A. (Tony), O. O. Green, D. DeCaro, A. Chase, and J.-G. Ewa. 2018*b*. Resilience of the Anacostia River Basin: Institutional, Social, and Ecological Dynamics. Pages 33–46 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words:** resilience, adaptive governance, water management, institutional analysis, resilience assessment, Clean Water Act, water quality

**Abstract:** The Anacostia watershed traverses the urban-suburban areas around Washington, D.C., and Maryland. Historically, the Anacostia River basin has transitioned from a biologically rich natural ecology prior to European settlement through three periods of ecosystem degradation due to agriculture and navigation, industrialization, and urbanization. The current regime is dominated by restoration and green-infrastructure activities yet is still influenced by previous regimes’ legacy effects and continued urban-development pressures. The major drivers of regime shifts from presettlement to the present are (1) societal treatment of the basin’s waters, lands, vegetation, and wildlife as exploitable goods and services for short-term economic benefit (even in the current regime in which improved water quality and restored lands are public goods and services); (2) shifts from weak to strong environmentalist values and activism; (3) changing ways that humans psychologically relate to the basin and its functions; (4) patterns of structural inequality, oppression, discrimination, and movements to seek social and environmental justice; and (5) changes in governance institutions, including laws, to support and facilitate the dominant social values and policies of the time. Institutions have played strong and pervasive roles in both the watershed’s declining ecological resilience and potential for improving social-ecological resilience. The greatest opportunities for a more resilient, climate-adaptive Anacostia River watershed require continued and improved changes in watershed governance, restoration and green-infrastructure initiatives, land-use regulation, public engagement, integration of social justice into watershed decision-making, and monitoring and feedback loops.

**DOI:** 10.1007/978-3-319-72472-0\_3

**Backstrom, A. C., G. E. Garrard, R. J. Hobbs, and S. A. Bekessy. 2018. Grappling with the social dimensions of novel ecosystems. *Frontiers in Ecology and the Environment* 16:109–117.**

**Key words**: novel ecosystem concept, values-based decision process, management

**Abstract:** The novel ecosystem concept has emerged in response to the increasing prevalence of modified ecosystems. Traditional conservation and restoration strategies have been deemed inadequate to guide the management of ecosystems that are the product of anthropogenic environmental change and have no “natural” analogs. Opinions about novel ecosystems are currently divided between those who embrace the flexibility offered by the concept and those who see it as a shift toward the abandonment of traditional strategies. However, the debate is missing a key element: recognition that all conservation decisions are socially constructed and that the concept of novel ecosystems is most practicable within a decision or management context. Management of novel ecosystems should be framed in such a context, and the concept evaluated for its capacity to meet social, ecological, and economic objectives.

**DOI:** 10.1002/fee.1769

**Bean, D., and T. Dudley. 2018. A synoptic review of *Tamarix* biocontrol in North America: tracking success in the midst of controversy. *BioControl* 63:361–376.**

**Key words**: Weed biological control, *Tamarix*, *Diorhabda*, Chrysomelidae, non-target impacts, Willow Flycatcher

**Abstract**: Woody shrubs in the genus *Tamarix* L. (Tamaricaceae) were introduced into western North America in the nineteenth century and have invaded riparian areas, acting as drivers of ecosystem change by altering fire cycles, soil chemistry, hydrology and native plant composition. The scope and severity of the invasions provided impetus for a classical weed biological control program using *Diorhabda* spp. (Coleoptera: Chrysomelidae). Since the first releases in 2001 *Diorhabda* spp. have moved into many of the areas dominated by *Tamarix* resulting in defoliations, canopy dieback, and in some locations substantial *Tamarix* mortality. Success of the program has been overshadowed by concern that *Tamarix* is used by a federally-listed bird sub-species, the southwestern willow flycatcher. The controversy has led to lawsuits, cancelled biological control research and release permits and to a negative perception of *Tamarix* biocontrol by some. Long term success is likely, but only with continued monitoring and riparian restoration will the program reach its full potential.

**DOI:** 10.1007/s10526-018-9880-x

**Bedford, A., T. T. Sankey, J. B. Sankey, L. Durning, and B. E. Ralston. 2018. Remote sensing of tamarisk beetle (*Diorhabda carinulata*) impacts along 412 km of the Colorado River in the Grand Canyon, Arizona, USA. *Ecological Indicators* 89:365–375.**

**Key words**: Riparian, Invasive, High resolution image, Herbivory, River regulation, Dam

**Abstract:** Tamarisk (*Tamarix* spp.) is an invasive plant species that is rapidly expanding along arid and semi-arid rivers in the western United States. A biocontrol agent, tamarisk beetle (*Diorhabda carinulata*), was released in 2001 in California, Colorado, Utah, and Texas. In 2009, the tamarisk beetle was found further south than anticipated in the Colorado River ecosystem within the Grand Canyon National Park and Glen Canyon National Recreation Area. Our objectives were to classify tamarisk stands along 412 km of the Colorado River from the Glen Canyon Dam through the Grand Canyon National Park using 2009 aerial, high spatial resolution multispectral imagery, and then quantify tamarisk beetle impacts by comparing the pre-beetle images from 2009 with 2013 post-beetle images. We classified tamarisk presence in 2009 using the Mahalanobis Distance method with a total of 2500 training samples, and assessed the classification accuracy with an independent set of 7858 samples across 49 image quads. A total of 214 ha of tamarisk were detected in 2009 along the Colorado River, where each image quad, on average, included an 8.4 km segment of the river. Tamarisk detection accuracies varied across the 49 image quads, but the combined overall accuracy across the entire study region was 74%. Using the Normalized Difference Vegetation Index (NDVI) from 2009 and 2013 with a region-specific ratio of >1.5 decline between the two image dates (2009NDVI/2013NDVI), we detected tamarisk defoliation due to beetle herbivory. The total beetle-impacted tamarisk area was 32 ha across the study region, where tamarisk defoliation ranged 1–86% at the local levels. Our tamarisk classification can aid long-term efforts to monitor the spread and impact of the beetle along the river and the eventual mortality of tamarisk due to beetle impacts. Identifying areas of tamarisk defoliation is a useful ecological indicator for managers to plan restoration and tamarisk removal efforts.

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**Benson, M. H., R. R. Morrison, D. Llewellyn, and M. Stone. 2018. Governing the Rio Grande: Challenges and Opportunities for New Mexico’s Water Supply. Pages 99–114 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience, Adaptive governance, Adaptive law, Resilience assessment, Climate change, Water management, Regime change

**Abstract:** The Rio Grande in New Mexico provides water to the urban environments of Albuquerque, Santa Fe, as well as surrounding small towns and rural agricultural communities. Long-term climate change projections suggest that New Mexico will experience ongoing drought in the coming decades, placing stress on a system already struggling to meet increasing water demands. Resilience theory provides a lens through which the governance challenges associated with climate change and other factors can be examined. The construction and operation of the many dams, reservoirs, and levees, along with channelization activities, have lowered the overall functional diversity of the river system through channel simplification and bed degradation, with implications for both riverine and riparian habitats. The earlier peak will require more nuanced and intensive water management, including more management flexibility. Changes in water governance strategies will be needed in order to adapt to increased temperatures and other challenges the future will bring. New strategies will include more aggressive management of the upland forest system to decrease the risk of wildfire in the watershed, more operational flexibility for dams and reservoirs, and a new approach to water storage and allocation.

**DOI:** 10.1007/978-3-319-72472-0\_7

**Benson, R. D. 2018. Keeping Power in Charge: Federal Hydropower and the Downstream Environment. Page 38 *in*. *63rd Annual Rocky Mountain Mineral Law Institute* (2017). Volume 39. Public Land & Resources Law Review.**

**Key words**: hydropower, dams, Federal Power Act, Endangered Species Act, Glen Canyon Dam, Colorado River, Wild and Scenic Rivers Act, National Environmental Policy Act

**Conclusion:** Since the FPA ironically applies only to non-federal projects, FERC relicensing does not apply to hydropower projects operated by the Corps or the Bureau. In the absence of anything like relicensing, there is no effective program for periodic review of federal reservoir operations, and no mechanism for ensuring that the operating plans for these old projects are consistent with today’s science, needs, and values. The federal courts have exacerbated the problem by effectively exempting most federal water project operating decisions from NEPA. And while the ESA has played a vital role in prompting reviews at several federal projects, it is an imperfect tool for the job, in part because it focuses narrowly on saving individual species rather than broadly on protecting aquatic and riparian ecosystems.

 The Glen Canyon Dam LTEMP represents a conceptually better approach, with a wider scope of review and greater opportunities for public and stakeholder participation. It considered a range of operating alternatives and evaluated their impacts on not only endangered species, but also other values including game fisheries, Grand Canyon beaches, and tribal resources. It also gave tribes, states, power customers, rafters, anglers, and environmentalists a rare opportunity to weigh in on the next 20 years of reservoir operations.

 Under the LTEMP, hydropower will continue to drive most daily operations at Glen Canyon Dam, although not to the extent that it did through the 1980s. Environmental values remain secondary despite the GCPA, which elevated those values but still required the dam to be operated in accordance with existing laws, including the requirement of generating as much hydropower as “practicable.” This kind of have-your-cake-and-eat-it-too approach virtually assures that hydropower will remain a higher priority than environmental values for federal water projects. It is not easy to restore life to a river that has died and been reborn as money.

**DOI:** Conference paper

**Birgé, H. E., C. R. Allen, R. K. Craig, and D. Twidwell. 2018. Resilience and Law in the Platte River Basin Social-Ecological System: Past, Present, and Future. Pages 115–130 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience, Adaptive governance, Adaptive law, Resilience assessment, Climate change, Water management, Restoration

**Abstract:** A characteristic of the Anthropocene is an acceleration in the rate of change of many global environmental resources, including loss of biodiversity and increased freshwater use. However, societal response to accelerated environmental change often does little to prevent the undesirable and sudden social-ecological system changes that occur in response to relatively incremental resource depletion. Resilience theory provides a framework for evaluating the interactions among social-ecological systems and the policies meant to guide them toward desirable outcomes. This chapter examines the resilience of the Platte River Basin system through time, assessing linkages among environmental change and governmental institutions, policies, and geophysical realities of the region during three distinct social-ecological regimes: pre-European settlement, heavy modification of the river and adjacent land, and the Platte River Recovery Implementation Program (PRRIP). Policy guided by resilience theory accommodates the potential for rapid, nonlinear change characteristic of complex systems such as the Platte River Basin. With increasingly extreme floods and droughts predicted for the Great Plains in coming decades as climate change progresses, a resilience approach to policy and decision-making will contribute to desirable outcomes for people and nature in the next iteration of the Platte River Basin.

**DOI:** 10.1007/978-3-319-72472-0\_8

**Blythe, D. E. 2018. Assessing the Ecological Implications of the Altered Flow and Sediment Regimes of the Rio Grande Along the West Texas-Mexico Border. Utah State University, Logan, UT.**

**Key words**: Rio Grande, aquatic, native fish diversity, flow regime, invasive, riparian

**Abstract:** Development of water resources alters flow and sediment regimes, often at the expense of aquatic ecological integrity and diversity. Many riverine species within the Rio Grande have been reduced or eradicated from the loss, or fragmentation, of viable habitat, poor water quality, and spread of invasive species. The primary goal of our study was to determine how the modified hydrologic and sediment regimes of the Rio Grande have impacted the aquatic ecological integrity, with an emphasis on native fish diversity. We used a multi-faceted approach to 1) examine the fish community between two segments of the river with varying levels of degradation (e.g., Forgotten Reach and Big Bend region) using a novel modeling approach, 2) quantify and describe the native fish community and aquatic food web structure in Big Bend National Park, and 3) determine if and how invasive vegetation impacts aquatic food resources. We found native fish richness to be more influenced by channel narrowing and low flows in the Big Bend region than in the Forgotten Reach. In contrast, water quality and channel narrowing were the most influential variables describing native fish richness in the Forgotten Reach. We found fish abundance (based on catch per unit effort estimates) was greatest and lowest in reaches we a priori classified as complex and simple, respectively, at the microhabitat scale. At the macrohabitat scale, where we compared abundance between alluvial valleys and canyons, fish abundance was greater in canyon reaches than in alluvial reaches. Food web structure followed a similar pattern as fish abundance, appearing to be more complex within complex and canyon sites, than simple and alluvial sites. Contrary to what we expected, native vegetation and periphyton appear to be contributing to the base of the aquatic food web more than nonnative vegetation. Collectively, our results suggest the modern flow and sediment regimes may limit the available habitat and potential food resources suitable for native fishes within the Rio Grande. Native fish recovery and maintenance may depend largely on the effective management of stream flow in the Rio Grande, and concordant changes in lower level productivity and food availability.

**DOI:** Thesis

**Blythe, T. L., and J. C. Schmidt. 2018. Estimating the Natural Flow Regime of Rivers with Long-Standing Development: The Northern Branch of the Rio Grande. *Water Resources Research* 54:1212–1236.**

**Key words**: flow regime, Rio Grande, aquatic, riparian, ecosystem

**Abstract:** An estimate of a river’s natural ﬂow regime is useful for water resource planning and ecosystem rehabilitation by providing insight into the predisturbance form and function of a river. The natural ﬂow regime of most rivers has been perturbed by development during the 20th century and in some cases, before stream gaging began. The temporal resolution of natural ﬂows estimated using traditional methods is typically not sufﬁcient to evaluate cues that drive native ecosystem function. Additionally, these traditional methods are watershed speciﬁc and require large amounts of data to produce accurate results. We present a mass balance method that estimates natural ﬂows at daily time step resolution for the northern branch of the Rio Grande, upstream from the Rio Conchos, that relies only on easily obtained streamﬂow data. Using an analytical change point method, we identiﬁed periods of the measured ﬂow regime during the 20th century for comparison with the estimated natural ﬂows. Our results highlight the signiﬁcant deviation from natural conditions that occurred during the 20th century. The total annual ﬂow of the northern branch is 95% lower than it would be in the absence of human use. The current 2 year ﬂood has decreased by more than 60%, is shorter in duration, and peaks later in the year. When compared to unregulated ﬂows estimated using traditional mass balance accounting methods, our approach provides similar results.

**DOI:** 10.1002/2017WR021919

**Boggie, M. A., S. A. Carleton, D. P. Collins, J. Vradenburg, and C. J. Sroka. 2018*a*. Using stable isotopes to estimate reliance on agricultural food subsidies and migration timing for a migratory bird. *Ecosphere* 9:e02083.**

**Key words**: food supplementation practices; isotopic incorporation; migration; sandhill crane; stable isotopes

**Abstract:** Anthropogenic activities have adversely transformed terrestrial ecosystems consequently limiting many species to more fragmented areas and increasing human–wildlife conﬂicts. Under some circumstances, this creates a need for management programs to support wildlife populations by subsidizing food resources. Evaluation and improvement of supplementary feeding practices should be implemented to determine dietary importance of supplementary food and identify when to make food resources available, an important consideration for migratory species using seasonal habitats. Large aggregations of greater sandhill cranes (*Antigone canadensis tabida*) wintering in the Middle Rio Grande Valley of central New Mexico have come into conﬂict with agricultural practices. Resulting crop depredation on private lands has consequently required a mitigation program that subsidizes cranes with cultivated corn to manage their foraging behavior and provide nutritive support. To assess dependency of cranes on corn subsidies and estimate arrival dates of migratory sandhill cranes, we measured stable isotope ratios of liver and muscle tissues of sandhill cranes and their food items during winter. Over 60% of sandhill crane diet in the winter came from corn subsidies. Rates of carbon isotope incorporation in liver and muscle tissues were 0.03 d-1 ± 0.02 (mean ± SE) and 0.02 d-1 ± 0.01, respectively, and differed predictably by metabolic activity of different tissues. Estimated arrival date on wintering grounds derived from rates of carbon isotope incorporation was November 6 ± 3 d (mean ± SE) and was within 17 d of the estimated arrival date on the wintering grounds of sandhill cranes equipped with satellite transmitters (November 23 ± 2 d). Our approach demonstrates a ﬁeld-based application of intrinsic biomarkers to inform supplementary feeding practices for wildlife populations by identifying dietary response to supplementary food. Additionally, estimating arrival on wintering grounds supports management and conservation decisions by synchronizing availability of supplementary food resources with arrival times.

**DOI:** 10.1002/ecs2.2083

**Boggie, M. A., D. P. Collins, J. P. Donnelly, and S. A. Carleton. 2018*b*. Land Use, anthropogenic disturbance, and riverine features drive patterns of habitat selection by a wintering waterbird in a semi-arid environment. *PLOS ONE* 13:e0206222.**

**Key words**: river ecosystems, Middle Rio Grande, landscape modification, anthropogenic disturbance, wetland, riparian, habitat

**Abstract:** River ecosystems in semi-arid environments provide an array of resources that concentrate biodiversity, but also attract human settlement and support economic development. In the southwestern United States, land-use change, drought, and anthropogenic disturbance are compounding factors which have led to departures from historical conditions of river ecosystems, consequently affecting wildlife habitat, including important wintering areas for migratory birds. The Rio Grande (River) in central New Mexico is the lifeblood of the Middle Rio Grande Valley (MRGV), maintaining large urban and agricultural centers and riparian and wetland resources, which disproportionately support a diversity of wildlife. The MRGV has been identified as the most important wintering area for the Rocky Mountain Population of greater sandhill cranes (*Antigone canadensis tabida*). Presently, however, changes in the hydrogeomorphology of the Rio Grande and landscape modification by humans have reshaped the MRGV and winter habitat for sandhill cranes. To evaluate these impacts, we investigated how land-use practices, anthropogenic disturbance, and river morphology influenced patterns of diurnal and roosting habitat selection by sandhill cranes. During the diurnal period, sandhill cranes relied heavily on managed public lands selecting agriculture crops, such as corn fields, and wetlands for foraging and loafing while avoiding areas with increasing densities of human structures. Sandhill cranes selected areas for roosting in the Rio Grande characterized by shallower water interspersed with sandbars, wide channel width, low bank vegetation, and farther away from disturbances associated with bridges. Our results establish and identify the central processes driving patterns of diel habitat selection by wintering sandhill cranes. Land use and riverine trends have likely gradually reduced winter habitat to managed public lands and limited reaches of the Rio Grande, underscoring the importance of natural resources agencies in supporting migratory birds and challenges involved when managing for wildlife in highly pressured semi-arid environments.

**DOI:** 10.1371/journal.pone.0206222

**Chaffin, B. C., H. Gosnell, and R. K. Craig. 2018. The Emergence of Adaptive Governance in the Klamath River Basin. Pages 83–97 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience, Adaptive governance, Adaptive law, Resilience assessment, Climate change, Water management

**Abstract:** The Klamath River Basin of south-central Oregon and northern California has been the locus of historic conflict over the governance of water situated at the spiritual, cultural, and economic confluence of fishing and farming livelihoods. In recent years, a series of crises have impacted communities and stakeholder groups across the basin and jeopardized the continued existence of endangered and threatened fish species as well as the dominant economic and social relations in the basin. From these crises, however, a set of human-driven processes emerged that closely resemble the seeds of adaptive environmental governance. This chapter describes social-ecological system structures and dynamics that led to this potential emergence of adaptive governance in the Klamath River Basin. The major aim of this chapter is to critically evaluate the role of law in the basin as a tool for both creating disturbances and opening windows of opportunity through which adaptive processes could emerge. The major insight from the Klamath case is that the distribution and application of political power cannot be underestimated as either a barrier or facilitator of adaptive governance. Without an explicit recognition and analysis of power dynamics, adaptive governance scholarship lacks a critical lens to interrogate the contexts of governance transitions and evaluate the potential for new arrangements to attain explicit goals such as the sustainability of ecosystem services, the fair allocation of resources, and other principles of good governance that promote social and environmental justice.

**DOI:** 10.1007/978-3-319-72472-0\_6

**Charnley, S., H. Gosnell, K. L. Wendel, M. M. Rowland, and M. J. Wisdom. 2018. Cattle grazing and fish recovery on US federal lands: can social–ecological systems science help? *Frontiers in Ecology and the Environment* 16:S11–S22.**

**Key words**: Endangered Species Act, grazing management, socio-ecological systems science, riparian, aquatic ecosystem, spawning

**Abstract:** In the western US, grazing management on federal lands containing habitat for fish species listed under the US Endangered Species Act (ESA) has sparked social conflict and litigation for decades. To date, the problem has been addressed through a top- down environmental governance system, but rangeland managers and grazing permittees now believe there is a need for more innovative management strategies. This article explores how social–ecological systems (SES) science can address rangeland management challenges associated with the survival and recovery of ESA- listed fish species on federal lands where cattle grazing is a dominant type of land use. We focus on the Blue Mountains of eastern Oregon, where the Mountain Social Ecological Observatory Network’s Blue Mountains Working Group is collaborating with diverse stakeholders to develop and test a novel grazing system designed to reduce the impact of cattle on riparian areas using an SES science approach. Although not a complete solution, SES science holds promise for improving rangeland management.

**DOI:** 10.1002/fee.1751

**Chaulagain, S. 2018. An investigation into remote sensing techniques for describing hydraulic roughness. University of New Mexico, Albuquerque, NM.**

**Key words**: hydraulic roughness, riparian vegetation, remote sensing, Middle Rio Grande, LiDAR, hydrodynamic modeling

**Abstract:** Riparian vegetation, an indicator of healthy river system, increases the hydraulic roughness and reduces the conveyance capacity of a channel. Vegetation provides dominant drag force influencing the velocity distribution, turbulence intensity and water depth. Thus, the study of hydraulic roughness due to vegetation is essential to determine the characteristics of flow. Traditionally, a constant Manning’s roughness value is assigned based on land cover maps and that does not adequately account for vegetation. The roughness due to vegetation is determined on the basis of its parameters like height, density, LAI and flexibility. Remote sensing data (LiDAR, aerial photos or satellite images) are preferred in determining detailed vegetation parameters to time consuming field data. The objective of this research was to evaluate the performance of remote sensing-based methods to estimate hydraulic roughness of vegetation. A Canopy Height Model (CHM) was used in this study to estimate the height of vegetation and an empirical relation (Beer Lambert law) to determine LAI from LiDAR data for Middle Rio Grande reach located at Albuquerque, New Mexico. The two two-dimensional hydrodynamic models, Sedimentation and River Hydraulics (SRH-2D) model and SRH-2DV, were used in this study. The models were simulated for four different flows (142 m3/s, 198 m3/s, 283 m3/s and 425 m3/s) for two roughness conditions i.e. constant and dynamic roughness. The results showed the minor changes in hydraulic parameters determined due to constant and dynamic roughness. The overall average dynamic roughness value predicted was more by 0.0008 compared to constant roughness for 283 m3/s. Due to increase in dynamic roughness, water depth increased by 4 cm reducing the velocity by 1.7 cm/s for 283 m3/s. Further study is suggested to determine the accuracy of hydraulic roughness estimated due to vegetation parameters derived from LiDAR through calibration of model results.

**DOI:**  Thesis

**Chavarria, S. B., and D. S. Gutzler. 2018. Observed Changes in Climate and Streamflow in the Upper Rio Grande Basin. *Journal of the American Water Resources Association* 54:644–659.**

**Key words**: climate variability/change; runoff; snow hydrology; water supply

**Abstract:** Observed streamﬂow and climate data are used to test the hypothesis that climate change is already affecting Rio Grande streamﬂow volume derived from snowmelt runoff in ways consistent with model-based projections of 21st-Century streamﬂow. Annual and monthly changes in streamﬂow volume and surface climate variables on the Upper Rio Grande, near its headwaters in southern Colorado, are assessed for water years 1958–2015. Results indicate winter and spring season temperatures in the basin have increased signiﬁcantly, April 1 snow water equivalent (SWE) has decreased by approximately 25%, and streamﬂow has declined slightly in the April–July snowmelt runoff season. Small increases in precipitation have reduced the impact of declining snowpack on trends in streamﬂow. Changes in the snowpack–runoff relationship are noticeable in hydrographs of mean monthly streamﬂow, but are most apparent in the changing ratios of precipitation (rain + snow, and SWE) to streamﬂow and in the declining fraction of runoff attributable to snowpack or winter precipitation. The observed changes provide observational conﬁrmation for model projections of decreasing runoff attributable to snowpack, and demonstrate the decreasing utility of snowpack for predicting subsequent streamﬂow on a seasonal basis in the Upper Rio Grande Basin.

**DOI:** 10.1111/1752-1688.12640

**Clark, L. B. 2018. The Ecology of Land Managers in Riparian Restoration. University of Denver.**

**Key words**: restoration ecology, *Tamarix*, collaboration, project monitoring, decisions, managers

**Abstract:** While previous studies in restoration ecology have focused on the efficacy of direct management actions, the driving forces on management decisions (e.g., managers’ characteristics or attitudes, environmental conditions) and the indirect impacts on restoration outcomes from management decisions (such as whether to collaborate) are quantified here for the first time. As a case study, I used data from 244 sites across the riparian Southwest US where the invasive shrubby tree *Tamarix* sp. was removed using various different methods. I surveyed and interviewed the 45 land managers who were responsible for the removal projects to determine their characteristics, attitudes, and management decisions. I found differences between agencies in which removal methods were used and project objectives (i.e., goals); goals were also correlated with climate (i.e., temperature and precipitation). Surprisingly, neither education nor any other characteristic measured predicted attitudes held by managers about science and/or nature. The resulting plant community after restoration (as measured by four PCA vectors) was associated with the governing agency or organization and the manner in which each manager prioritized management goals. Finally, managers’ attitude toward nature was related to plant community composition after restoration, while not associated with any measured manager characteristics or decisions, suggesting that there were subtle interactions at play. This study contributes to our understanding of what makes restoration projects successful and how to improve restoration outcomes by understanding the managers themselves.

**DOI:** Thesis

**Connon, R. E., K. M. Jeffries, L. M. Komoroske, A. E. Todgham, and N. A. Fangue. 2018. The utility of transcriptomics in fish conservation. *Journal of Experimental Biology* 221:jeb148833.**

**Key words**: Conservation physiology, Endangered species, Molecular approaches

**Abstract:** There is growing recognition of the need to understand the mechanisms underlying organismal resilience (i.e. tolerance, acclimatization) to environmental change to support the conservation management of sensitive and economically important species. Here, we discuss how functional genomics can be used in conservation biology to provide a cellular-level understanding of organismal responses to environmental conditions. In particular, the integration of transcriptomics with physiological and ecological research is increasingly playing an important role in identifying functional physiological thresholds predictive of compensatory responses and detrimental outcomes, transforming the way we can study issues in conservation biology. Notably, with technological advances in RNA sequencing, transcriptome-wide approaches can now be applied to species where no prior genomic sequence information is available to develop species-specific tools and investigate sub-lethal impacts that can contribute to population declines over generations and undermine prospects for long-term conservation success. Here, we examine the use of transcriptomics as a means of determining organismal responses to environmental stressors and use key study examples of conservation concern in fishes to highlight the added value of transcriptome-wide data to the identification of functional response pathways. Finally, we discuss the gaps between the core science and policy frameworks and how thresholds identified through transcriptomic evaluations provide evidence that can be more readily used by resource managers.

**DOI:** 10.1242/jeb.148833

**Cosens, B., and A. H. Arthington. 2018. Assessing Adaptive Water Governance for Lake Eyre Basin and Linked Portions of the Great Artesian Basin in Australia. Pages 131–147 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive governance Adaptive law Resilience assessment Climate change Water management Groundwater Dryland rivers

**Abstract:** The Lake Eyre Basin in the heart of the outback of Australia is a place in which the social-ecological system is not only highly dependent on but is also defined by the intermittent presence and absence of water. Tributary rivers of this hydrologic system arise in Queensland and the Northern Territory and feed the landlocked Kati Thanda-Lake Eyre in central Australia. Due to decadal cycles of rain, the basin has one of the most variable flows in the world; in any given year, the lake may be a vast expanse of blue against the red soils of the arid lands or a white salt flat. The Great Artesian Basin that underlies portions of the Lake Eyre Basin has been an important source of fresh water for humans, initially serving Aboriginal inhabitants, then the railroad system, and today large pastoral farms of the basin. The setting provides an opportunity to consider the link among resilience, governance, and law outside the North American context yet within a federal system. The efforts of the Australian Commonwealth and state governments to engage in catchment planning and involve both scientists and local stakeholders can be characterized as a governmental effort to achieve adaptive governance across jurisdictions. This much more formal and intentional approach has indeed enhanced the adaptive capacity of Australian water basins and moved them beyond their North American counterparts in which emergence of adaptive governance remains ad hoc in response to a social or ecological disturbance. At the same time, the Australian approach is top-down and, without both greater authority and capacity at the local level, may not achieve the level of adaptive governance needed to navigate the changes to come.

**DOI:** 10.1007/978-3-319-72472-0\_9

**Cosens, B., R. K. Craig, S. Hirsch, C. A. (Tony) Arnold, M. H. Benson, D. DeCaro, A. S. Garmestani, H. Gosnell, J. B. Ruhl, and E. Schlager. 2018*a*. Legal Pathways to Adaptive Governance in Water Basins in North America and Australia. Pages 151–165 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive governance, Adaptive law, Environmental governance, Resilience, Water law, Nesting, Polycentricity, Legitimacy

**Abstract:** Law dictates the structure, boundaries, rules, and processes within which governmental action takes place and in doing so becomes one of the focal points for analysis of governmental barriers to adaptation as the effects of climate change are felt. Governance encompasses both governmental and nongovernmental participation in collective choice and action. Adaptive governance contemplates a level of flexibility and evolution in governmental action beyond that currently found in the heavily administrative governments in the United States and Australia. Nevertheless, over time, law itself has proven highly adaptive in democracies, evolving to address and even facilitate the emergence of new social norms (such as the rights of women and minorities) or to provide remedies for emerging problems (such as pollution). Thus, law can adapt, evolve, and be reformed to facilitate adaptive governance. In doing so, not only may barriers be removed, but law may be adjusted to facilitate adaptive governance and to aid in institutionalizing new and emerging approaches to governance. The key is to do so in a way that also enhances legitimacy, accountability, and justice (i.e., good governance), or such reforms will never be adopted by democratic societies or, if adopted, will destabilize those very societies. By identifying those aspects of adaptive governance relevant to the legal system, this chapter presents guidelines for evaluating the role of law in environmental governance and demonstrates their use by applying them to the basin studies presented in Part I of this volume.

**DOI:** 10.1007/978-3-319-72472-0\_10

**Cosens, B., and A. Fremier. 2018. Social-Ecological Resilience in the Columbia River Basin: The Role of Law and Governance. Pages 47–64 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience, Adaptive governance, Adaptive law, Resilience assessment, Climate change, Water management

**Abstract:** The Columbia River is a complex water basin shared by 2 countries, 15 Native American Tribes, 15 First Nations, 7 US states, and 1 Canadian province. Dam construction during the twentieth century has engendered a basin economy that is dependent on low-cost electricity and irrigated agriculture. Yet, these dams are a major factor in the decline of populations of salmon and steelhead species that are critical to the culture of Indigenous peoples. Climate change scenarios predict a transformation from snow- to rain-dominated precipitation in the basin’s lower latitudes, greater extremes in flood and drought, and an increasing water deficit as a result of higher rates of evapotranspiration with increasing temperature. Reduced late summer flow may pose challenges for the sustainability of irrigation and fish. The basin provides a unique laboratory to explore resilience of a highly developed social-ecological system to changing climate and rising empowerment of Indigenous peoples. Review of the Columbia River Treaty between the United States and Canada that governs much of the operation of the river presents a window of opportunity for change. This window provides a moment in time to rethink environmental governance and to consider an approach which reflects neither top-down nor bottom-up control of resources but a third path in which each level of government plays a supporting role to a regional vision of the basin’s future governance.

**DOI:** 10.1007/978-3-319-72472-0\_4

**Cosens, B., and L. Gunderson. 2018*a*. An Introduction to Practical Panarchy: Linking Law, Resilience, and Adaptive Water Governance of Regional Scale Social-Ecological Systems. Pages 1–16 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive law, Adaptive water governance, Climate change, Resilience, Social-ecological systems

**Abstract:** This chapter introduces the volume on Practical Panarchy: Linking Law, Resilience, and Adaptive Water Governance of Regional Scale Social-Ecological Systems. It begins by defining the terminology and theoretical concepts to present the bridging framework among ecological resilience, governance, and law relied on throughout this volume and then introduces this three-part volume. Part I presents the effort to assess resilience and transformation in riverine and wetland social-ecological systems in six US watersheds (the Anacostia River, Columbia River, Everglades wetlands, Klamath River, Middle Rio Grand River, and central Platte River) and one Australian system (the Lake Eyre and Great Artesian basin). Part II focuses on the legal dimensions of watershed governance that directly relate to ecological resilience and transformability of the social-ecological systems and synthesizes the results of the basin assessments to advance the understanding of the role of law and governance as a trigger, facilitator, or barrier to adaptation and transformation in the face of rapid environmental change, including shifting climate. Part III looks at the broader relation between social-ecological resilience and governance through synthesis of the basin assessments and resort to the broader literature on institutions and governance. As a whole, this volume presents the results of a 3-year pursuit on the cross-scale interactions among law, ecosystem dynamics, and governance to address the adaptive capacity of regional scale watersheds as they respond to accelerating environmental change.

**DOI:** 10.1007/978-3-319-72472-0\_1

**Cosens, B., L. Gunderson, and B. Chaffin. 2018*b*. Introduction to the Special Feature Practicing Panarchy: Assessing legal flexibility, ecological resilience, and adaptive governance in regional water systems experiencing rapid environmental change. *Ecology and Society* 23.**

**Key words**: adaptive governance; climate change; environmental law; resilience; water law; water management

**Abstract:** This special feature presents articles on the cross-scale interactions among law, ecosystem dynamics, and governance to address the adaptive capacity of six watersheds in the United States as they respond to rapid environmental change. We build on work that assesses resilience and transformation in riverine and wetland social-ecological systems across the United States at a variety of scales, levels of development, and degrees of degradation, focusing specifically on the Anacostia River, Central Platte River, Klamath River, Columbia River, Middle Rio Grand River, and the Everglades wetlands. All of these cases involve complex institutional systems, histories involving ecological and social regime shifts, and are operated under similar constitutional and legal frameworks for the division of authority among federal, state, local, and where applicable, tribal governments. We focus on the legal dimensions of watershed governance that directly relate to ecological resilience and transformability of the social-ecological systems. We synthesize the results of these assessments to advance our understanding of the role of law and governance as a trigger, facilitator, or barrier to adaptation and transformation in the face of rapid environmental change, including shifting climate. This introductory article defines terminology and theoretical concepts to present a bridging framework between U.S. law and ecological resilience that can be used by the remaining articles in this special issue.

**DOI:** 10.5751/ES-09524-230104

**Cosens, B., and L. H. Gunderson. 2018*b*. Adaptive Water Governance: Summary and Synthesis. Pages 313–322 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience and law, Adaptive law, Adaptive governance, Water management,

Social-ecological systems, Windows of opportunity, Good governance, Panarchy Adaptive capacity, Participatory capacity

**Abstract:** The Adaptive Water Governance project was set up to examine how law, policy, and ecological dynamics influence the governance of regional-scale water-based social-ecological systems in the United States and Australia. With the onset of the Anthropocene, global and regional changes in biophysical inputs to these systems will challenge their capacity to respond while maintaining functions of water supply, flood control, hydropower production, water quality, and biodiversity in a time of aging infrastructure. At the heart of the capacity of these systems to respond to these challenges is their governance. Governance of these complex and dynamic social-environmental systems has moved beyond state-centric, legally bounded control to a complex mix of public/private self-organization. The resilience assessments of case studies and integrative scholarship led to this synthesis, which is presented in the form of three challenges to adaptive water governance. The first is to consider the role of government in removing barriers to adaptive governance by facilitating actions that take advantage of windows of opportunity and institutionalize the results of innovative solutions. The second challenge is to assure that in embracing these new approaches, society must continue to evaluates trade-offs. Such governance should assure that engagement of private and economic actors and the increase in governmental flexibility do not destabilize nor come at the expense of legitimacy, accountability, equity, and justice. Law in its role of establishing the structure and process of government and in placing bounds on the interaction of governmental entities with private actors is a key component in striking the balance between stability in government and adaptability of governance. The third challenge is to identify whether government might be given the authority to facilitate and participate in adaptive governance. Meeting these challenges will increase the capacity of these social-ecological systems to innovate, adapt, and learn their way into an uncertain future, by increasing participation in adaptive governance in ways that are legitimate, transparent, and just.

**DOI:** 10.1007/978-3-319-72472-0\_18

**Counihan, T. D., I. R. Waite, A. F. Casper, D. L. Ward, J. S. Sauer, E. R. Irwin, C. G. Chapman, B. S. Ickes, C. P. Paukert, J. J. Kosovich, and J. M. Bayer. 2018. Can data from disparate long-term fish monitoring programs be used to increase our understanding of regional and continental trends in large river assemblages? K. A. Young, editor. *PLOS ONE* 13:e0191472.**

**Key words**: management, decisions, monitoring, fish assemblages, climate change, biodiversity, hydropower, invasive species, urbanization, water quality

**Abstract:** Understanding trends in the diverse resources provided by large rivers will help balance tradeoffs among stakeholders and inform strategies to mitigate the effects of landscape scale stressors such as climate change and invasive species. Absent a cohesive coordinated effort to assess trends in important large river resources, a logical starting point is to assess our ability to draw inferences from existing efforts. In this paper, we use a common analytical framework to analyze data from five disparate fish monitoring programs to better understand the nature of spatial and temporal trends in large river fish assemblages. We evaluated data from programs that monitor fishes in the Colorado, Columbia, Illinois, Mississippi, and Tallapoosa rivers using non-metric dimensional scaling ordinations and associated tests to evaluate trends in fish assemblage structure and native fish biodiversity. Our results indicate that fish assemblages exhibited significant spatial and temporal trends in all five of the rivers. We also document native species diversity trends that were variable within and between rivers and generally more evident in rivers with higher species richness and programs of longer duration. We discuss shared and basin-specific landscape level stressors. Having a basic understanding of the nature and extent of trends in fish assemblages is a necessary first step towards understanding factors affecting biodiversity and fisheries in large rivers.

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

**Key words**: Salt buildup, Pedogenic carbonate, Salinity and sodicity

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

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

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

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

**DOI:** 10.1016/j.apgeochem.2017.12.019

**Darrah, A. J., and C. van Riper III. 2018. Riparian bird density decline in response to biocontrol of *Tamarix* from riparian ecosystems along the Dolores River in SW Colorado, USA. *Biological Invasions* 20:709–720.**

**Key words**: Defoliation, Density, Phenology, Point counts, Tamarisk beetles

**Abstract:** Biocontrol of invasive tamarisk (*Tamarix* spp.) in the arid Southwest using the introduced tamarisk beetle (*Diorhabda elongata*) has been hypothesized to negatively affect some breeding bird species, but no studies to date have documented the effects of beetle-induced defoliation on riparian bird abundance. We assessed the effects of tamarisk defoliation by monitoring defoliation rates, changes in vegetation composition, and changes in density of six obligate riparian breeding bird species at two sites along the Dolores River in Colorado following the arrival of tamarisk beetles. We conducted bird point counts from 2010 to 2014 and modeled bird density as a function of native vegetation density and extent of defoliation using hierarchical distance sampling. Maximum annual defoliation decreased throughout the study period, peaking at 32–37% in 2009–2010 and dropping to 0.5–15% from 2011–2014. Stem density of both tamarisk and native plants declined throughout the study period until 2014. Density of all bird species declined throughout most of the study, with Song Sparrow disappearing from the study sites after 2011. Blue Grosbeak, Yellow-breasted Chat, and Yellow Warbler densities were negatively related to defoliation in the previous year, while Lazuli Bunting exhibited a positive relationship with defoliation. These findings corroborate earlier predictions of species expected to be sensitive to defoliation as a result of nest site selection. Tamarisk defoliation thus had short-term negative impacts on riparian bird species; active restoration may be needed to encourage the regrowth of native riparian vegetation, which in the longer-term may result in increased riparian bird density.

**DOI:** 10.1007/s10530-017-1569-z

**De Stefano, L., C. Welch, J. Urquijo, and D. Garrick. 2018. Groundwater Governance in the Rio Grande: Co-evolution of Local and Intergovernmental Management. *Water Alternatives* 11:824–846.**

**Key words:** Groundwater, transboundary water management, federal, interstate, institutional interplay, Rio Grande/Rio Bravo

**Abstract:** The physical interconnection of ground and surface waters is rarely acknowledged in inter-state and international agreements over surface water. This is especially true in the Rio Grande/Rio Bravo basin, where groundwater pumping is at the heart of several disputes and legal cases related to compliance with intergovernmental water agreements. This research considers the Upper and Middle Rio Grande basin to explore how groundwater use and management interact with interstate (i.e. intranational within the US) and international relations (US-Mexico). We consider three distinct geographic regions to address the following questions: how have intergovernmental surface water agreements affected local groundwater management and policies? And, how does groundwater management at local scale influence intergovernmental relations over water? We combine documentary data and interview data collected through extensive fieldwork during 2016 and 2017. The analysis reveals the emergence of both state-driven and community-based groundwater initiatives aimed at reconciling needs and obligations stemming from different geographical and institutional levels. The analysis uncovers strong institutional interplay across water management levels and suggests that compliance with intergovernmental agreements in federal and international contexts both affects and is affected by local groundwater management. Moreover, we observed that while local water managers are sometimes prevented from solving problems locally due to interstate rules, opportunities for innovation in local groundwater governance can also be triggered by compliance obligations at other levels.

**DOI:** Creative Commons

**DeCaro, D. A., C. A. (Tony) Arnold, E. Frimpong Boamah, and A. S. Garmestani. 2018*a*. Theory and Research to Study Principles of Social Cognition and Decision-Making in Adaptive Environmental Governance. Pages 289–309 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive governance, Cognition, Cooperation, Environmental law, Legitimacy,

Social decision making

**Abstract:** Environmental governance systems must adapt to address increased uncertainty and new social-ecological conditions posed by stressors like climate change. This chapter presents several principles of social cognition and decision-making that influence adaptive governance. The principles are illustrated with examples from six US river basins. Future research opportunities are also outlined.

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**DeCaro, D. A., B. C. Chaffin, E. Schlager, A. S. Garmestani, and J. B. Ruhl. 2018*b*. Theory and Research to Study the Legal and Institutional Foundations of Adaptive Governance. Pages 269–288 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive governance, Climate change, Design principles, Environmental law,

 Social-ecological resilience, State-reinforced self-governance, Water governance

**Abstract:** Adaptation to major social and ecological changes requires the participation, innovation, social learning, and political deliberation of many stakeholders, doing many different governance activities at different scales. Legal and institutional systems set the ground rules for this governance activity, establishing boundaries and opportunities for widespread innovation and cooperation. However, the enabling conditions for adaptive governance are poorly understood, making it difficult to facilitate. Candidate design principles that describe enabling conditions for adaptive environmental governance are proposed. Research opportunities are outlined to study the effects of these factors in different social-ecological systems and to further refine the principles.

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**Dietze, M. C., A. Fox, L. M. Beck-Johnson, J. L. Betancourt, M. B. Hooten, C. S. Jarnevich, T. H. Keitt, M. A. Kenney, C. M. Laney, L. G. Larsen, H. W. Loescher, C. K. Lunch, B. C. Pijanowski, J. T. Randerson, E. K. Read, A. T. Tredennick, R. Vargas, K. C. Weathers, and E. P. White. 2018. Iterative near-term ecological forecasting: Needs, opportunities, and challenges. *Proceedings of the National Academy of Sciences* 115:1424–1432.**

**Key words**: forecast, ecology, prediction

**Abstract:** Two foundational questions about sustainability are “How are ecosystems and the services they provide going to change in the future?” and “How do human decisions affect these trajectories?” Answering these questions requires an ability to forecast ecological processes. Unfortunately, most ecological forecasts focus on centennial-scale climate responses, therefore neither meeting the needs of near-term (daily to decadal) environmental decision-making nor allowing comparison of specific, quantitative predictions to new observational data, one of the strongest tests of scientific theory. Near-term forecasts provide the opportunity to iteratively cycle between performing analyses and updating predictions in light of new evidence. This iterative process of gaining feedback, building experience, and correcting models and methods is critical for improving forecasts. Iterative, near-term forecasting will accelerate ecological research, make it more relevant to society, and inform sustainable decision-making under high uncertainty and adaptive management. Here, we identify the immediate scientific and societal needs, opportunities, and challenges for iterative near-term ecological forecasting. Over the past decade, data volume, variety, and accessibility have greatly increased, but challenges remain in interoperability, latency, and uncertainty quantification. Similarly, ecologists have made considerable advances in applying computational, informatic, and statistical methods, but opportunities exist for improving forecast-specific theory, methods, and cyberinfrastructure. Effective forecasting will also require changes in scientific training, culture, and institutions. The need to start forecasting is now; the time for making ecology more predictive is here, and learning by doing is the fastest route to drive the science forward.

**DOI:** 10.1073/pnas.1710231115

**Dudley, R. K., A. L. Barkalow, S. P. Platania, and G. C. White. 2018*a*. Rio Grande Silvery Minnow Reproductive Monitoring During 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: ecological models, spawning, egg passage rates, Rio Grande Silvery Minnow, reproductive monitoring, sampling

**Summary:** The primary objectives of the Rio Grande Silvery Minnow Reproductive Monitoring Program are to characterize the timing, duration, and magnitude of spawning of this species in the Angostura, Isleta, and San Acacia reaches of the Middle Rio Grande. Additional objectives include assessing differences in Rio Grande Silvery Minnow egg passage rates across years; examining the relationships between flow, temperature, and spawning; and characterizing spatial spawning patterns in the Angostura, Isleta, and San Acacia reaches over time. This long-term monitoring study provides insight into the key environmental factors affecting trends in the temporal and spatial spawning patterns of Rio Grande Silvery Minnow, which can assist managers in developing successful strategies for its recovery.

Systematic monitoring of the reproduction of Rio Grande Silvery Minnow has been conducted annually since 2001. Previous studies demonstrated mid-April to mid-June as the primary period of spawning activity. The 2018 study was a continuation of the long-term monitoring effort in the lower portion of the San Acacia Reach (San Marcial), just upstream of Elephant Butte Reservoir. Two additional sites (one in the Angostura Reach [Albuquerque] and one in the Isleta Reach [Sevilleta]), which had been sampled periodically from 2006 to 2011, were also sampled in 2017 and 2018.

Rio Grande Silvery Minnow mixture-model estimates (E(x)), using standardized egg passage rate data (Ep = eggs / s) from 2003 to 2018 in the San Acacia Reach, were highest in 2011 (6.05 x 101) and lowest in 2004 (1.36 x 10-3). Values of Ep are indicative of the relative downstream transport of eggs across years, corrected for annual differences in flow magnitude. There was a steady decline in estimated egg passage rates from 2011 to 2013, followed by an increase in 2014. Egg passage rates declined (P < 0.05) from 2015 (7.75 x 10-1) to 2016 (6.12 x 10-2), but increased slightly in 2017. We were unable to estimate the 2018 egg passage rate, and its associated confidence interval, as only a single egg was collected this year at San Marcial. However, the methods-of-moments estimate for this site in 2018 (1.40 x 10-5) was the lowest ever recorded.

Ecological models revealed that changes in the density and occurrence of Rio Grande Silvery Minnow eggs were reliably predicted by seasonal differences in river flows over time (2003–2018). Out of 129 models considered, we found that high flows during spring were crucial (i.e., > 70% of model weight) in explaining why some years had substantially lower egg passage rates (i.e., reduced downstream transport of eggs) than others. In summary, we found that low egg passage rates were most common during years with elevated and extended spring flows, whereas high egg passage rates occurred most frequently during years with reduced and truncated spring flows.

Logistic regression modeling of Rio Grande Silvery Minnow egg presence-absence data revealed strong associations with the percentage change in mean daily discharge just prior to egg collection (X2 = 28.86 and P < 0.001). The probability of collecting eggs (i.e., occurrence), as opposed to egg density (i.e., abundance), was predicted to increase rapidly up to about a 100% increase in mean daily discharge between days just prior to egg collection. The probability of collecting eggs during a 100% increase in flow was 0.81 and during a 200% increase was 0.97.

Rio Grande Silvery Minnow egg presence-absence data also revealed associations with water temperatures, though not as robust as the discharge relationships, during the study period (X2 = 16.71 and P < 0.001). The probability of collecting eggs ranged from 0.64 (temperature = 14°C) to 0.23 (temperature = 26°C). The probability of collecting eggs showed a steady decrease as a function of elevated water temperatures. Sampling at the Albuquerque and Sevilleta sites was reinitiated in 2017, which allowed for long-term comparisons of egg passage rates (2006–2011, 2017–2018). Annual trends in egg passage rates (i.e., relative increases/decreases across years) were similar for all three sampling sites. Overall, the estimated egg passage rates at Sevilleta and San Marcial were consistently higher than at Albuquerque. The mixture-model was used to estimate and compare the 2018 egg passage rates at Albuquerque (0.85; n = 4,161) and Sevilleta (16.75; n = 100,091). The estimated egg passage rates in 2018, at Sevilleta and Albuquerque, were generally higher than in previous years. While there was a significant increase (P < 0.05) in the egg passage rate at Albuquerque from 2017 to 2018, the slight increase at Sevilleta from 2017 to 2018 was not significant.

Additionally, several Flathead Chub eggs were captured, and positively identified from hatched larvae, at the Albuquerque site in 2018. Flathead Chub produce nonadhesive eggs that sink faster and develop more slowly than pelagic-spawning fishes, like Rio Grande Silvery Minnow, although their eggs may be transported downstream during increased flows, particularly in sand-bedded rivers. This is the first time that drifting Flathead Chub eggs have been documented during the Rio Grande Silvery Minnow Reproductive Monitoring Program.

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

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*b*. Rio Grande Silvery Minnow Population Monitoring During 2017. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Middle Rio Grande, management, Rio Grande Silvery Minnow, population monitoring, sampling, mixture models, CPUE

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

The occurrence and density of Rio Grande Silvery Minnow has fluctuated widely over the past two decades (1993–2017). While its estimated density (E(x); fish per 100 m2), using October data, was notably lower from 2010 to 2015 as compared with 2007 to 2009, there was a marked improvement in 2016 and 2017. Population monitoring efforts in 2017 revealed an elevated density of Rio Grande Silvery Minnow (23.17), which was over 100 times higher than in 2015 (0.16) and over 700 times higher than in 2013 (0.03). While Rio Grande Silvery Minnow represented only 0.9% of the total fish community in October 2015, it had increased to 35.7% by October 2017.

Ecological models revealed that changes in the occurrence and density of Rio Grande Silvery Minnow were reliably predicted by seasonal differences in river flows across years (1993–2017). Further, our findings were consistent regardless of whether dry sites or additional sites were or were not included in the analyses (see Introduction). Out of 449 models considered, we found that the top three models, which represented extended high flows during spring, were crucial (i.e., > 90% of model weight) in explaining why some years had dramatically elevated densities of Rio Grande Silvery Minnow. In contrast, we found that extended low flows during summer were key to explaining reductions in the occurrence of this species across years. Thus, prolonged high flows during spring were most predictive of increased density and prolonged low flows during summer were most predictive of decreased occurrence of Rio Grande Silvery Minnow over the study period.

Additional analyses revealed that population trends in different mesohabitats (October [2002– 2017]), or on different days during repeated sampling (November [2005–2017]), were remarkably similar to population trends obtained from the long-term dataset (October [1993–2017]). These results suggest that the current sampling protocols are resulting in a reliable level of sampling precision and population trend consistency, especially when considering the substantial changes in the occurrence and density of Rio Grande Silvery Minnow over time. Further, the variance in estimated densities was consistently highest across years, followed distantly by sampling site, river reach, and sampling day. Thus, changes in the occurrence and density of Rio Grande Silvery Minnow were much more strongly related to seasonal flow conditions across years than to subtleties in local sampling conditions (i.e., across sites, reaches, or sampling days).

Site occupancy models lend further support to these findings. We found that Rio Grande Silvery Minnow occupancy probabilities declined progressively from 2010 (0.90) to 2013 (0.14) before increasing markedly from 2014 (0.49) to 2017 (0.99). While estimated extinction probabilities were notably elevated during recent drought years (i.e., 2012–2014), they have decreased substantially since 2014 as seasonal river flows have progressively improved. Likewise, estimated colonization probabilities increased considerably in recent years (2014–2017), as this species repatriated multiple sites that had been previously unoccupied. The conservation status of Rio Grande Silvery Minnow showed encouraging signs of improvement from 2014 to 2017, and site occupancy probabilities were as favorable as they were during the earliest years of the study (i.e., 2005–2009).

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

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

While extensive and diverse management efforts over the past two decades have provided invaluable protection against the extinction of Rio Grande Silvery Minnow, ongoing and planned efforts (e.g., restoring dynamic river flows, reconnecting fragmented reaches, and reestablishing a functional floodplain) should help to promote resilient and self-sustaining populations of this imperiled species. Encouragingly, both the occurrence and density of Rio Grande Silvery Minnow increased markedly from 2015 to 2017, as compared with recent drought years (2012–2014), following notably improved spring and summer flow conditions. Continued efforts to provide reasonable spring spawning and summer survival conditions will be essential for securing a self-sustaining wild population of Rio Grande Silvery Minnow in the Middle Rio Grande. Additionally, the reestablishment of resilient populations of this species at other locations within its historical range would help to further ensure its long-term persistence in the wild. Future study of the relationships among aquatic species (i.e., from phytoplankton to fish) and seasonal river flows in the Rio Grande Basin should continue to elucidate key factors that control this complex ecosystem, which will be essential for developing and implementing successful management strategies for the long-term recovery of Rio Grande Silvery Minnow.

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*c*. Rio Grande Silvery Minnow Population Monitoring During April 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The April population monitoring efforts were conducted at the 20 standard sites and at 10 additional sites. Ten sites were located in each of the three sampling reaches: Angostura, Isleta, and San Acacia. The Middle Rio Grande Endangered Species Collaborative Program requested that the additional sampling be conducted once in the spring and fall of each year. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For April 2018, comparisons were made between standard sites and all sites (i.e., standard plus additional sites). For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.*** A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were also collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 30)***

 ***During April, sampling covered 15,344.4 m2 (surface area) of water and yielded 3,400 fish. There were no dry sampling sites. Cumulative fish density during April was 22.16 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 2,779), Rio Grande Silvery Minnow (n = 427), and Flathead Chub (n = 92). The sampling sites yielded a total of 15 fish species. Rio Grande Silvery Minnow was present in 107 of the 320 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 24 of the 30 sampling sites, and its overall density was 2.78 (n = 427) individuals/100 m2 sampled. Densities of unmarked and marked individuals were 2.77 (n = 425) and 0.01 (n = 2) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.00 (n = 0), 2.68 (n = 411), and 0.10 (n = 16) individuals/100 m2 sampled, respectively.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*d*. Rio Grande Silvery Minnow Population Monitoring During August 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The August population monitoring efforts were conducted at the 20 standard sites. Five sites were located in the Angostura Reach, six sites were located in the Isleta Reach, and nine sites were located in the San Acacia Reach. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For August 2018, no comparisons were made between standard sites and all sites (i.e., standard sites plus replacement sites), as no standard sites were dry. For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.*** A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 20)***

 ***During August, sampling covered 10,554.6 m2 (surface area) of water and yielded 4,794 fish. There were no dry sampling sites. Cumulative fish density during August was 45.42 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 3,030), Channel Catfish (n = 515), and Western Mosquitofish (n = 407). The sampling sites yielded a total of 14 fish species. Rio Grande Silvery Minnow was present in 25 of the 335 seine hauls that yielded fish and at 14 of the 20 sampling sites. Densities of unmarked and marked individuals were 0.29 (n = 31) and 0.00 (n = 0) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.04 (n = 4), 0.26 (n = 27), and 0.00 (n = 0) individuals/100 m2 sampled, respectively. During August 2018, the overall density of Rio Grande Silvery Minnow was 0.29 (n = 31) individuals/100 m2 sampled. Based on all August surveys since 1993, its overall density averaged 9.35 (range = 0.05–41.58) individuals/100 m2 sampled.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*e*. Rio Grande Silvery Minnow Population Monitoring During July 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The July population monitoring efforts were conducted at the 20 standard sites and at three replacement sites. Five sites were located in the Angostura Reach, six sites were located in the Isleta Reach, and twelve sites were located in the San Acacia Reach. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For July 2018, comparisons were made between standard sites and all sites (i.e., standard sites plus replacement sites). For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.*** A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 23)***

 ***During July, sampling covered 10,238.4 m2 (surface area) of water and yielded 12,546 fish. There were three dry sampling sites. Cumulative fish density during July was 122.54 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 6,657), Western Mosquitofish (n = 1,423), and Flathead Chub (n = 1,096). The sampling sites yielded a total of 22 fish species. Rio Grande Silvery Minnow was present in 59 of the 373 seine hauls that yielded fish and at 14 of the 23 sampling sites. Densities of unmarked and marked individuals were 2.99 (n = 306) and 0.01 (n = 1) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.02 (n = 2), 2.89 (n = 296), and 0.09 (n = 9) individuals/100 m2 sampled, respectively. During July 2018, the overall density of Rio Grande Silvery Minnow was 3.00 (n = 307) individuals/100 m2 sampled. Based on all July surveys since 1993, its overall density averaged 29.01 (range = 0.26–140.98) individuals/100 m2 sampled.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*f*. Rio Grande Silvery Minnow Population Monitoring During June 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The June population monitoring efforts were conducted at the 20 standard sites and at two replacement sites. Five sites were located in the Angostura Reach, six sites were located in the Isleta Reach, and eleven sites were located in the San Acacia Reach. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For June 2018, comparisons were made between standard sites and all sites (i.e., standard sites plus replacement sites). For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.***  A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 22)***

 ***During June, sampling covered 9,717.8 m2 (surface area) of water and yielded 6,765 fish. There were two dry sampling sites. Cumulative fish density during June was 69.61 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 2,826), White Sucker (n = 1,101), and Common Carp (n = 874). The sampling sites yielded a total of 18 fish species. Rio Grande Silvery Minnow was present in 52 of the 330 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 16 of the 22 sampling sites, and its overall density was 1.46 (n = 142) individuals/100 m2 sampled. Densities of unmarked and marked individuals were 1.43 (n = 139) and 0.03 (n = 3) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age2+ individuals were 0.13 (n = 13), 1.29 (n = 125), and 0.04 (n = 4) individuals/100 m2 sampled, respectively.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*g*. Rio Grande Silvery Minnow Population Monitoring During May 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The May population monitoring efforts were conducted at the 20 standard sites and at one replacement site. Five sites were located in the Angostura Reach, six sites were located in the Isleta Reach, and ten sites were located in the San Acacia Reach. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For May 2018, comparisons were made between standard sites and all sites (i.e., standard sites plus replacement sites). For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.*** A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 21)***

 ***During May, sampling covered 9,218.6 m2 (surface area) of water and yielded 4,750 fish. There was one dry sampling site. Cumulative fish density during May was 51.53 individuals/100 m2 sampled. The three most common species were White Sucker (n = 2,110), Red Shiner (n = 1,812), and Rio Grande Silvery Minnow (n = 492). The sampling sites yielded a total of 15 fish species. Rio Grande Silvery Minnow was present in 61 of the 221 seine hauls that yielded fish. We collected Rio Grande Silvery Minnow at 13 of the 21 sampling sites, and its overall density was 5.34 (n = 492) individuals/100 m2 sampled. Densities of unmarked and marked individuals were 5.29 (n = 488) and 0.04 (n = 4) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.00 (n = 0), 5.09 (n = 469), and 0.25 (n = 23) individuals/100 m2 sampled, respectively.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*h*. Rio Grande Silvery Minnow Population Monitoring During October 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The October population monitoring efforts were conducted at the 20 standard sites, at the 10 additional sites, and at one replacement site. Ten sites were located in the Angostura Reach, ten sites were located in the Isleta Reach, and eleven sites were located in the San Acacia Reach. While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For October 2018, comparisons were made between standard sites and all sites (i.e., standard, additional, and replacement sites). For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports. A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age-2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 31)***

 ***During October, sampling covered 15,783.6 m2 (surface area) of water and yielded 10,243 fish. There was one dry sampling site. Cumulative fish density during October was 64.90 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 6,552), Western Mosquitofish (n = 1,920), and Flathead Chub (n = 662). The sampling sites yielded a total of 14 fish species. Rio Grande Silvery Minnow was present in 12 of the 496 seine hauls that yielded fish and at 9 of the 31 sampling sites. Densities of unmarked and marked individuals were 0.11 (n = 17) and 0.00 (n = 0) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.02 (n = 3), 0.06 (n = 9), and 0.03 (n = 5) individuals/100 m2 sampled, respectively. During October 2018, the overall density of Rio Grande Silvery Minnow was 0.11 (n = 17) individuals/100 m2 sampled. Based on all October surveys since 1993, its overall density averaged 7.63 (range = 0.00–37.86) individuals/100 m2 sampled.***

**DOI:** Report

**Dudley, R. K., S. P. Platania, and G. C. White. 2018*i*. Rio Grande Silvery Minnow Population Monitoring During September 2018. Prepared by American Southwest Ichthyological Researchers, L.L.C. Prepared for U.S. Bureau of Reclamation.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, sampling

**Summary:** The September population monitoring efforts were conducted at the 20 standard sites. Five sites were located in the Angostura Reach, six sites were located in the Isleta Reach, and nine sites were located in the San Acacia Reach. ***While this report follows the typical monthly report format, key changes to the text, tables, and figures are highlighted in bold-italic font. For September 2018, no comparisons were made between standard sites and all sites (i.e., standard sites plus replacement sites), as no standard sites were dry. For the 2018 monthly trends, data were based on all sites (i.e., standard, additional, and replacement sites) to maintain consistency across all monthly reports.*** A list of all collection localities is appended (Appendix A). Adult and juvenile fish were obtained by rapidly drawing a 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats. Larval fish were collected with a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine. All fishes were identified to species and enumerated. We used length-age relationships to assign ages (i.e., age-0, age-1, and age2+) to all Rio Grande Silvery Minnow collected. Age-0 individuals are, however, only present after annual spring spawning occurs (ca. April–June). Figures illustrating fish densities (i.e., fish per 100 m2) were prepared for the ten focal species to facilitate comparisons across reaches.

***All Sites (n = 20)***

 ***During September, sampling covered 10,813.9 m2 (surface area) of water and yielded 5,507 fish. There were no dry sampling sites. Cumulative fish density during September was 50.93 individuals/100 m2 sampled. The three most common species were Red Shiner (n = 2,970), Western Mosquitofish (n = 866), and Channel Catfish (n = 712). The sampling sites yielded a total of 16 fish species. Rio Grande Silvery Minnow was present in 24 of the 321 seine hauls that yielded fish and at 14 of the 20 sampling sites. Densities of unmarked and marked individuals were 0.40 (n = 43) and 0.00 (n = 0) individuals/100 m2 sampled, respectively. Densities of age-0, age-1, and age-2+ individuals were 0.08 (n = 9), 0.28 (n = 30), and 0.04 (n = 4) individuals/100 m2 sampled, respectively. During September 2018, the overall density of Rio Grande Silvery Minnow was 0.40 (n = 43) individuals/100 m2 sampled. Based on all September surveys since 1993, its overall density averaged 6.08 (range = 0.01–26.32) individuals/100 m2 sampled.***

**DOI:** Report

**Ebberts, B. D., B. D. Zelinsky, J. P. Karnezis, C. A. Studebaker, S. Lopez‐Johnston, A. M. Creason, L. Krasnow, G. E. Johnson, and R. M. Thom. 2018. Estuary ecosystem restoration: implementing and institutionalizing adaptive management. *Restoration Ecology* 26:360–369.**

**Key words**: collaboration, habitat restoration, learning, monitoring

**Abstract:** We implemented and institutionalized an adaptive management (AM) process for the Columbia Estuary Ecosystem Restoration Program, which is a large-scale restoration program focused on improving ecosystem conditions in the 234-km lower Columbia River and estuary. For our purpose, “institutionalized” means the AM process and restoration programs are embedded in the work flow of the implementing agencies and affected parties. While plans outlining frameworks, processes, or approaches to AM of ecosystem restoration programs are commonplace, their establishment for the long-term is not. This article presents the basic AM process and explains how AM was implemented and institutionalized. Starting with a common goal, we pursued a well-understood governance and decision-making structure, routine coordination and communication activities, data and information sharing, commitment from partners and upper agency management to the AM process, and meaningful cooperation among program managers and partners. The overall approach and steps to implement and institutionalize AM for ecosystem restoration explained here are applicable to situations in which it has been incomplete or, as in our case, the restoration program is just getting started.

**DOI:** 10.1111/rec.12562

**El Waer, H. N., A. Henry, K. Merewether, and A. A. Sher. 2018. Chapter 4. Invasion and restoration of Western Rivers Dominated by *Tamarix* spp. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: *Tamarix*, restoration, riparian, soil salinization, invasive plant species, *Diorhabda*, cottonwoods, Colorado

**Conclusion and Implications:** In summary, active removal of *Tamarix* was highly successful and had significant effects on the understory that differed by region. In the western sites where the biocontrol beetle *Diorhabda* spp. was present, *Tamarix* cover decreased over time in both *Tamarix* active removal sites and non-active removal sites, and the former was associated with decreases in other exotics while increasing native species. The eastern sites where there was no biological control and no active removal had very high cover of *Tamarix*, but differences between these sites were not as great for the understory, due to the poor results seen in those sites with aerial application of herbicide. Generally, *Tamarix* removal led to an increase in native understory vegetation except when herbicide was applied by helicopter. Spraying herbicide by helicopter was associated with the increased importance of *Bassia scoparia*, an understory exotic. These results are consistent with other studies in which secondary invasions were less notable following biocontrol than other treatment methods (González et al. 2017a; Sher et al., in review), particularly *B. scoparia* (González et al. 2017b). It is also important to note that we observed positive reference sites to increase in native cover over time, whereas sites with no *Tamarix* removal decreased in native cover, and when the biocontrol was absent, increased in *Tamarix* cover. This suggests a risk of site depredation if nothing is done to reduce this exotic tree. In conclusion, our results suggest that removal of *Tamarix* by commonly used methods is either neutral or positive for the native plant community. Although 2 years post removal is too short a period to reach any broad conclusions about impact, our results are consistent with those over longer time periods and greater geographic range that suggest that native cover can be promoted through *Tamarix* removal (González et al. 2017a). Although this should not be confused with a return to the mesic riparian forests associated with pre-invasion and pre-damming, it does bode well for improvement of these communities.

**DOI:** Book chapter

**Embke, H. S., P. M. Kocovsky, T. Garcia, C. M. Mayer, and S. S. Qian. 2018. Modeling framework to estimate spawning and hatching locations of pelagically spawned eggs. *Canadian Journal of Fisheries and Aquatic Sciences* 999:1–11.**

**Key words**: invasive species, threatened species

**Abstract:** Identifying spawning and hatching locations is vital to controlling invasive fish and conserving imperiled fish, which can be difficult for pelagically-spawning species with semi-buoyant eggs. In freshwater systems, this reproductive strategy is common among cyprinid species, such as Chinese carp species currently threatening the Great Lakes. Following the confirmation that one of these species, Grass Carp (*Ctenopharyngodon idella*), was spawning in a Great Lakes tributary, we developed a modeling framework to combine field data with hydraulic models to calculate the most probable spawning and hatching locations for collected eggs. Our results indicate that the estimated spawning location encompassed habitat consistent with spawning sites in Grass Carp’s native range. Additionally, all eggs were identified to have hatched in the river, increasing the likelihood of successful recruitment. This modeling framework can be used to estimate spawning and hatching locations for Chinese carp species, as well as all pelagic, riverine spawners. Spawning and hatching locations provide key information to researchers about the reproductive requirements of species and to agencies about how best to manage populations for control or restoration.

**DOI:** 10.1139/cjfas-2018-0047

**Flanagan, S. P., B. R. Forester, E. K. Latch, S. N. Aitken, and S. Hoban. 2018. Guidelines for planning genomic assessment and monitoring of locally adaptive variation to inform species conservation. *Evolutionary Applications* 11:1035–1052.**

**Key words**: adaptive management, conservation genetics, conservation planning, local

adaptation, natural selection, next-generation sequencing, outlier detection

**Abstract:** Identifying and monitoring locally adaptive genetic variation can have direct utility for conserving species at risk, especially when management may include actions such as translocations for restoration, genetic rescue, or assisted gene flow. However, genomic studies of local adaptation require careful planning to be successful, and in some cases may not be a worthwhile use of resources. Here, we offer an adaptive management framework to help conservation biologists and managers decide when genomics is likely to be effective in detecting local adaptation, and how to plan assessment and monitoring of adaptive variation to address conservation objectives. Studies of adaptive variation using genomic tools will inform conservation actions in many cases, including applications such as assisted gene flow and identifying conservation units. In others, assessing genetic diversity, inbreeding, and demographics using selectively neutral genetic markers may be most useful. And in some cases, local adaptation may be assessed more efficiently using alternative approaches such as common garden experiments. Here, we identify key considerations of genomics studies of locally adaptive variation, provide a road map for successful collaborations with genomics experts including key issues for study design and data analysis, and offer guidelines for interpreting and using results from genomic assessments to inform monitoring programs and conservation actions.

**DOI:** 10.1111/eva.12569

**Fluke, J. 2018. Characterizing patterns in *E. coli* levels in Rio Grande river water and riverbed sediments near Albuquerque, NM. University of New Mexico.**

**Key words**: waterborne pathogens, *Escherichia coli*, Rio Grande, Clean Water Act, riverbed sediments, sampling, Total Maximum Daily Load

**Abstract:** In this work I examined how Fecal indicator Bacteria (FIB) behave in a large environmental system (Rio Grande near Albuquerque, ~60 km distance). I addressed the questions: How do FIB levels in river water and riverbed sediments of this reach change with distance along the river and throughout one year? I conducted year-round river water and sediment sampling for concentration of *E. coli* bacteria, a persistent contaminant in the area. I found that over the year, *E. coli* loading in river water increased along the 60 km reach and *E. coli* in the sediments mainly increased near the Albuquerque urban area. Site by site along the reach, relative fluctuations in *E. coli* loadings and sediment concentrations were seasonally coupled. This study found high *E. coli* sediment concentrations during Summer and Fall co-occur with higher Summer and Fall loadings, and higher *E. coli* sediment concentrations downstream may be related to more frequent exceedances of the Total Maximum Daily Load (TMDL) in the downstream section. However, the net direction of *E. coli* transfer (river water to sediment or sediment to river water) is unknown at any point and the physical interactions between river water and sediment causing transfer of *E. coli* cells are not well understood on the reach-scale.

**DOI:** Thesis

**Forester, B. R., E. L. Landguth, B. K. Hand, and N. Balkenhol. 2018. Landscape Genomics for Wildlife Research. Population Genomics. Springer, Cham.**

**Key words**: Adaptive capacity, Adaptive genetic variation, Conservation genomics, Genome-wide association studies, Genotype-environment associations, Natural selection

**Abstract:** Landscape genomics investigates how spatial and environmental factors influence geographic patterns of genome-wide genetic variation. Adaptive landscape genomics focuses on how these spatial and environmental processes structure the amount and distribution of selection-driven genetic variation among populations, which ultimately determines how phenotypic variation is arrayed across landscapes. This adaptive landscape genomics approach can be used to identify the causal factors underlying local adaptation and has great potential to guide decision-making in applied wildlife research, especially in light of anthropogenic climate and land use change. Conservation and management applications include delineating conservation units, designing conservation monitoring programs, and predicting changes in the spatial distribution and potential loss of adaptive genomic variation under environmental change. However, there remains great untapped potential for the application of adaptive landscape genomics to wildlife research, including moving beyond correlative genotype-environment association tests. In this chapter, we explore and discuss the potential of adaptive landscape genomics for improving wildlife research, including case studies that illustrate its application in wildlife management and conservation. We also present a comprehensive workflow for adaptive landscape genomics studies in wildlife, including sampling design, genomic and environmental data production, and data analysis. We conclude with avenues and perspectives for future work and ongoing challenges in adaptive landscape genomics.

**DOI**: 10.1007/13836\_2018\_56

**Fouty, S. C. 2018. Chapter 7. Euro-American Beaver Trapping and Its Long- Term Impact on Drainage Network Form and Function, Water Abundance, Delivery, and System Stability. Page 32 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: beaver trapping, drainage network development, grazing, disturbances, watershed response, conceptual models, fluvial geomorphology

**From Present to Future:** Climate change is bringing increased variability. The impacts on wild and human communities are already large and will only increase. As water is essential to all communities, we need to shift our landscapes from “water-sheds” to “water-stores” by allowing the missing parts to return and take up their places and functions on the landscape. Public lands are the ideal place to start beaver-driven stream system restoration. Public lands provide large contiguous areas where beavers can rapidly create vast ecologically complex water storage zones and diverse habitat with limited infrastructure conflicts. Large portions of these lands occur in the headwaters, making them uniquely situated to store water during times of abundance and then release it during times of drought. Because many of the streams are first- through fourth-order streams, they are the appropriate size for beavers and their dam complexes to rapidly restore stream processes and form in these areas.

The challenges inherent in recovering at least some of the stream-valley floor hydrologic connections and the water storage capability of stream systems without beavers become clear when examining the amount of channel incision and/or widening that has occurred (table 3) and volume of stream sediment eroded post-EA trapping. Bryan (1928a) estimated that the Rio Puerco in New Mexico, with a drainage area of roughly 6,220 mi2 (USGS stream gage), had lost more than 394,882 acre-ft of sediment over a 42-year period as a result of channel incision and widening. On a smaller scale, an estimate of 7.2 acre-ft of sediment has been eroded from the 3.4 miles of headwater stream reaches studied by Fouty (2003). These drainages are located in southwest Montana and east-central Arizona and range from 692 to 18,775 acres.

The channelization of drainages across the North American continent resulted in the permanent removal of large volumes of sediment. Therefore, restoration of the stream-valley floor hydrologic connection, and the processes that result from that connection, requires abundant beaver dam complexes with their ponds in order to fill the void left by the eroded sediment. Where the amount of erosion prevents recovering the original stream-valley floor hydrologic connection, beaver dam complexes are still required to restore stream processes. However, in these cases these new beaver-dominated systems will be inset into the larger channels as is the case at Bridge Creek in eastern Oregon (Demmer and Beschta 2008; Pollock et al. 2007) and streams near Elko, Nevada (Swanson et al. 2015).

Two key factors prevent beavers from expanding in numbers and distribution. The first is recreational and commercial beaver trapping (Muller-Schwarze and Sun 2003), which removes not only existing beavers but their future progeny. An example of the cumulative effect of trapping on numbers is found in the data collected by Oregon Department of Fish and Wildlife and USDA Wildlife Services for the State of Oregon. The data listed 54,034 beavers reported killed between 2000 and 2015. Of this number, 83 percent (44,784) of the beavers killed were due to hunting and trapping with the vast majority from trapping (about 97 percent).

The second factor is insufficient food and building material due to past and current land uses, with browse pressure on riparian woody vegetation by livestock and wild ungulates being a key contributor on public lands. When livestock are the dominant browser, as was the case for streams near Elko, Nevada, changes in livestock management resulted in rapid improvements in the quality of riparian habitat (Swanson et al. 2015). The expansion of riparian vegetation and the absence of trapping allowed beavers in this area to expand their range such that during an extreme drought in 2012 the rivers with beavers still had water (Fouty, personal observation, July 15, 2012). Where wild ungulates are the browsers, work by Beschta and Ripple (2009, 2010) in Yellowstone National Park has shown the role that wolves play in decreasing elk and deer use of riparian areas leading to increased willows, aspen and cottonwoods. Here too beavers have expanded their range in response to improved habitat and no trapping (Smith and Tyers 2008). These studies show that sufficient food and building materials and the absence of trapping are required for beaver populations and their water storage benefits to expand. On public lands where both wild and domestic ungulates graze, changes in livestock management and expansion of wolf populations will be needed to reduce the browse pressure on key beaver food and building materials, along with the elimination of commercial and recreational trapping.

**Conclusions:** Separating out cause-and-effect relationships in fluvial systems is challenging because changes to their form and function are the result of many factors interacting over time and space. This chapter explored some of those factors in its examination of how EA beaver trapping altered the appearance and hydrologic behavior of stream systems and why the influence of beavers and beaver trapping were missed in the discipline of fluvial geomorphology until recently. It also examined how information gaps led to the development of relationships of process and form based on observations and measurements of channelized drainages and altered uplands that created conditions whereby water was rapidly shed from the landscape rather than stored and released slowly. Given the magnitude of the historic changes and their hydrologic consequences, the scale of restoration and the rate at which it must occur is enormous if the impact of climate change on water availability, and the systems that depend on water, are to be minimized. Partnering with beavers to restore the water-holding capability of our stream corridors would rapidly dampen fluctuations in the abundance and scarcity of water and leave wild and human communities less vulnerable. Efforts will require broad public support and an integrated approach by State and Federal agencies given their respective areas of influence and impact. Scientists are in a position to help inform the discussions by sharing what we have learned about how past and current land uses affect the ability of the landscape to naturally store water for future use; however, our effectiveness will first require that we change the lens we have been looking through. Because the discipline of fluvial geomorphology has internalized and codified degraded systems as normal, our stream restoration efforts fall short. By placing these fluvial geomorphic relationships within their historic disturbance context, one that includes EA beaver trapping, new strategies, approaches, and partnerships emerge that are essential for restoration to successfully occur. This new lens reveals the essential role beavers play in this recovery process.

**DOI:** Book chapter

**Frey, J. K. 2018. Chapter 6. Beavers, Livestock, and Riparian Synergies: Bringing Small Mammals into the Picture. Page 17 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: riparian, beaver dam, ecosystem, plant community, restoration, small mammals, succession

**Conclusions:** Small mammals are an often overlooked but vitally important component of healthy riparian ecosystems. These species provide critical ecosystem services to riparian zones by virtue of their high biomass, support of diverse predator communities, physical alterations of the soil, and regulation of plant communities. Small mammal communities are best developed in riparian systems that provide an abundance of tall, dense, and diverse herbaceous vegetation. Beavers are capable of increasing the capacity of riparian systems to produce these early seral plant communities and hence benefit small mammal communities. In contrast, excessive livestock grazing can disrupt small mammal communities by causing loss of tall, dense, and diverse herbaceous vegetation, and can also limit the capacity of riparian systems to support beavers. This negative synergism can result in riparian ecosystems that are depleted and fail to support critical ecosystem services.

Thus, restoration of full ecosystem services of riparian zones requires consideration of the herbaceous plant and small mammal communities. In contrast, riparian restoration that focuses mainly on woody plants might restore habitats for birds and stabilize stream banks, but may fail to provide full restoration of crucial ecosystem function. Additional research is needed on livestock grazing management that can enhance herbaceous riparian vegetation and thereby support beavers and healthy small mammal communities. In addition, there is need for more research on the roles of small mammals in riparian ecosystem function and the patterns of riparian mammal diversity and abundance in relation to various disturbances and management actions.

**DOI:** Book chapter

**Funk, W. C., B. R. Forester, S. J. Converse, C. Darst, and S. Morey. 2018. Improving conservation policy with genomics: a guide to integrating adaptive potential into U.S. Endangered Species Act decisions for conservation practitioners and geneticists. *Conservation Genetics* 1–20.**

**Key words**: Adaptation, Genomics, U.S. Endangered Species Act, Conservation policy, Extinction risk

**Abstract:** Rapid environmental change makes adaptive potential—the capacity of populations to evolve genetically based changes in response to selection—more important than ever for long-term persistence of at-risk species. At the same time, advances in genomics provide unprecedented power to test for and quantify adaptive potential, enabling consideration of adaptive potential in estimates of extinction risk and laws protecting endangered species. The U.S. Endangered Species Act (ESA) is one of the most powerful environmental laws in the world, but so far, the full potential of genomics in ESA listing and recovery decisions has not been realized by the federal agencies responsible for implementing the ESA or by conservation geneticists. The goal of our paper is to chart a path forward for integrating genomics into ESA decision making to facilitate full consideration of adaptive potential in evaluating long-term risk of extinction. For policy makers, managers, and other conservation practitioners, we outline why adaptive potential is important for population persistence and what genomic tools are available for quantifying it. For conservation geneticists, we discuss how federal agencies can integrate information on the effect of adaptive potential on extinction risk—and the related uncertainty—into decisions, and suggest next steps for advancing understanding of the effect of adaptive potential on extinction risk. The mechanisms and consequences of adaptation are incredibly complex, and we may never have a complete understanding of adaptive potential for any organism. Nevertheless, we argue that the best available evidence regarding adaptive potential can now be incorporated by federal agencies into modeling and decision making processes, while at the same time conserving genome-wide variation and striving for a deeper understanding of adaptive potential and its effects on population persistence to improve decision making into the future.

**DOI:** 10.1007/s10592-018-1096-1

**Garrick, D. E. 2018. Decentralisation and drought adaptation: Applying the subsidiarity principle in transboundary river basins. *International Journal of the Commons* 12:301.**

**Key words**: Adaptation, Colorado River, decentralization, diagnosis, drought, Rio Grande River, subsidiarity

**Abstract:** Determining how to adapt to freshwater scarcity and variability has become an important question for institutional analysis and development. This paper addresses the assignment challenge in drought adaptation, namely the challenge of assigning and coordinating governance responsibilities across nested levels of social organisation. The subsidiarity principle suggests that adaptation decisions and associated governance responsibilities should occur at the lowest level at which they can be performed competently. Droughts and related slow-onset ‘shocks’ throw into question which level is lowest, and how this varies with the duration, severity and extent of the event. This paper explores the potential for the subsidiarity principle to guide the assignment and assessment of governance responsibilities associated with drought adaptation. It reviews literature at the intersection of common pool resource studies and new institutional economics to elaborate four diagnostic questions: (1) what are the opportunities and limits of decentralised (independent) drought adaptation?; (2) how are social dilemmas and spillovers associated with drought adaptation managed?; (3) when do higher level institutions complement versus crowd out decentralised adaptation?; and (4) how does adaptation by individuals and groups affect adaptive efficiency? An illustrative comparison of drought adaptation in the US portions of the Colorado and Rio Grande Rivers of North America demonstrates: (i) the potential and limits of decentralised adaptation through urban water conservation and irrigation efficiency (ii) the importance of both formal and informal coordination institutions (e.g. river basin organisations) to address cross-border externalities, including conflicts and economies of scale, and (iii) the pivotal role of groundwater management for adaptive efficiency, requiring a balance between local, short-term dependence on groundwater for drought adaptation with transboundary, long-term outcomes caused by unsustainable extractions.

**DOI:** 10.18352/ijc.816

**Garrick, D. E., E. Schlager, L. D. Stefano, and S. Villamayor‐Tomas. 2018. Managing the Cascading Risks of Droughts: Institutional Adaptation in Transboundary River Basins. *Earth’s Future* 6:809–827.**

**Key words**: droughts, decision-making, institutional catchments, Rio Grande, Rio Bravo, transboundary river basins, institutional analysis and development framework

**Abstract:** Transboundary river basins experience complex coordination challenges during droughts. The multiscale nature of drought creates potential for spillovers when upstream adaptation decisions have cascading impacts on downstream regions. This paper advances the institutional analysis and development (IAD) framework to examine drought adaptation decision-making in a multijurisdictional context. We integrate concepts of risk management into the IAD framework to characterize drought across its natural and human dimensions. A global analysis identiﬁes regions where severe droughts combine with institutional fragmentation to require coordinated adaptation. We apply the risk-based IAD framework to examine drought adaptation in the Rio Bravo/Grande—an archetypical transboundary river shared by the United States and Mexico and by multiple states within each country. The analysis draws on primary data and a questionnaire with 50 water managers in four distinct, yet interlinked, “institutional catchments,” which vary in terms of their drought characteristics, socioeconomic attributes, and governance arrangements. The results highlight the heterogeneity of droughts and uneven distribution of their impacts due to the interplay of drought hazards and institutional fragmentation. Transboundary water sharing agreements inﬂuence the types and sequence of interactions between upstream and downstream jurisdictions, which we describe as spillovers that involve both conﬂict and cooperation. Interdependent jurisdictions often draw on informal decision-making venues (e.g., data sharing, operational decisions) due to the higher transaction costs and uncertainty associated with courts and planning processes, yet existing coordination and conﬂict resolution venues have proven insufﬁcient for severe, sustained droughts. Observatories will be needed to measure and manage the cascading risks of drought.

**DOI:** 10.1002/2018EF000823

**Gavin, M., J. McCarter, F. Berkes, A. Mead, E. Sterling, R. Tang, and N. Turner. 2018. Effective Biodiversity Conservation Requires Dynamic, Pluralistic, Partnership-Based Approaches. *Sustainability* 10:1846.**

**Key words**: adaptive management and governance; biocultural approaches to conservation; different worldviews and knowledge systems; Gwaii Haanas; nested institutional frameworks; multiple stakeholders and objectives; New Conservation Science; partnerships and relationship building; rights and responsibilities; social-ecological context

**Abstract:** Biodiversity loss undermines the long-term maintenance of ecosystem functions and the well-being of human populations. Global-scale policy initiatives, including the Convention on Biological Diversity, have failed to curb the loss of biodiversity. This failure has led to contentious debates over alternative solutions that represent opposing visions of value-orientations and policy tools at the heart of conservation action. We review these debates and argue that they impede conservation progress by wasting time and resources, overlooking common goals, failing to recognize the need for diverse solutions, and ignoring the central question of who should be involved in the conservation process. Breaking with the polarizing debates, we argue that biocultural approaches to conservation can guide progress toward just and sustainable conservation solutions. We provide examples of the central principles of biocultural conservation, which emphasize the need for pluralistic, partnership-based, and dynamic approaches to conservation.

**DOI:** 10.3390/su10061846

**Gill, K. M., L. A. Goater, J. H. Braatne, and S. B. Rood. 2018. The Irrigation Effect: How River Regulation Can Promote Some Riparian Vegetation. *Environmental Management* 61:650–660.**

**Key words**: *Celtis reticulate*, Hells canyon, Hydropeaking, Salmon river, Snake river

**Abstract:** River regulation impacts riparian ecosystems by altering the hydrogeomorphic conditions that support streamside vegetation. Obligate riparian plants are often negatively impacted since they are ecological specialists with particular instream flow requirements. Conversely, facultative riparian plants are generalists and may be less vulnerable to river regulation, and could benefit from augmented flows that reduce drought stress during hot and dry periods. To consider this ‘irrigation effect’ we studied the facultative shrub, netleaf hackberry (*Celtis reticulata*), the predominant riparian plant along the Hells Canyon corridor of the Snake River, Idaho, USA, where dams produce hydropeaking, diurnal flow variation. Inventories of 235 cross-sectional transects revealed that hackberry was uncommon upstream from the reservoirs, sparse along the reservoir with seasonal draw-down and common along two reservoirs with stabilized water levels. Along the Snake River downstream, hackberry occurred in fairly continuous, dense bands along the high water line. In contrast, hackberry was sparsely scattered along the free-flowing Salmon River, where sandbar willow (*Salix exigua*), an obligate riparian shrub, was abundant. Below the confluence of the Snake and Salmon rivers, the abundance and distribution of hackberry were intermediate between the two upstream reaches. Thus, river regulation apparently benefited hackberry along the Snake River through Hells Canyon, probably due to diurnal pulsing that wets the riparian margin. We predict similar benefits for some other facultative riparian plants along other regulated rivers with hydropeaking during warm and dry intervals. To analyze the ecological impacts of hydropeaking we recommend assessing daily maxima, as well as daily mean river flows.

**DOI:** 10.1007/s00267-017-0991-4

**Gordon, T. a. C., H. R. Harding, F. K. Clever, I. K. Davidson, W. Davison, D. W. Montgomery, R. C. Weatherhead, F. M. Windsor, J. D. Armstrong, A. Bardonnet, E. Bergman, J. R. Britton, I. M. Côté, D. D’Agostino, L. A. Greenberg, A. R. Harborne, K. K. Kahilainen, N. B. Metcalfe, S. C. Mills, N. J. Milner, F. H. Mittermayer, L. Montorio, S. L. Nedelec, J. M. Prokkola, L. A. Rutterford, A. G. V. Salvanes, S. D. Simpson, A. Vainikka, J. K. Pinnegar, and E. M. Santos. 2018. Fishes in a changing world: learning from the past to promote sustainability of fish populations. *Journal of Fish Biology* 92:804–827.**

**Key words**: challenges; fish; fisheries; future; global change; sustainability

**Abstract:** Populations of fishes provide valuable services for billions of people, but face diverse and interacting threats that jeopardize their sustainability. Human population growth and intensifying resource use for food, water, energy and goods are compromising fish populations through a variety of mechanisms, including overfishing, habitat degradation and declines in water quality. The important challenges raised by these issues have been recognized and have led to considerable advances over past decades in managing and mitigating threats to fishes worldwide. In this review, we identify the major threats faced by fish populations alongside recent advances that are helping to address these issues. There are very significant efforts worldwide directed towards ensuring a sustainable future for the world’s fishes and fisheries and those who rely on them. Although considerable challenges remain, by drawing attention to successful mitigation of threats to fish and fisheries we hope to provide the encouragement and direction that will allow these challenges to be overcome in the future.

**DOI:** 10.1111/jfb.13546

**Gosnell, H., B. C. Chaffin, J. B. Ruhl, C. A. (Tony) Arnold, R. K. Craig, M. H. Benson, and A. Devenish. 2018. Finding Flexibility in Section 7 of the Endangered Species Act Through Adaptive Governance. Pages 183–202 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience.**

**Key words**: Adaptive capacity, Biodiversity governance, Biological opinion, Collaboration,

Empathy, Endangered Species Act, Hydrologic modeling, Integrated natural resource management, Klamath Basin, Participatory capacity, Resilience Section 7 consultation, Trust

**Abstract:** The US Endangered Species Act (ESA) prohibits federal agency actions likely to jeopardize listed species or adversely modify critical habitat. Scholarship on the application of the ESA characterizes the process as unwaveringly rigid, a legal “hammer.” This chapter draws on lessons derived from applying the ESA in the Klamath Basin along the Oregon-California border, where an integrated implementation strategy lessened rigidities and barriers to change. Collaboration among leaders in the US Fish and Wildlife Service, the National Marine Fisheries Service, and the US Bureau of Reclamation supported efforts to replace an ecologically and socially fragmented approach to ESA implementation that was fraught with conflict with a more adaptive, flexible, integrated approach to water sharing among competing interests. Keys to success included existing collaborative capacity related to improved tribal-irrigator relations and a shift in local agency culture facilitated by empathic leadership which led to a greater sense of shared responsibility for ESA compliance. This effort exemplifies governmental adaptive capacity for flexibility and evolution within constraints of formal law. A truly bioregional approach to endangered species recovery, however, will necessitate greater integration between federal and nonfederal activities.

**DOI:** 10.1007/978-3-319-72472-0\_12

**Gunderson, L., and B. Cosens. 2018. Case Studies in Adaptation and Transformation of Ecosystems, Legal Systems, and Governance Systems. Pages 19–31 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Climate change, Panarchy, Resilience assessment, Adaptive governance, Water management

**Abstract:** Seven water basins, six in North America and one in Australia, were chosen as case studies to investigate the dynamic interactions among ecosystems, society, and legal systems. These cases were chosen because of local knowledge and expertise of a group of interdisciplinary scholars. The teams were asked to describe the structures and processes that contribute to resilience, adaptations, and transformations in both the ecological and social components of the linked system. The role of law in triggering or hindering change in governance and institutional reformation was explored. The cases also describe conditions for emergence of adaptive governance in heavily regulated and developed water systems nested within a hierarchical governmental system.

**DOI:** 10.1007/978-3-319-72472-0\_2

**Gunderson, L., B. Cosens, and B. C. Chaffin. 2018*a*. Trajectories of Change in Regional-Scale Social-Ecological Water Systems. Pages 229–241 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Adaptive governance, Cross scale dynamics, Social ecological system,

Transformation Panarchy

**Abstract:** The six North American case studies described in Part I of this volume provide the opportunity to explore patterns of change over time associated with the development and management of social-ecological systems. The historical assessments show the trajectories that have led to the current heavily regulated and developed social-ecological systems nested within a hierarchical governmental system. This chapter uses Panarchy theory as a general framework to evaluate the interactions between societal and ecological regime shifts and the governance regimes that mediate those interactions. The resilience assessments indicate that complex interactions among the governance and ecosystem components of these systems can produce different trajectories, which include patterns of (a) development and stabilization, (b) cycles of crisis and recovery which include lurches in adaptation and learning, and (c) periods of innovation, novelty, and transformation. Exploration of cross-scale interactions (Panarchy) among levels and sectors of government and society reveals that larger-scale processes and structures may constrain development and growth, but may also provide resources for recovery and renewal following crises or create windows or opportunities for system change. Smaller-scale processes provide opportunities for innovation and novelty, but may also be the source of revolts or crises that lead to broader system transformations. The case studies illustrate different ways that adaptive governance may be triggered, facilitated, or constrained by ecological and social (and particularly legal) processes.

**DOI:** 10.1007/978-3-319-72472-0\_14

**Gunderson, L., A. S. Garmestani, K. W. Rizzardi, J. B. Ruhl, and A. R. Light. 2018*b*. Social, Legal, and Ecological Capacity for Adaptation and Transformation in the Everglades. Pages 65–81 *in* B. Cosens and L. Gunderson, editors. Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience. Springer International Publishing, Cham.**

**Key words**: Resilience, Adaptive governance, Adaptive law, Resilience assessment, Climate change, Water management

**Abstract:** The Florida Everglades is a subtropical wetland in the southeastern USA that has been hydrologically modified to protect urban and agricultural lands from flooding, while supplying water for urban interests and Everglades National Park. The social-ecological system has sought control over the surface water through infrastructure of canals, levees, and pumps to direct water movement, managed by a complex institutional arrangement of federal, state, and local governments. Water control has been largely achieved through adaptation and transformation to unforeseen environmental events, too much or too little rainfall and nutrient movement across the wet landscapes. Law has provided both the resources to foster economic and conservation objectives but also resulted in rigid planning and continuing litigation, constraining the adaptive capacity of the social-ecological system of the Florida Everglades to respond to seen and unforeseen environmental changes. Rigid management at higher levels and failure to balance stability of economic investment and varied stakeholder values of the Everglades with flexibility to adjust management measures have limited the emergence of adaptive governance.

**DOI:** 10.1007/978-3-319-72472-0\_5

**Harrow, R. L., V. J. Horncastle, and C. L. Chambers. 2018. Track plates detect the endangered New Mexico jumping mouse. Wildlife Society Bulletin 42:693–700.**

**Key words**: Arizona, detection, endangered species, New Mexico, noninvasive methods, survey methodology, track plate, *Zapus hudsonius luteus*, *Zapus luteus luteus*

**Abstract:** The New Mexico jumping mouse (*Zapus luteus luteus*, formerly *Z. hudsonius luteus*), an endangered subspecies found in the southwestern United States, inhabits riparian areas with tall, dense herbaceous vegetation as habitat. To detect presence of this species for use in defining life history and habitat use, we developed and tested 4 noninvasive track-plate methods, and selected the best for field use. New Mexico jumping mice have unique feet and toes that are readily distinguishable from other small mammals within their geographic range. We created reference photos of rodent tracks that confirmed the unique footprints of the jumping mouse and tested this method against detection with live traps in the Apache–Sitgreaves, Arizona, and Santa Fe, New Mexico, USA, National Forests, 2016 and 2017. When comparing the 2 detection methods, in only 1 of 16 comparisons did results differ, where we captured jumping mice in live traps, but did not detect them with track plates. Based on our success with this approach, we developed a 14-minute instructional video (https://www.youtube.com/watch?v=i2x0Ydc1XVM) on assembly, deployment, and interpretation of track plates. Although trapping provided specific information about individuals, the noninvasive nature of our track-plate design minimized risk of injury or mortality to animals and lowered study costs.

**DOI:** 10.1002/wsb.927

**Havstad, K. M., J. R. Brown, R. Estell, E. Elias, A. Rango, and C. Steele. 2018. Vulnerabilities of Southwestern U.S. Rangeland-based animal agriculture to climate change. *Climatic Change* 148:371–386.**

**Key words**: climate change, rangeland, degradation, surface water, arid, drought

**Abstract:** The Southwestern US is a five-state region that has supported animal agriculture since the late 16th Century when European settlers crossed the Rio Grande into present day west Texas and southern New Mexico with herds of cattle, sheep, goats and horses. For the past 400 years the rangeland livestock industry, in its many forms and manifestations, has developed management strategies and conservation practices that impart resilience to the climatic extremes, especially prolonged droughts, that are common and extensive across this region. Livestock production from rangelands in the southwest (SW) is adapted to low rainfall and high ambient temperatures, but will have to continue to adapt management strategies, such as reduced stocking rates, proper grazing management practices, employing animal genetics suited to arid environments with less herbaceous production, erosion control conservation practices, and alternative forage supplies, in an increasingly arid and variable climatic environment. Even though the aging demographics of western ranchers could be a deterrent to implementing various adaptations, there are examples of creative management coalitions to cope with climatic change that are emerging in the SW that can serve as instructive examples. More importantly, there are additional opportunities for incorporation of transformative practices and technologies that can sustain animal agriculture in the SW in a warmer environment. Animal agriculture in the SW is inherently resilient, and has the capacity to adapt and transform as needed to the climatic changes that are now occurring and will continue to occur across this region. However, producers and land managers will need to thoroughly understand the vulnerabilities and sensitivities that face them as well as the ecological characteristics of their specific landscapes in order to cope with the emerging climatic changes across the SW region.

**DOI:** 10.1007/s10584-016-1834-7

**Hopkins, A. A. 2018. Habitat Selection by Small Mammals in a Restored Wetland System. Purdue University, Fort Wayne, IN.**

**Key words**: wetlands, *Zapus*, microhabitat, restoration

**Abstract:** Wetland habitat loss has occurred throughout the United States resulting in a 53 percent loss by the 1980s. Due to this, governmental agencies and private organizations are working to restore wetland habitat. One such organization, Little River Wetlands Project, undertook one of the largest wetland restoration projects in Northeast Indiana. After the restoration project was completed in 2009, a biodiversity survey was conducted to inventory the species present. However, after the survey took place in 2014, no further monitoring of the small mammal community has been conducted at this restored wetland system. Diversity and abundances of small mammals in a restored wetland system were assessed to determine if a wetland restoration can host small mammal communities found in the region. Additionally, microhabitat characteristics were collected to ascertain their effects on habitat selection by small mammals. Four species of small mammals were captured including *Microtus pennsylvanicus, Blarina brevicauda, Peromyscus leucopus,* and *Zapus hudsonius.*A total of 110 individuals were caught during the three trapping cycles in five macrohabitats throughout Eagle Marsh. *Microtus pennsylvanicus*was the most abundant species with 61 captures while *Z. hudsonius* was the least abundant with one capture. Significant positive correlations were found between *B. brevicauda* abundance and organic litter depth and DBH. There were no significant correlations between *M. pennsylvanicus* nor *P. leucopus* abundances and microhabitat variables. Finding these species viii throughout Eagle Marsh confirms their life history traits as habitat generalists but demonstrates the need for continued monitoring of small mammals at Eagle Marsh.

**DOI:** Thesis

**Horwitz, R. J., D. H. Keller, P. F. Overbeck, S. P. Platania, R. K. Dudley, and E. W. Carson. 2018. Age and Growth of the Rio Grande Silvery Minnow, an Endangered, Short-Lived Cyprinid of the North American Southwest. *Transactions of the American Fisheries Society* 147:265–277.**

**Key words**: Rio Grande Silvery Minnow, population monitoring, otoliths, field standard lengths

**Abstract:** This study provides the first comprehensive evaluation of age and age–length relationships from an extant population of the federally endangered Rio Grande Silvery Minnow *Hybognathus* amarus. The surveyed population was from three fragmented reaches within about 290 km of the middle Rio Grande in New Mexico, the last protected population in the historical range of the species. A total of 158 Rio Grande Silvery Minnows were collected in autumn 2009 (n = 83) and spring 2010 (n = 75), with sampling designed to fill six 10-mm size-class bins that represent the size range characteristic of the juvenile and adult population. Age was then determined directly for each specimen independently by two investigators, each using otoliths and scales; growth rates were estimated via back-calculation of length at age from otoliths. The results confirm that individuals in the contemporary population are short-lived, with very few surviving to their second or third summers. For historical comparison, the ages of a small collection of Rio Grande Silvery Minnows taken in August 1874 were evaluated using scales. The specimens in this historical collection ranged from age 0 to age 2, similar to the age range for the autumn 2009 collection and incongruent with a previously published report of five age-classes (ages 1–5) for 13 of these specimens. Our results corroborate the age-structure derived from temporal tracking of length frequency histograms generated under the Rio Grande Silvery Minnow Population Monitoring Project and validate current management of the species as short-lived. Our age range and age–length relationships are also similar to those of other well-studied *Hybognathus* spp., and the results from our study may aid management of these closely related, short-lived pelagophil minnows. While additional research is needed to clarify the areas of age–length overlap, the crucial findings of this study should facilitate implementation of an appropriate management policy for this short-lived, federally endangered cyprinid.

**DOI:** 10.1002/tafs.10012

**Hultine, K. R., S. E. Bush, J. K. Ward, and T. E. Dawson. 2018. Does sexual dimorphism predispose dioecious riparian trees to sex ratio imbalances under climate change? *Oecologia* 187:921–931.**

**Key words**: Riparian cottonwoods, Riparian willows, Boxelder, Leaf gas exchange, Sex ratio bias

**Abstract:** Environmental changes have resulted in significant declines in native riparian forests that are comprised largely of dioecious tree taxa, including boxelder and iconic cottonwood/willow gallery forests. Dioecious species may be especially vulnerable to the effects of climate change given that they often exhibit skewed sex ratios that are reinforced by physiological and morphological specialization of each sex to specific microhabitats. A comprehensive data synthesis suggests that male individuals of boxelder and cottonwood taxa have a higher representation on dry microhabitats than females and are less physiologically sensitive to increased aridity than co-occurring females. Consequently, extreme male-biased sex ratios are possible under future climate conditions that could reduce population fitness below a sustainable threshold. Riparian willows, on the other hand, generally do not express obvious sexual dimorphism in habitat preference or physiological sensitivity to aridity. Thus, it is unclear whether climate change will impact population structure of willows in ways that parallel other dioecious riparian tree taxa. Future riparian tree restoration programs should aim to maintain future sex ratio balance that maximizes population fitness under projected hydro-climatological conditions. Recent advances in genomics will likely provide the critical tools for early sex determination in pre-reproductive trees across riparian tree species such that sex ratio balance could be targeted during initial stages of restoration, along with adaptations for drought tolerance and other key traits that are essential for survival under future conditions.

**DOI:** 10.1007/s00442-018-4190-7

**Hunter, M. E., S. M. Hoban, M. W. Bruford, G. Segelbacher, and L. Bernatchez. 2018. Next-generation conservation genetics and biodiversity monitoring. *Evolutionary Applications* 11:1029–1034.**

**Key words**: adaptive management, effective population size, genetic diversity, minimally invasive sampling, RAD-seq, single nucleotide polymorphisms

**Abstract:** This special issue of Evolutionary Applications consists of 10 publications investigating the use of next-generation tools and techniques in population genetic analyses and biodiversity assessment. The special issue stems from a 2016 Next Generation Genetic Monitoring Workshop, hosted by the National Institute for Mathematical and Biological Synthesis (NIMBioS) in Tennessee, USA. The improved accessibility of next-generation sequencing platforms has allowed molecular ecologists to rapidly produce large amounts of data. However, with the increased availability of new genomic markers and mathematical techniques, care is needed in selecting appropriate study designs, interpreting results in light of conservation concerns, and determining appropriate management actions. This special issue identifies key attributes of successful genetic data analyses in biodiversity evaluation and suggests ways to improve analyses and their application in current population and conservation genetics research.

**DOI:** 10.1111/eva.12661

**Hutson, A. M., L. A. Toya, and D. Tave. 2018. Determining preferred spawning habitat of the endangered Rio Grande silvery minnow by hydrological manipulation of a conservation aquaculture facility and the implications for management. *Ecohydrology* 11:e1964.**

**Key words**: *Hybognathus amarus*, hydrology, life history, response to flood, spawning habitat

**Abstract:** The endangered Rio Grande silvery minnow *(Hybognathus amarus*) was induced to spawn in both 2012 and 2013, using hydrological manipulation of a conservation aquaculture facility to create floodplain habitat. Fish responded to the flood by leaving the stream and entered both deep (20–97 cm) and shallow (14–18 cm) low-velocity off-channel habitats, spawning in the deep ones; fish did not spawn in the stream. When water level was brought down from flood stage, fry actively moved into the stream 2.5 weeks postspawn. This study supports the hypothesis that this species is a floodplain spawner. The results show that habitat restoration of the Rio Grande to create floodplains is needed for recovery of this species as floodplains are both spawning and nursery habitats. The study provides guidelines about how deep floodplain inundation must inundate for spawning to occur and for the duration of inundation so fry can actively swim with the water when flood waters recede. This project also shows that a conservation facility can be used for all stages of fish's life history. Equally important, it shows that a conservation aquaculture facility can be used to conduct hydrological experiments to determine how an endangered fish will respond to changes in river management.

**DOI:** 10.1002/eco.1964

**Jamison, L. R., M. J. Johnson, D. W. Bean, and C. van Riper III. 2018. Phenology and Abundance of Northern Tamarisk Beetle, *Diorhabda carinulata* Affecting Defoliation of *Tamarix*. *Southwestern Entomologist* 43:571–585.**

**Key words**: *Tamarix*, *Diorhabda carinulata*, defoliation, diapause

**Abstract:** Timing and spatial dynamics of tamarisk (*Tamarix* spp. L.) defoliation by the biological control agent *Diorhabda carinulata* (Desbrochers) were evaluated. Relative abundance of *D. carinulata* and the phenology of tamarisk along the San Juan and Colorado rivers were recorded in 2011–2012. D. carinulata began reproducing in the spring when temperatures were >15°C. Variation in spring temperature-rise affected the timing of development of larvae of the first summer generation and initial defoliation of tamarisk at each site. Shortening day lengths in mid- to late-summer cued *D. carinulata* to enter reproductive diapause resulting in cessation of defoliation. The critical day length for inducing reproductive diapause was 33–47 minutes shorter than that of populations of *D. carinulata* released into North America in 2001. Variation in spring temperature-rise combined with timing of shortening day length resulted in differences in *D. carinulata* voltinism per site. During the active season, larvae were less likely to establish in areas where defoliation was >70%. Lack of reestablishment of larvae led to temporary loss of *D. carinulata* from the locations and allowed tamarisks to sprout new canopies. Defoliation of tamarisk was dictated by environmental cues and abundance of *D. carinulata*, and in turn large amounts of defoliation negatively affected abundance of *D. carinulata*.

**DOI:** 10.3958/059.043.0302

**Jamison, L. R., and C. van Riper III. 2018. Population Dynamics of the Northern Tamarisk Beetle (*Diorhabda carinulata*) in the Colorado River Basin. Open-File Report, U.S. Geological Survey.**

**Key words**:*Tamarix*, tamarisk beetle, defoliation, Colorado River

**Abstract:**

Chapter 1: The Influence of *Tamarix ramosissima* Defoliation on Population Movements of the Northern Tamarisk Beetle (*Diorhabda carinulata*) on the Colorado Plateau

The northern tamarisk beetle (*Diorhabda carinulata*) was introduced into the Colorado River basin on the Colorado Plateau in 2004 in an effort to control invasive/exotic tamarisk (*Tamarix ramosissima*) plants. Since the initial release, rapid beetle colonization and subsequent defoliation of tamarisk have occurred along the Colorado River corridor. We collected plant phenology and beetle abundance data from the Dolores and San Juan Rivers, two major tributaries of the Colorado River, to document tamarisk defoliation and beetle movement patterns. We observed that *D. carinulata* population movement patterns are strongly influenced by the availability of food resources and local beetle “boom and bust” events appear to be common. Beetles defoliated from 35 to 65 kilometers (km) of river-corridor tamarisk habitat each year. After intensive tamarisk defoliation of large riparian reaches, beetles displayed a pattern of temporary abandonment with recolonization of that same habitat in the subsequent year. Larvae appeared primarily in areas of partial defoliation, whereas adults appeared throughout the river corridor but most commonly on the leading edge of defoliated reaches. Understanding this type of beetle behavior and movement patterns will be useful in the management of both areas where *D. carinulata* has already been established and areas that it has not yet colonized. It will also assist land managers to better understand how defoliation and the presence of *D. carinulata* affect tamarisk-dominated habitats within Colorado Plateau riparian ecosystems.

**Abstract:**

Chapter 2: Utilizing Temperature, Day Length, and *Diorhabda carinulata* Geographic Distribution for Predicting the Intensity of *Tamarix* Species Defoliation

We have investigated the spatial dynamics and timing of defoliation of tamarisk (*Tamarix* spp.) by the biological control agent *Diorhabda carinulata* at three sites along the Colorado River and its tributaries. We determined that the location and timing of defoliation were predictable on the basis of (1) abiotic cues for *D. carinulata* activity, (2) spatial distributions and abundances of *D. carinulata* across each study site, and (3) movement *of D. carinulata* as a result of available tamarisk foliage. We found that average spring temperatures >15 °C related to how soon D. carinulata began reproducing and defoliation occurred at a study site, leading to variations in voltinism rates of *D. carinulata*. The critical day length for inducing diapause in *D. carinulata* at our study sites was 33–47 minutes shorter than that of populations first released in North America in 2001, suggesting adaptation in response to abiotic cues. We noted a significant positive correlation between the spatial distributions of *D. carinulata* populations in the fall and those of the first generation of larvae in the next spring, suggesting that the areas of defoliation as a result of abundant larval populations could be predicted in advance. We found a significant decrease in *D. carinulata* populations in areas that were 50-percent defoliated relative to those that were 100-percent defoliated, indicating that *D. carinulata* will abandon areas once defoliation levels become high. We also measured that the main *D. carinulata* population area at one study site grew by 19.3±5.6 kilometers (km) and that the overall range of this population at that study site grew by 62.8±5.6 km over 1 year along a linear riparian corridor. These results will enable conservationists to better understand the timing of defoliation events across a landscape and provide a rationale to forecast tamarisk defoliation in areas colonized by *D. carinulata.*

**DOI:** Report

**Johnson, R Roy, E. E. Johnson, and S. W. Carothers. 2018. Chapter 11. Terrestrial Vertebrates of Mesquite Bosques in Southwestern North America. Page 24 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: riparian, species richness, vertebrate fauna, population densities, bosque, cottonwood

**Summary:** The importance of mesquite bosques to the riparian fauna and flora of lowlands of the western United States cannot be overemphasized and in recent times there has been an ever-increasing effort toward stream restoration (Appendix B; Carothers et al. 1974; Stanley et al., in prep.) and reestablishment of cottonwood-willow riparian gallery forests. There has, however, been a general lack of effort toward reestablishment of riparian mesquite bosques. An online search found several references to planting cottonwoods and willows to reestablish riparian forests, including a 22-page manual published by the Natural Resources Conservation Service (Hoag 2007). Contrastingly, the only online references to planting of mesquites were as ornamentals or as urban shade trees. Until there is equal emphasis on reestablishment of mesquite bosques as well as cottonwood-willow riparian gallery forests, there will be a continuing, and possibly increasing, loss in biodiversity of riparian vertebrate faunas of the lowlands of the western United States.

**DOI:** Book chapter

**Johnson, R. Roy, S. W. Carothers, D. M. Finch, K. J. Kingsley, and J. T. Stanley, editors. 2018. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: riparian, fire, climate change, watershed, drought, ecosystem

**Abstract:** Fifty years ago, riparian habitats were not recognized for their extensive and critical contributions to wildlife and the ecosystem function of watersheds. This changed as riparian values were identified and documented, and the science of riparian ecology developed steadily. Papers in this volume range from the more mesic northwestern United States to the arid Southwest and Mexico. More than two dozen authors—most with decades of experience—review the origins of riparian science in the western United States, document what is currently known about riparian ecosystems, and project future needs. Topics are widespread and include: interactions with fire, climate change, and declining water; impacts from exotic species; unintended consequences of biological control; the role of small mammals; watershed response to beavers; watershed and riparian changes; changes below large dams; water birds of the Colorado River Delta; and terrestrial vertebrates of mesquite bosques. Appendices and references chronicle the field’s literature, authors, “riparian pioneers,” and conferences.

**DOI:** 10.2737/RMRS-GTR-377

**Kui, L., J. C. Stella, R. M. Diehl, A. C. Wilcox, A. Lightbody, and L. S. Sklar. 2018. Can environmental flows moderate riparian invasions? The influence of seedling morphology and density on scour losses in experimental floods. *Freshwater Biology*.**

**Key words:** biogeomorphic feedback, invasive species, plant uprooting, riparian seedlings,

river point bar

**Abstract:** Environmental flow releases are an effective tool to meet multiple management objectives, including maintaining river conveyance, restoring naturally functioning riparian plant communities, and controlling invasive species. In this context, predicting plant mortality during floods remains a key area of uncertainty for both river managers and ecologists, particularly with respect to how flood hydraulics and sediment dynamics interact with the plants’ own traits to influence their vulnerability to scour and burial.

To understand these processes better, we conducted flume experiments to quantify different plant species’ vulnerability to flooding across a range of plant sizes, patch densities, and sediment condition (equilibrium transport versus sediment deficit), using sand‐bed rivers in the U.S. southwest as our reference system. We ran 10 experimental floods in a 0.6 m wide flume using live seedlings of cottonwood and tamarisk, which have contrasting morphologies.

Sediment supply, plant morphology, and patch composition all had significant impacts on plant vulnerability during floods. Floods under sediment deficit conditions, which typically occur downstream of dams, resulted in bed degradation and a 35% greater risk of plant loss compared to equilibrium sediment conditions. Plants in sparse patches dislodged five times more frequently than in dense patches. Tamarisk plants and patches had greater frontal area, larger basal diameter, longer roots, and lower crown position compared to cottonwood across all seedling heights. These traits were associated with a 75% reduction in tamarisk seedlings’ vulnerability to scour compared to cottonwood.

*Synthesis and applications*. Tamarisk's greater survivability helps to explain its vigorous establishment and persistence on regulated rivers where flood magnitudes have been reduced. Furthermore, its documented influence on hydraulics, sediment deposition, and scour patterns in flumes is amplified at larger scales in strongly altered river channels where it has broadly invaded. Efforts to remove riparian vegetation using flow releases to maintain open floodways and/or control the spread of non‐native species will need to consider the target plants’ size, density, and species‐specific traits, in addition to the balance of sediment transport capacity and supply in the river system.

**DOI:** 10.1111/fwb.13235

**Lai, J. 2018. U.S. Fish and Wildlife Service Summer Fellowship: GIS Study of Threatened and Endangered Species in Colorado.**

**Key words**: endangered species, area of influence, Southwestern Willow Flycatcher, Preble’s Meadow Jumping Mouse, Yellow-billed Cuckoo

**Task 4**: The last listed species I worked on was the threatened Preble’s Meadow Jumping Mouse

(PMJM), tasked with creating a conservation potential map of this species. Preble’s mouse inhabits well-developed riparian habitats with adjacent relatively undisturbed grassland communities (ECOS). They regularly use uplands at least as far out as 100 meters beyond the

100-yr flood plain, and have limited dispersal (ECOS). This work serves as preliminary grounds for future conservation potential mapping methodologies.

**DOI:** Master’s paper

**Lee, S.-R., Y.-S. Jo, C.-H. Park, J. M. Friedman, and M. S. Olson. 2018. Population genomic analysis suggests strong influence of river network on spatial distribution of genetic variation in invasive saltcedar across the southwestern United States. *Molecular Ecology* 27:636–646.**

**Key words**: invasive species, landscape genomics, population structure, range expansion, *Tamarix*

**Abstract:** Understanding the complex influences of landscape and anthropogenic elements that shape the population genetic structure of invasive species provides insight into patterns of colonization and spread. The application of landscape genomics techniques to these questions may offer detailed, previously undocumented insights into factors influencing species invasions. We investigated the spatial pattern of genetic variation and the influences of landscape factors on population similarity in an invasive riparian shrub, saltcedar (*Tamarix* L.) by analysing 1,997 genomewide SNP markers for 259 individuals from 25 populations collected throughout the southwestern United States. Our results revealed a broad-scale spatial genetic differentiation of saltcedar populations between the Colorado and Rio Grande river basins and identified potential barriers to population similarity along both river systems. River pathways most strongly contributed to population similarity. In contrast, low temperature and dams likely served as barriers to population similarity. We hypothesize that large-scale geographic patterns in genetic diversity resulted from a combination of early introductions from distinct populations, the subsequent influence of natural selection, dispersal barriers and founder effects during range expansion.

**DOI:** 10.1111/mec.14468

**Macfarlane, W. W., J. T. Gilbert, J. D. Gilbert, W. C. Saunders, N. Hough-Snee, C. Hafen, J. M. Wheaton, and S. N. Bennett. 2018. What are the Conditions of Riparian Ecosystems? Identifying Impaired Floodplain Ecosystems across the Western U.S. Using the Riparian Condition Assessment (RCA) Tool. *Environmental Management* 62:548–570.**

**Key words**: Conservation planning, Riparian restoration, Watershed condition assessment, Riparian degradation, Floodplain ecology, Columbia River Basin, Utah

**Abstract:** Environmental stressors associated with human land and water-use activities have degraded many riparian ecosystems across the western United States. These stressors include (i) the widespread expansion of invasive plant species that displace native vegetation and exacerbate streamﬂow and sediment regime alteration; (ii) agricultural and urban development in valley bottoms that decouple streams and rivers from their ﬂoodplains and reduce instream wood recruitment and retention; and (iii) ﬂow modiﬁcation that reduces water quantity and quality, degrading aquatic habitats. Here we apply a novel drainage network model to assess the impacts of multiple stressors on reach-scale riparian condition across two large U.S. regions. In this application, we performed a riparian condition assessment evaluating three dominant stressors: (1) riparian vegetation departure from historical condition; (2) land-use intensity within valley bottoms; and (3) ﬂoodplain fragmentation caused by infrastructure within valley bottoms, combining these stressors in a fuzzy inference system. We used freely available, geospatial data to estimate reach-scale (500 m) riparian condition for 52,800 km of perennial streams and rivers, 25,600 km in Utah, and 27,200 km in 12 watersheds of the interior Columbia River Basin (CRB). Model outputs showed that riparian condition has been at least moderately impaired across ≈70% of the streams and rivers in Utah and ≈49% in the CRB. We found 84% agreement (Cohen’s ĸ = 0.79) between modeled reaches and ﬁeld plots, indicating that modeled riparian condition reasonably approximates on-the-ground conditions. Our approach to assessing riparian condition can be used to prioritize watershed-scale ﬂoodplain conservation and restoration by providing network-scale data on the extent and severity of riparian degradation. The approach that we applied here is ﬂexible and can be expanded to run with additional riparian stressor data and/or ﬁner resolution input data.

**DOI:** 10.1007/s00267-018-1061-2

**Mahoney, J. L., P. E. Klug, and W. L. Reed. 2018. An assessment of the US endangered species act recovery plans: using physiology to support conservation. *Conservation Physiology* 6.**

**Key words**: Conservation physiology, Endangered Species Act, physiology, review

**Abstract:** Applying physiology to help solve conservation problems has become increasingly prominent. It is unclear, however, if the increased integration into the scientiﬁc community has translated into the application of physiological tools in conservation planning. We completed a review of the use of animal physiology in the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) Endangered Species Act (ESA) recovery plans released between 2005 and 2016. Over those 11 years, 135 of the 146 recovery plans mentioned physiology, with 56% including it as background information on the natural history of the species and not as part of the recovery process. Fish and bird species had the lowest proportion of recovery plans to include physiology beyond the description of the natural history. When considering multiple sub-disciplines of physiology, immunology and epidemiology were incorporated as part of the recovery process most often. Our review suggests a disconnect between available physiological tools and the potential role of physiology in developing conservation plans. We provide three suggestions to further guide conservation scientists, managers and physiologists to work synergistically to solve conservation problems: (1) the breadth of knowledge within a recovery plan writing team should be increased, for example, through increased training of federal scientists in new physiology methodologies and tools or the inclusion of authors in academia that have a background in physiology; (2) physiologists should make their research more available to conservation scientists and federal agencies by clearly linking their research to conservation and (3) communication should be enhanced between government conservation scientists and physiologists.

**DOI:** 10.1093/conphys/coy036

**Mahoney, S. M., J. B. Mike, J. M. Parker, L. S. Lassiter, and T. G. Whitham. 2019. Selection for genetics-based architecture traits in a native cottonwood negatively affects invasive tamarisk in a restoration field trial. *Restoration Ecology* 27:15–22.**

**Key words**: common garden, *Populus fremontii*, restoration, *Tamarix* spp., tree architecture

**Abstract:** Climate change and competition from invasive species remain two important challenges in restoration. We examined the hypothesis that non-native tamarisk (*Tamarix* spp.) reestablishment after aboveground removal is affected by genetics-based architecture of native Fremont cottonwood (*Populus fremontii*) used in restoration. As cottonwood architecture (height, canopy width, number of stems, and trunk diameter) is, in part, determined by genetics, we predicted that trees from different provenances would exhibit different architecture, and mean annual maximum temperature transfer distance from the provenances would interact with the architecture to affect tamarisk. In a common garden in Chevelon, AZ, U.S.A. (elevation 1,496 m), with cottonwoods from provenances spanning its elevation distribution, we measured the performance of both cottonwoods and tamarisk. Several key findings emerged. On average, cottonwoods from higher elevations were (1) two times taller and wider, covered approximately 3.5 times more basal area, and were less shrubby in appearance, by exhibiting four times fewer number of stems than cottonwoods from lower elevations; (2) had 50% fewer tamarisk growing underneath, which were two times shorter and covered 6.5 times less basal area than tamarisk growing underneath cottonwoods of smaller stature; and (3) the number of cottonwood stems did not affect tamarisk growth, possibly because the negative relationship between cottonwood stems and basal area. In combination, these findings argue that cottonwood architecture is affected by local conditions that interact with genetics-based architecture. These interactions can negatively affect the growth of reinvading tamarisk and enhance restoration success. Our study emphasizes the importance of incorporating genetic and environmental interactions of plants used in restoration.

**DOI:** 10.1111/rec.12840

**Mason, C. M. 2018. How Old Are Sunflowers? A Molecular Clock Analysis of Key Divergences in the Origin and Diversification of *Helianthus* (Asteraceae). International Journal of Plant Sciences 179:182–191.**

**Key words**: dating, divergence time, *Helianthus*, molecular clock, sunflower

**Abstract:** Premise of research. For many questions in evolutionary ecology, it is quite valuable to have an estimate of the span of geologic time over which a group of species has arisen and diversiﬁed. This study uses a molecular clock approach to generate a ﬁrst estimate of key divergences in the evolutionary history of the genus *Helianthus*, which to date has lacked such an estimate.

Methodology. Divergence time analysis was performed with well-resolved phylogenies of Asteraceae and *Helianthus* in a stepping-stone manner using the RelTime maximum likelihood method with a variety of available macrofossil, fossil pollen, and molecular clock calibrations derived from the literature.

Pivotal results. Mean estimates from nine individual calibration scenarios time the divergence of *Helianthus* from the sister genus *Phoebanthus* at between 2.47 and 5.41 Ma. Composite calibration incorporating all literature estimates time this divergence at 3.63 Ma, with a 95% conﬁdence interval spanning 0–8.26 Ma. Subsequent diversiﬁcation within *Helianthus* is therefore conﬁned to the last few million years.

Conclusions. These ﬁndings place the origin and diversiﬁcation of *Helianthus* into the temporal context of the Pliocene expansion of open habitats across North America and the subsequent vegetation ﬂuctuations of the Pleistocene glacial-interglacial cycles.

**DOI:** 10.1086/696366

**McLeod, M. A. 2018. Chapter 5. Unintended Consequences: Tamarisk Control and Increasing Threats to the Southwestern Willow Flycatcher. Page 23 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: riparian, Southwestern Willow Flycatcher, tamarisk, tamarisk leaf beetle, defoliation

**Long-Term Prospects:** Beetles are expected to be eventually found in all areas of North America that have tamarisk (Bean et al. 2013), and these areas completely overlap the breeding range of the southwestern willow flycatcher. In the long term, tamarisk biocontrol may have exactly the effect on tamarisk that its proponents advertised: reducing the density of tamarisk by up to 85 percent. The authors of the 1998 biocontrol proposal suggested this would “reduce the abundance of saltcedar to below the level where it causes important damage to western riparian ecosystems.” At this level of suppression, however, tamarisk would also no longer provide much ecological value. Recovery of native vegetation is unlikely to occur in many areas that will be affected by the tamarisk beetle, and in these places, biocontrol will result in a long-term reduction in habitat quality.

Tamarisk is a symptom as well as a cause of the degradation of riparian ecosystems, and removing the tamarisk does not address the underlying changes that limit native riparian species and allow tamarisk to proliferate. The Flycatcher Recovery Team identified this concern early on and reiterated it in the letter sent to the Regional Director of the USFWS in 1998 expressing their concerns about the proposed beetle releases, pointing out that without extensive regional changes in the management of water and land, existing conditions would continue to preclude the establishment of native riparian vegetation.

The long-term effects of tamarisk beetles on vegetation conditions are likely to vary widely between river systems and between reaches, depending on the prevalence of tamarisk and on the many factors, such as flood regimes, groundwater levels, and soil and water salinity, that influence whether native riparian vegetation can become established and persist. The fact that some of the largest flycatcher populations occur in sites dominated by tamarisk makes the flycatcher, among riparian obligate wildlife, particularly susceptible to the detrimental effects of tamarisk beetles. Based on the observed responses of flycatchers to tamarisk defoliation, flycatcher productivity will almost certainly decrease immediately following the arrival of beetles in any area where flycatchers nest in vegetation with a significant tamarisk component, including at Elephant Butte Reservoir and on the Gila River.

Whether beetles cause a long-term reduction in, or even extirpation of, the flycatcher population in these areas remains to be seen. The health, and possibly persistence, of flycatcher populations in reaches that can still support native vegetation may depend on active restoration of native vegetation prior to and immediately following the arrival of beetles. Even beetle researchers have recently acknowledged that defoliation and subsequent dieback of tamarisk can have adverse effects on flycatchers, including in stands that are not dominated by tamarisk (Tracy et al. 2014). Researchers have advocated restoration efforts in advance of the arrival of beetles (Tracy 2014).

Beetle proponents and opponents differ, often passionately, on whether tamarisk biocontrol was a good idea, but both sides ostensibly have the same goal: the preservation and improvement of riparian health. Now that the beetle has been set loose and is spreading rapidly, the common focus should be on mitigating the detrimental effects and maximizing the beneficial results of the inevitable arrival of beetles. The lawsuit that was filed in 2013 against APHIS and the USFWS by CBD and Maricopa Audubon Society sought, in part, a declaration that the defendants had violated the Endangered Species Act and the development of “an appropriate mitigation plan to address the impacts of the beetle populations on flycatchers and their critical habitat.” The District Court found that APHIS was in violation of section 7(a)(1) of the Endangered Species Act, which requires Federal agencies to take actions to preserve endangered species (Center for Biological Diversity et al. v Vilsack et al., Dkt. 87), and issued a remedial order instructing the defendants to take several measures, including considering funding intensive third-party restoration efforts (Center for Biological Diversity et al. v Vilsack et al., Dkt. 104).

Flycatchers have received much attention because of their status as a Federally endangered species, but they are, of course, not the only species affected by tamarisk defoliation. A study of riparian-nesting birds on the Virgin River showed that species richness and abundance were higher in 2009 and 2010, prior to the arrival of beetles, than they were in 2013, after 2 or 3 years of defoliation, with yellow warblers (*Setophaga petechia*) being particularly affected (Johnson 2015). Similarly, herpetofauna were less abundant after defoliation in both monotypic tamarisk and stands of mixed vegetation (Bateman et al. 2014). No study of riparian-nesting birds has been undertaken to compare the pre- and post-beetle nest success of species other than the flycatcher.

For the sake of all riparian obligate wildlife, restoration of native vegetation is urgently needed wherever tamarisk constitutes a significant portion of the woody riparian vegetation and the arrival of beetles is imminent or has already occurred. Restoration is often costly and labor intensive, and it will likely be prohibitively so in places where soil treatments are needed or depth to groundwater is such that irrigation would be required in perpetuity. Restoring habitat where flycatchers can nest successfully is even more difficult, given their propensity to select dense vegetation close to surface water.

One strategy in places where beetles are already present is to target monotypic or mixed tamarisk stands that supported breeding flycatchers prior to the arrival of beetles. These stands likely still have the same surface water conditions that attracted breeding flycatchers but no longer have suitably dense vegetation. This strategy has been employed around St. George, and two successful flycatcher nests were located in one of the restored areas in 2017 (Christian Edwards, Utah Division of Wildlife Resources, personal communication, September 11, 2017). Prior to the arrival of beetles, restoration efforts should target sites that can support dense vegetation in proximity to breeding flycatchers, as nearby sites are the most likely to be colonized. This approach is being used on the Gila River in the Safford Valley. Either approach requires careful planning and close coordination with the USFWS. These strategies represent a change from more traditional flycatcher management, which required avoiding nesting sites and their surroundings, but this kind of proactive management may be critical to the long-term success of the southwestern willow flycatcher.

**DOI:** Book chapter

**Mellink, E., and O. Hinojosa-Huerta. 2018. Chapter 10. Breeding Waterbirds of the Mexican Portion of the Colorado River Delta. Page 14 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: Colorado River, habitat degradation, riparian, wetlands, waterbirds, dams, marshes

**Restoration and Conservation Actions:** One of the key strategies to restore waterbird habitat has included securing water sources for the different wetland areas in the delta. This has involved securing the effluent of wastewater plants as instream flows, maintaining the agricultural return flows to the wetlands, and the dedication of irrigation water rights to restore key areas (Hinojosa-Huerta and Carrillo-Guerrero 2010; Zamora-Arroyo et al. 2008). The Colorado River corridor has recently received allocated flows for ecological restoration under Minute 319 of the International Water Treaty, securing 195 million cubic meters of water on a 5-year period (2012–2017), with one-third of the water provided by Mexico, one-third by the United States, and one-third by a binational coalition of environmental organizations (Gerlak 2015). Part of this water (130 million cubic meters) was delivered as a “pulse flow” during 2014, to revitalize the delta ecosystem, to promote the greening-up of the existing vegetation and the germination of new native plants, and to learn more about the hydrological and biological response of the system (Flessa et al. 2013). Since then, and until 2017, the rest of the water (65 million cubic meters) is being delivered as “base flows” at critical areas of the corridor, to maintain the habitat that has been restored (Flessa et al. 2013).

These efforts have been coupled with intensive restoration actions in specific locations along the riparian corridor, where the intervention includes clearing exotic vegetation, grading the land, establishing native plants, and adding water to sustain the new vegetation and create open water zones (Hinojosa-Huerta et al. 2005). Between 2008 and 2014, a total of 337 ha has been restored and maintained.

Part of the efforts in the delta also includes the implementation of land conservation strategies. One of the earliest achievements was the establishment of the Upper Gulf of California and Colorado River Delta Biosphere Reserve, which protects the Ciénega de Santa Clara, El Doctor Wetlands, Laguna del Indio, and the mudflats near the mouth of the river. To complement the public conservation efforts implemented by the Mexican government with the Biosphere Reserve, environmental organizations have established conservation easement agreements with landowners in key wetlands (Ciénega de Santa Clara and El Doctor) to protect priority habitat for endangered and migratory species. A total of 1,200 ha has been protected under this mechanism in the delta.

**DOI:** Book chapter

**Mu, J. E., and J. R. Ziolkowska. 2018. An integrated approach to project environmental sustainability under future climate variability: An application to U.S. Rio Grande Basin. *Ecological Indicators* 95:654–662.**

**Key words**: environmental sustainability, climate change, integrated approach, ecological footprint analysis, econometric regressions

**Abstract:** Extreme weather events have been affecting local environmental sustainability. Previous literature in this field evaluates environmental sustainability based mainly on past and current resource consumption and availability, however, knowledge about the status and potential changes of environmental sustainability under future climate extremes is missing. This paper proposes an integrated approach (combining the Ecological Footprint Analysis with econometric regressions) to predict future environmental sustainability under different climate scenarios. Based on the case study of the U.S. Rio Grande Basin, the results show that this region has been sustainable in 1982–2012, although sustainability levels have been declining over time. In addition, projections for the future show that the entire region will most likely move away from sustainability by the end of this century under the high emission scenario (e.g., RCP8.5). These findings are relevant for sustainable resource management and allocation of local environmental resources as well as for decision-making support regarding climate risk adaptation and mitigation strategies.

**DOI:** 10.1016/j.ecolind.2018.07.066

**Mubako, S., O. Belhaj, J. Heyman, W. Hargrove, and C. Reyes. 2018. Monitoring of Land Use/Land-Cover Changes in the Arid Transboundary Middle Rio Grande Basin Using Remote. *Remote Sensing* 10:2005.**

**Key words**: transboundary; arid; water resources; urbanization; agriculture; land use; land cover; environmental impacts

**Abstract:** Expanding urbanization in highly fragile desert environments requires a thorough understanding of the current state and trends of land uses to achieve an optimal balance between development and the integrity of vital ecosystems. The objectives of this study are to quantify land use change over the 25-year period 1990–2015 and analyze temporal and spatial urbanization trends in the Middle Rio Grande Basin. We conclude by indicating how the results can inform on-going water resource research and public policy discussion in an arid region. Results show that the predominant upland mixed vegetation land cover category has been steadily declining, giving up land to urban and agricultural development. Urban development across the region of interest increased from just under three percent in 1990 to more than 11 percent in 2015, mainly around the major urban areas of El Paso, Ciudad Juárez, and Las Cruces. Public policy aspects related to results from this study include transfer of water rights from agriculture to land developers in cities, higher risk of flooding, loss of natural ecosystems, and increased water pollution from point and non-point sources. Various stakeholders can find the study useful for a better understanding of historical spatial and temporal aspects of urban development and environmental change in arid regions. Such insights can help municipal authorities, farmers, and other stakeholders to strike a balance between development needs and protecting vital ecosystems that support the much needed development, especially in regions that are endowed with transboundary natural resources that often are incompletely represented in single nation data.

**DOI:** 10.3390/rs10122005

**Murray, M. 2018. Mapping Rio Grande Water Rights: Duke University.**

**Key words**: The Nature Conservancy, water markets, water rights, Rio Grande

**EXECUTIVE SUMMARY:** For centuries, scant water supplies dictated settlement patterns and life cycles in Far West Texas. Life depended on close proximity to the few water bodies, with the remaining space left vast and deserted. However, modern water technologies like dams, reservoirs, and aqueducts have allowed the desert to bloom. Cities along the Rio Grande continue to grow. Large swaths of landscape are now perpetually green with rows of produce. While the region has prospered from these innovations, the environment has suffered. There are long segments of the Rio Grande that consistently have no flow, nicknamed the “Forgotten Reach.” Numerous species in the region are considered threatened or endangered under the Endangered Species Act. The river is in peril and so too are the people who depend on it.

 The implications of the failing ecosystem have not gone unnoticed. Regional stakeholders have attempted to remedy the manifold issues through various task forces, basin assessments, initiatives, and outreach programs. However, these initiatives can only go so far. The real issue at hand is that there is simply not enough water to go around. Fierce competition for water between municipalities, agriculture, and industry leaves little room for nature. Unfortunately, the problem cannot be fixed with more dams and reservoirs, a solution that has been championed in the past. Thus, it necessary for this water-scarce region to rethink the way it manages its water resources.

One management solution is the use of water markets. If set up correctly, water markets have the potential to stimulate water savings, improve water’s productivity and allocation efficiency, and return water to nature. The Nature Conservancy is particularly interested in water markets’ capability to return water to nature. The Nature Conservancy of Texas (TNC-Texas) and TNC (TNC-Global) are pursing efforts to identify and acquire water rights that could be dedicated or in other ways managed for the benefit and protection of environmental flows. Due to recent alliances and funding streams, TNC is particularly interested in water rights in the Lower Pecos and Upper Rio Grande watersheds, sub-watersheds of the Rio Grande in Far West Texas.

Before any transactions are made, The Nature Conservancy must determine which water rights they are interested in acquiring. TNC has been working on a water rights mapping platform that allows them to assess how much water is left in the river after the initial diversion, where the return flows go, and if purchased water will reach TNC’s designated priority streams. However, this analysis is limited when water rights are not in the correct location. Thus, this project remedied these inaccuracies in the Lower Pecos and Upper Rio Grande by moving the water right to the correct location.

The resulting products are a static map and web application version that contain the water rights along with other important features like watershed boundaries, water monitoring stations, priority stream segments, and endangered species’ ranges. With water rights in the correct location, it is possible to characterize how water is used in the region and by whom. This report highlights the major water users in each watershed and explains their operations in detail. The Nature Conservancy intends to use the map and supporting documentation as a decision support tool for their ecosystem restoration projects.

While the who, what, and where of water use are important factors, The Nature Conservancy must also examine the nuances of water markets prior to their participation. Water markets are inherently complicated and controversial due to the legal framework as well due to negative community perceptions. This report emphasizes some of the key legal and third-party considerations TNC should evaluate as part of their decision analysis. Through careful consideration of all relevant factors, TNC can work to overcome these obstacles and acquire water rights for their ecosystem rehabilitation work.

**DOI:** Thesis

**Nagler, P. L., U. Nguyen, H. L. Bateman, C. J. Jarchow, E. P. Glenn, W. J. Waugh, and C. van Riper III. 2018. Northern tamarisk beetle (*Diorhabda carinulata*) and tamarisk (*Tamarix* spp.) interactions in the Colorado River basin. *Restoration Ecology* 26:348–359.**

**Key words**: biological control, Colorado Plateau, *Diorhabda*, endangered species, remote sensing, riparian evapotranspiration, saltcedar

**Abstract:** Northern tamarisk beetles (*Diorhabda carinulata*) were released in the Upper Colorado River Basin in the United States in 2004–2007 to defoliate introduced tamarisk shrubs (*Tamarix* spp.) in the region's riparian zones. The primary purpose was to control the invasive shrub and reduce evapotranspiration (ET) by tamarisk in an attempt to increase stream flows. We evaluated beetle–tamarisk interactions with MODIS and Landsat imagery on 13 river systems, with vegetation indices used as indicators of the extent of defoliation and ET. Beetles are widespread and exhibit a pattern of colonize–defoliate–emigrate, so that riparian zones contain a mosaic of completely defoliated, partially defoliated, and refoliated tamarisk stands. Based on satellite data and ET algorithms, mean ET before beetle release (2000–2006) was 416 mm/year compared to postrelease (2007–2015) ET of 355 mm/year (p < 0.05) for a net reduction of 61 mm/year. This is lower than initial literature projections that ET would be reduced by 300–460 mm/year. Reasons for the lower-than-expected ET reductions are because baseline ET rates are lower than initially projected, and percentage ET reduction is low because tamarisk stands tend to regrow new leaves after defoliation and other plants help maintain canopy cover. Overall reductions in tamarisk green foliage during the study are 21%. However, ET in the Upper Basin has shown a steady decline since 2007 and equilibrium has not yet been reached. Defoliation is now proceeding from the Upper Basin into the Lower Basin at a rate of 40 km/year, much faster than initially projected.

**DOI:** 10.1111/rec.12575

**Osborne, M. J., and T. F. Turner. 2018. Genetic Monitoring of the Rio Grande Silvery Minnow: Genetic Status of Wild and Captive Stocks in 2018. Annual Report, Department of Biology and Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM.**

**Key words**: genetic diversity, monitoring, Rio Grande, Silvery Minnow, brookstock, microsatellite, mitochondrial DNA

**Executive Summary:** We have conducted genetic monitoring of the Middle Rio Grande population of Rio Grande Silvery Minnow annually from 1999-2012 and resumed monitoring from 2014 through 2018. This work has included monitoring stocks that were bred or reared in captivity and released to the Rio Grande in New Mexico since 2002 at the commencement of the augmentation program. Genetic monitoring was based on genotyping 443 ‘wild’ Rio Grande Silvery Minnow collected (in December 2017 – February 2018) in all three occupied reaches of the Middle Rio Grande, and progeny of captive stocks from Southwestern Native Aquatic Resources and Recovery Center (n=399) and Albuquerque Biological Park (n=50). These fish comprise the potential breeding population in 2018. In 2018, we also genotyped broodstock used to produce fish for release in fall of 2018, from Southwestern ARRC and Albuquerque Biological Park.

**DOI:** Report

**Parker, S., J. Moore, and L. Warren. 2018. Ecological values of the Amargosa River in California. Unpublished Report, The Nature Conservancy, Los Angeles, CA.**

**Key words**: Amargosa River, Mojave Desert, biodiversity, aquatic habitats, conservation, groundwater, riparian, Southwestern Willow Flycatcher, Yellow-billed Cuckoo, wetlands

**Executive Summary:** The 185 mile-long Amargosa River, one of only two rivers with perennial flow in the California portion of the Mojave Desert, is fed by an ancient carbonate groundwater aquifer. The aquatic habitats of the Amargosa River Watershed provide habitat for hundreds of organisms, including a unique suite of rare, endemic, and imperiled species. For nearly 50 years, the conservation of the waters, landscape, and organisms associated with the Amargosa River has occurred through the joint efforts of various agencies, institutions, and not-for-profit organizations. In 2009, Congress designated a 26.3-mile stretch of the Amargosa in California as a Wild and Scenic River, and as of 2017, most the riparian and spring-fed habitats in this region were in the public domain and managed for biodiversity values.

 The ecological values of the Amargosa River in California include a variety of habitats, plant communities, and special organisms, some of which are endemic to the region. Associated wetland habitats include springs, seeps, river channels, and alkali meadows. In addition to mesquite bosque, screwbean mesquite bosque, and willow gallery forest, other rare and important habitats that are found within the Wild and Scenic River designation include herbaceous wetland plant communities, including American bulrush marsh, alkali sacaton grassland, salt grass flats, and spring-fed hanging gardens.

 Many species of animals live in and around the river and its associated habitats, including the Amargosa vole (*Microtus californicus scirpensis*), which is found only within spring-fed marsh habitat containing more than 50% cover of Olney's three-square bulrush (*Schoenoplectus americanus*) near the town on Tecopa Hot Springs. Other mammals found within the region are more wide-ranging, including coyote (*Canis latrans*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), and desert kit fox (*Vulpes macrotis arsipus*), black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), mountain lion (*Puma concolor*), desert bighorn sheep (*Ovis canadensis nelsoni*), and pronghorn (*Antilocapra americana*). Hundreds of bird species use the riparian habitat along the Amargosa River as year-round or as seasonal habitat. Three observed species of conservation concern include the Federally Endangered Least Bell’s Vireo (*Vireo belli pusillus*), the Willow Flycatcher (*Empidonax trailii*), and the Southwestern Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*). Other animals of interest include reptiles and amphibians, two species of fish-- the endemic Amargosa pupfish (*Cyprinodon* *nevadensis* *amargosae*) and the speckled dace (*Rhinichthys* *osculus* spp.), and springsnails.

 In addition to Amargosa niterwort (*Nitrophila mohavensis*) and spring-loving centaury (*Zeltnera namophila*), plant species of concern along the Amargosa River in California include Tecopa bird’s-beak (*Chloropyron tecopense*), Amargosa beardtongue (*Penstemon fruticiformis* var. *amargosae*), Stephens' beardtongue (*Penstemon stephensii*), Pahrump orache (*Atriplex*

*argentea* var. *longitrichoma*), forked buckwheat (*Eriogonum* *bifurcatum*), Kingston Mountains bedstraw (*Galium* *hilendiae* ssp. *kingstonense*), Kingston Mountains ivesia (*Ivesia* *patellifera*), Clark Mountain monardella (*Monardella* *eremicola*), Parish's phacelia (*Phacelia* *parishii*), Rusby's desert-mallow (*Sphaeralcea rusbyi* var. *eremicola*), and alkali mariposa lily (*Calochortus striatus*).

Given that most of the lands surrounding the Amargosa River in California are managed for conservation, the biggest threat to biodiversity is reductions in spring flow caused by the lowering of the groundwater table due to pumping of groundwater from the regional aquifer for agricultural, residential, and industrial use. To maintain the biodiversity values of the Amargosa River in California, both river base flow and the sustainable and continued natural expression of groundwater as seeps and springs must be protected.

**DOI:** Report

**Patten, D. T., S. W. Carothers, R. R. Johnson, and R. H. Hamre. 2018. Chapter 1. Development of the Science of Riparian Ecology in the Semi-Arid Western United States. Page 24 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: River Continuum Concept, riparian, tamarisk, phreatophyte, restoration ecology

**Summary:** A review of the history of riparian ecological science shows an evolution from attempting to solve anthropogenic issues relating to water supply to guiding broad programs of riverine management. In the early years of riparian ecology, river systems were primarily considered sources of water for urban systems, agriculture, and industry. Consequently, the more water made available for these uses, that is, the social ecological system, the more the economy and human welfare would be advanced. To improve delivery of water by riverine systems, science was expected to reduce competing uses of water along the delivery system. This included lining canals and removing, or challenging, the use of water by vegetation growing along the riverine floodplain, that is, riparian vegetation.

Scientists began to evaluate the amount of water used by riparian vegetation and suggested that removing this vegetation could salvage enough water to balance any negative aspects of removal. Consequently, “experiments” were untaken to remove riparian trees and shrubs from the edge of the rivers, or total removal of that plant community where it had overrun the extended floodplain. Success in improving water yield by these procedures was never proven as significant.

Concurrent studies in the 1970s and 1980s shed light on the ecological values of the riparian vegetation, not just as an aggregation of plants but as a complex ecosystem important to riverine functions and one that formed important habitat for many species. Other studies documented the ecological values and disproportionate diversity and density of some vertebrates using these systems. Most early studies along these lines were avian studies. Birds were found to use many strata of the riparian vegetation and thus these habitats were critical in survival and maintenance of most of the avian species of the Southwest lowlands. This information, along with evidence of little or no water savings with riparian vegetation removal, essentially put a stop to programs that removed or highly modified riparian vegetation.

Unfortunately, discovery of the importance of riparian vegetation followed on a lengthy period of dam building in the West. Some dams were constructed many years earlier but, again to improve water delivery to urban/industrial/agricultural centers, water needed to be “stored” and these social ecological systems also needed electrical power that the dams could supply. Dams were managed to control downstream flows along with inundating upstream riverine systems. Many important riparian systems went under water and the negative consequences of a highly modified downstream river flow was demonstrated by riparian research. The importance of the whole riverine system took on a new meaning with the development of the River Continuum Concept, and importance of natural flows (including the concept of environmental flows) was emphasized and supported through extensive riparian/riverine research.

Into the 1980s, more riparian research was initiated to address the response of different components of riparian ecosystems to alterations of the many drivers that influenced these systems. Changes in flows, alteration of groundwater levels, introduction of exotic species, and diversion of channel systems are all examples of modifications studied. Exotic species became of great importance with the expansion of *Tamarix* throughout the West. *Tamarix* impacted many functions of both modified and unmodified riparian ecosystems. Consequently, removing or destroying some riparian systems, those dominated by *Tamarix*, was back in vogue. The rise and fall of the *Tamarix* spp. in the western United States is a classic story of the unintended consequences of not just the introduction of an exotic species, but of ecosystem destruction. *Tamarix* changed the natural hydrograph of streams and rivers, followed later by largely unadvisable attempts to fight it, but it was found to be beneficial as wildlife habitat, with yet another introduced species, the tamarisk leaf beetle.

Today, basic research on riparian functions is still ongoing but more emphasis is being placed on understanding and restoring riparian systems that have been altered. This effort will reach new heights in the shadow of the *Tamarix* beetle’s impacts as hundreds of thousands of acres of second-growth riparian habitats are becoming available for restoration efforts. Although costs for this restoration will be substantial, benefits to wildlife and stream ecology should more than adequately justify the expense and effort.

Riparian research in the West will continue to develop more refined data on function and how this information can guide management. These efforts must include continuing dialog among riparian specialists, users, and the public if we expect riparian systems to continue to be part of the western mosaic of ecosystems and habitat for those species for which this system is critical. The future of riparian ecology is not only better understanding of functional components of these important systems but better ways in which scientists, managers, decisionmakers, and the public can work together to use all forms of data to create a successful future for these critical western riverine systems.

**DOI:** Book chapter

**Penaluna, B. E., G. H. Reeves, Z. C. Barnett, P. A. Bisson, J. M. Buffington, C. A. Dolloff, R. L. Flitcroft, C. H. Luce, K. H. Nislow, J. D. Rothlisberger, and M. L. Warren. 2018. Using Natural Disturbance and Portfolio Concepts to Guide Aquatic–Riparian Ecosystem Management. *Fisheries* 43:406–422.**

**Key words**: natural disturbances, aquatic ecosystems, management, portfolio concept, riparian, habitat, connectivity, climate change

**Abstract:** The U.S. Forest Service and other federal land managers are responsible for maintaining the productivity of aquatic–riparian ecosystems, the associated native biota, and the ecosystem services they provide. These public lands are important sources of water, recreation opportunities, and habitat for a suite of animals and plants, including many that are protected under the Endangered Species Act. To meet these challenges and responsibilities, recent science suggests modifying practices to provide a broader array of habitat, biological conditions, and ecosystem functions than are associated with traditional management approaches. We suggest that by linking approaches based on natural disturbance and portfolio concepts, managers can achieve a robust strategy and desired outcomes more reliably and cost effectively. Locally complex habitat conditions created by natural disturbances provide the template for biological diversity to play out if provided enough time. Accordingly, natural disturbance regimes play an important role in creating and sustaining habitat and biological complexities on the landscape, suggesting that, to the extent possible, management actions should emulate natural disturbance processes at appropriate spatial and temporal scales. In concert with this approach, the portfolio effect (i.e., diversity that mitigates risk) provides justification for promoting connected heterogeneous habitats that reduce the risk of synchronous large-scale population and ecosystem collapse. In this article, we describe how disturbance and portfolio concepts fit into a broader strategy of conserving ecosystem integrity and dynamism and provide examples of how these concepts can be used to address a wide range of management concerns. Ultimately, the outcome for populations, habitats, and landscapes depends on how well environmental change is understood, the degree to which change is appropriately addressed by natural resource managers, and solutions that allow populations and ecosystems to persist in the presence of and be resilient to a growing scope of human influences.

**DOI:** 10.1002/fsh.10097

**Perry, L. G., L. V. Reynolds, and P. B. Shafroth. 2018. Divergent effects of land-use, propagule pressure, and climate on woody riparian invasion. *Biological Invasions* 20:3271–3295.**

**Key words**: Climate, Disturbance, Land-use, Propagule pressure, Saltcedar, Streamﬂow

**Abstract:** Landscape-scale analyses of biological invasion are needed to understand the relative importance of environmental drivers that vary at larger scales, such as climate, propagule pressure, resource availability, and human disturbance. One poorly understood landscape-scale question is, how does human land-use inﬂuence riparian plant invasion? To evaluate the relative importance of land-use, climate, propagule pressure, and water availability in riparian invasion, we examined tamarisk (*Tamarix ramosissima*, *T. chinensis*, hybrids), Russian olive (*Elaeagnus angustifolia*), and Siberian elm (*Ulmus pumila*) occurrence, abundance, and dominance in 238 riparian sites in developed, cultivated, and undeveloped areas of four western USA river basins (281,946 km2). Temperature and propagule pressure from individuals planted nearby largely drove invasive species occurrence, whereas factors likely to affect resource availability (e.g., land-use, precipitation, streamﬂow intermittency) were more important to abundance and dominance, supporting the argument that species distribution models based on occurrence alone may fail to identify conditions where invasive species have the greatest impact. The role of land-use varied among taxa: urban and suburban land-use increased Siberian elm occurrence, abundance, and dominance, and urban land-use increased Russian olive occurrence, whereas suburban land-use reduced tamarisk dominance. Surprisingly, Siberian elm, which has received scant prior scientiﬁc and management attention, occurred as or more frequently than tamarisk and Russian olive (except in undeveloped areas of the Colorado River headwaters) and had higher density and dominance than tamarisk and Russian olive in developed areas. More research is needed to understand the impacts of this largely unrecognized invader on riparian ecosystem services, particularly in urban and suburban areas.

**DOI:** 10.1007/s10530-018-1773-5

**Perry, R. W., J. M. A. Jenkins, R. E. Thill, and F. R. Thompson. 2018. Long-term effects of different forest regeneration methods on mature forest birds. *Forest Ecology and Management* 408:183–194.**

**Key words**: Clearcut, Forest birds, Mature forest, Ouachita Mountains, Shelterwood, Single-tree selection, Timber harvest

**Abstract:** Changes in forest structure that result from silviculture, including timber harvest, can positively or negatively aﬀect bird species that use forests. Because many bird species associated with mature forests are facing population declines, managers need to know how timber harvesting aﬀects species of birds that rely on mature trees or forests for breeding, foraging, and other purposes. We used generalized linear mixed models to determine eﬀects of clearcutting, shelterwood, single-tree selection, and group selection on detection of 18 species of bird associated with mature forests in the Ouachita Mountains of Oklahoma and Arkansas. We surveyed birds for 16 years after harvest. Most species (67%) responded positively to partial harvest that retained some overstory. Less intensive harvests had positive eﬀects on more species and negative eﬀects on fewer species than more intensive harvests, but responses to diﬀerent treatments varied among species. Five species showed a signiﬁcant positive response to the most intensive harvest (clearcuts), whereas 2 species showed a negative response. For the second most-intensive harvest (shelterwoods), 7 species showed a signiﬁcant positive response and 1 species showed a negative response. For the less-intensive harvests, 9 species showed a positive response and no species had negative responses to single-tree selection, whereas 7 species had positive and no species showed negative responses to group selection. Ovenbird (*Seiurus aurocapilla*) and scarlet tanager (*Piranga olivacea*) responded negatively to all timber harvests; ovenbird appeared to be particularly susceptible to timber harvest, especially more intensive harvests such as clearcut and shelterwood. A variety of regeneration methods, including some more intensive treatments, along with maintenance of mature forest stands that retain well-developed midstories can be used to maintain the full suite of forest birds.

**DOI:** 10.1016/j.foreco.2017.10.051

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

**Key words**: Pupﬁsh, Tagging eﬀects, Passive integrated transponder tag, Elastomeric tag

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

**DOI:** 10.1016/j.fishres.2017.08.019

**Pierson, J. C., T. A. Graves, S. C. Banks, K. C. Kendall, and D. B. Lindenmayer. 2018. Relationship between effective and demographic population size in continuously distributed populations. *Evolutionary Applications* 11:1162–1175.**

**Key words**: effective population size, genetic indicator, genetic monitoring, LDNe, population trends

**Abstract:** Genetic monitoring of wild populations can offer insights into demographic and genetic information simultaneously. However, widespread application of genetic monitoring is hindered by large uncertainty in the estimation and interpretation of target metrics such as contemporary effective population size, Ne. We used four long-term genetic and demographic studies (≥9 years) to evaluate the temporal stability of the relationship between Ne and demographic population size (Nc). These case studies focused on mammals that are continuously distributed, yet dispersal-limited within the spatial scale of the study. We estimated local, contemporary Ne with single-sample methods (LDNE, Heterozygosity Excess, and Molecular Ancestry) and demographic abundance with either mark–recapture estimates or catch-per-unit effort indices. Estimates of Ne varied widely within each case study suggesting interpretation of estimates is challenging. We found inconsistent correlations and trends both among estimates of Ne and between Ne and Nc suggesting the value of Ne as an indicator of Nc is limited in some cases. In the two case studies with consistent trends between Ne and Nc, FIS was more stable over time and lower, suggesting FIS may be a good indicator that the population was sampled at a spatial scale at which genetic structure is not biasing estimates of Ne. These results suggest that more empirical work on the estimation of Ne in continuous populations is needed to understand the appropriate context to use LDNe as a useful metric in a monitoring programme to detect temporal trends in either Ne or Nc.

**DOI:** 10.1111/eva.12636

**Propst, D. L., and K. Bixby. 2018. Conserving Native Rio Grande Fishes in Southern New Mexico and West Texas:  A Conceptual Approach. 47.**

**Key words**: Rio Grande, river ecosystem, restoration, native fish, conceptual approach, habitat enhancement

**Conclusions:** Certainly, the most critical issue facing native fishes in the Truth or Consequences to Fort Quitman reach of the Rio Grande is the annual drying of practically the entire river during the non-irrigation season. What surface water there is during the non-irrigation season is limited to scattered pools in a few reaches (e.g., Selden Canyon) and that discharged by the Las Cruces Wastewater Treatment Facility. Even if refuge habitats were constructed/provided through the reach, the abrupt cessation of flow when the irrigation season ends means that few fish have adequate warning or time to retreat to them. Under this operational approach, practically the only fish that might use a refuge are those present in it when flows cease. With a few exceptions, persistence of fishes in each constructed/restored habitat will depend upon stocking. Overall, year-round flowing water with a mix of mesohabitats (e.g., pools, riffles, and runs) is the most critical need to support a more diverse and numerous fish assemblage in the Rio Grande in the Truth or Consequences to Fort Quitman reach.

 Constructed in-channel refuges are most likely to provide some relief to native fishes where some surface water persists after releases from Caballo Reservoir cease. Among the four locations considered in this report, Broad Canyon provides the best opportunity to increase non-irrigation persistence of native fishes in the main channel.

 The lower three locations (LCWTF, La Mancha, and Mesilla Valley Bosque State Park) could collectively provide a complex of habitats; each location has specific attributes that make it best suited to provide specific habitats that are largely, if not completely, absent in the Truth or Consequences to Fort Quitman reach of the Rio Grande. Thus, LCWTF has the potential to support species preferring clear water springs (e.g., Mexican tetra), debris pools adjacent to flowing water (e.g., Rio Grande chub), riffles (e.g., longnose dace and red shiner), pool-run habitats with undercut banks (e.g., flathead catfish) and vegetated shorelines (e.g., fathead minnow and western mosquitofish). Largemouth bass and bluegill currently occupy the offchannel pond at La Mancha Wetland Project and improvements to habitat there (including establishing native prey species such as fathead minnow) helps secure their persistence. With excavation of the lower Picacho Drain and the adjacent pond and increasing the structural heterogeneity of each, the Mesilla Valley Bosque State Park has the potential to support populations of fish that naturally occupied oxbow habitats associated with low-gradient meandering rivers. In addition to largemouth bass and bluegill, longnose gar, fathead minnow, western mosquitofish are potential inhabitants of the park’s aquatic habitats.

 Movement of individuals among the lower three locations will be precluded during the nonirrigation season and limited by main channel flow regime when surface water is present. While access to La Mancha Wetland Project would be unrestricted that at LCWTF would be controlled.

 In time, the knowledge gained from restoration efforts at each location can be used to design additional refuges and improve upon efforts at these initial locations, including Broad Canyon. Unless there are changes in river operations to slowly attenuate discharge when the irrigation season is over, the proposed refuges (except Broad Canyon) will have to function as self-contained fish assemblages.

Although aquatic habitats have been dramatically altered in the Truth or Consequences to Fort Quitman reach of the Rio Grande to the point that most observers would doubt the existence of a single fish, several species persist. The tenacity of these species suggests that with provision of an array of perennial aquatic habitats, ranging from mimicked tributaries to ponds and oxbow lakes, the abundance of each could be increased and sustaining populations maintained.

**DOI:** Report

**Reale, J. K. 2018. Evaluating the effects of catastrophic wildfire on water quality, whole-stream metabolism and fish communities. University of New Mexico.**

**Key words**: wildfire, aquatic ecosystems, disturbances, water quality, fish communities, River Continuum Concept, Rio Grande River, postfire

**Abstract:** This dissertation investigated the initial and multi-year effects of a catastrophic wildfire (Las Conchas fire in 2011) on adjacent and downstream aquatic ecosystems in comparison to pre-fire conditions. Specifically, the research looked at 1) multi-year water quality responses along the river continuum using data collected before, immediately after and for multiple years post-fire, 2) differential water quality and whole-stream metabolism responses of paired headwater catchments over multiple years after disturbance, and 3) fish communities at two sites on a larger river downstream of the extensive region impacted by the catastrophic wildfire. Overall, the research in this dissertation highlights the importance of long-term ecological data collection using advanced instrumentation that can be used to evaluate the effects of a changing climate and climate-mediated disturbances on water resources. Secondly, these studies emphasize the need to collect water quality and biological data at temporal and spatial scales that more effectively capture the hydrology and water quality dynamics of landscape-scale disturbances that are becoming more common and more destructive with climate change and growing human impingement on forested lands. Thirdly, this research highlights the importance of evaluating streamflow pathways, geomorphology, physiochemical properties with biogeochemical processes, and watershed-specific hydrologic connections within their landscapes prior to and following landscape-scale disturbance.

**DOI:** Thesis

**Reside, A. E., N. Butt, and V. M. Adams. 2018. Adapting systematic conservation planning for climate change. *Biodiversity and Conservation* 27:1–29.**

**Key words**: Climate change, Connectivity, Multiple objective planning, Synergies, Trade-offs Uncertainty

**Abstract:** With the high rate of ecosystem change, effective systematic conservation planning must account for ongoing and imminent threats to biodiversity to ensure its persistence. Accordingly, guidance on appropriate conservation actions in the face of climate change has been accumulating. We review this guidance and bring together the key recommendations needed to successfully account for climate change impacts, relevant to the scale at which natural resource management is carried out. We discuss how the traditional conservation tools of protection and restoration need to be adjusted to be effective in the face of climate change. We highlight the conservation innovations such as moveable and temporary reserves, and Targeted Gene Flow. We build on recent work to provide critical advice for considering climate change in conservation planning. In particular, we discuss how stating explicit objectives related to climate change adaptation, quantifying uncertainty, and exploring trade-offs will better place conservation plans to meet objectives for multiple goals such as protection of species, ecosystems, geophysical diversity and ecological processes.

**DOI:** 10.1007/s10531-017-1442-5

**Roeder, K. A., D. V. Roeder, and M. Kaspari. 2018. Disturbance Mediates Homogenization of Above and Belowground Invertebrate Communities. *Environmental Entomology* 47:545–550.**

**Key words**: biodiversity, community assembly, disturbance, flood, weather

**Abstract:** Natural disturbances can occur stochastically with profound impacts on fauna and flora. Here we quantified the impact of a one in 100-yr flood on terrestrial invertebrate communities in south central Oklahoma. Before the flood, we observed 4,082 individuals from 92 species weighing a total of 18.61 g that belonged to compositionally different above or belowground communities. One year after the initial sampling period and 9 mo post-flood, we measured a 93% decrease in abundance, a 60% decrease in species richness, and a 64% decrease in biomass as well as increased compositional similarity between the above and belowground communities. Of the eight insect orders that were present before the flood, only the Coleoptera and Orthoptera increased immediately after the flood. Of these, only the Orthoptera remained at an elevated level across all post-flood sampling periods, specifically due to an increase in crickets (Orthoptera: Gryllidae). As we enter an era of global change, using natural perturbation experiments will improve our knowledge about the ecological processes that shape patterns of community assembly and biodiversity.

**DOI:** 10.1093/ee/nvy022

**Roth, D. 2018. Pecos Sunflower 2013-2017 Monitoring Report: Blue Hole Cienega Nature Preserve, Santa Rosa, NM. NM Energy, Minerals, & Natural Resources Department Forestry Division, Santa Fe, NM.**

**Key words**: Pecos sunflower, transects, monitoring

**Discussion:** Although Pecos sunflowers can be locally abundant, they are globally rare and are known from only seven isolated populations in New Mexico and Texas. The main factors limiting density and growth of plants include water availability, competition with other species, grazing, and other disturbances. These factors do not act independently. Water availability and salinity combined with disturbances control the growth of Pecos sunflowers (Van Auken and Bush 1995). Annual plants are often found in disturbed areas where there is little competition from perennial plants. Pecos sunflowers appear to respond favorably to certain types of disturbance such as fire and tilling, but negatively to grazing (Van Auken and Bush 2004). The number of sunflowers on the Cienega has fluctuated widely from one year to the next, primarily driven by water availability, but also in response to disturbances, such as hail storms and prescribed fires. Reduced competition in combination with increased availability of soil nutrients following the fire likely contributed to the germination and establishment of seedlings in the spring following the fire of 2017. Abundant rainfall increased survival of established plants and contributed to abundant flowering in August and September of 2017. Although Pecos sunflowers are palatable to livestock and livestock impacts can be detrimental to sunflowers, the impacts of grazing as a ground disturbing treatment during the dormant season has not been studied.

Seed banks of annual plants are important to the reestablishment of populations after periods of unfavorable environmental conditions including climatic variability, salinity, and drought (Van Auken 2001). Although the majority of Pecos sunflower seeds have shown to germinate within 4 to 6 months after dispersal, some remain dormant and act as an insurance for species survival in response to adverse environmental conditions by remaining viable in the seedbank (Van Auken 2001). In the Santa Rosa area, sunflower populations flower in early- to mid-September and seed dispersal occurs through October. Seeds germinate in March, after the potential for killing frosts is low, the water table is at or near the surface, and longer daylight hours and temperatures favor germination and establishment of seedlings.

Photopoint monitoring may lead to conclude that restoration efforts have little or inconclusive response from the sunflower populations. However, competition from other species is just one part of what drives sunflower abundance on the Cienega. In years of good rainfall competition for essential resources, such as water, may not impact the abundance of sunflowers as it would during drought years. 2004 was an exceptional wet year in the Santa Rosa area, producing more than 6 inches above average rainfall values (WRCC 2018). Therefore, the abundant sunflower population in the 2004 photo may be a product of ample moisture, not influenced by the strong presence of competing invasive woody species. No reliable rainfall data is available for Santa Rosa after 2009 and we have no photos or population data on how sunflower abundance may have responded to rainfall amounts following herbicide treatments and a prescribed burn in 2008. However, similar high amounts of total annual rainfall were recorded in 2004 and in 2015 in Tucumcari, located approximately 60 miles to the east, with similar large rainfall events in the spring for both recording years. An automated rain gauge installed at the Cienega in July of 2016 may give us better insights on how localized rainfall influences the abundance of sunflowers. The highest number of sunflower since 2013 was recorded in 2017. Significantly more sunflowers were recorded in the 11 monitoring transect over any of the previously recorded years. This is likely the response to the prescribed burn in early February of 2017, approximately 1 month before these sunflowers germinate. In addition, August and September of 2017 incurred unusually large amounts of rainfall, likely contributing the survival of plants established in the spring. This was also true during 2004, but not during 2015 (August or September). More likely than not, sunflower abundance is driven by multiple environmental factors, including the height of the water table in the spring, rainfall amounts during the monsoons, and the type and degree of disturbance within the habitat of the species.

**DOI:** Report

**Rubin, Z., B. Rios‐Touma, G. M. Kondolf, M. E. Power, P. Saffarinia, and J. Natali. 2018. Using prey availability to evaluate Lower Colorado River riparian restoration. *Restoration Ecology*.**

**Key words**: aquatic-terrestrial subsidies, desert rivers, ecological assessment, effectiveness monitoring, Lower Colorado River Multi-Species Conservation Program, Southwestern Willow Flycatcher

**Abstract:** The Lower Colorado River Multi-species Conservation Program (MSCP) is charged with restoring habitat for 26 species such as the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) impacted by water development projects on the river. As of 2015, the MSCP had spent $200 million to create 1,200 ha of habitat at nine sites, but the benefits to these insectivorous birds and other target species have not been quantified. Many MSCP projects emphasized riparian plantings of willow (*Salix exigua*, *Salix gooddingii*) and cottonwood (*Populus fremontii*) on high terraces disconnected from the river. We documented prey availability for insectivores in constructed habitats as an indicator of restoration effectiveness. Using sticky traps as a proxy to estimate aerial insect flux, we found the number of aquatic insects, proportion of aquatic insects, total number of insects, and number of insect orders were all significantly lower in MSCP plantation sites than at the river's edge. Riparian restoration sites over 100 m from the river had only 4% of the aquatic insects, 20% of the total insects, and only half as many insect orders as sites adjacent to the river. Thus, food availability and overall habitat quality for insectivores are likely low in restoration sites that are distant from the river.

**DOI:** 10.1111/rec.12829

**Ruegg, K., R. A. Bay, E. C. Anderson, J. F. Saracco, R. J. Harrigan, M. Whitfield, E. H. Paxton, and T. B. Smith. 2018. Ecological genomics predicts climate vulnerability in an endangered southwestern songbird. *Ecology Letters* 21:1085–1096.**

**Key words**: climate change, ecological genomics, genomic vulnerability, local adaptation

**Abstract:** Few regions have been more severely impacted by climate change in the USA than the Desert Southwest. Here, we use ecological genomics to assess the potential for adaptation to rising global temperatures in a widespread songbird, the willow flycatcher (*Empidonax traillii*), and find the endangered desert southwestern subspecies (E. t. extimus) most vulnerable to future climate change. Highly significant correlations between present abundance and estimates of genomic vulnerability – the mismatch between current and predicted future genotype–environment relationships – indicate small, fragmented populations of the southwestern willow flycatcher will have to adapt most to keep pace with climate change. Links between climate-associated genotypes and genes important to thermal tolerance in birds provide a potential mechanism for adaptation to temperature extremes. Our results demonstrate that the incorporation of genotype–environment relationships into landscape-scale models of climate vulnerability can facilitate more precise predictions of climate impacts and help guide conservation in threatened and endangered groups.

**DOI:** 10.1111/ele.12977

**Samson, E. A., K. G. Boykin, W. G. Kepner, M. C. Andersen, and A. Fernald. 2018. Evaluating Biodiversity Metric Response to Forecasted Land Use Change in the Northern Rio Grande Basin. *Environments* 5:91.**

**Key words**: biodiversity; ecosystem services; land use change; wildlife species; urban growth; deductive habitat models; wildlife habitat; biodiversity metrics; land use scenarios; Rio Grande River

**Abstract:** The effects of future land use change on arid and semi-arid watersheds in the American Southwest have important management implications. Seamless, national-scale land-use-change scenarios for developed land were acquired from the US Environmental Protection Agency Integrated Climate and Land Use Scenarios (lCLUS) project and extracted to fit the Northern Rio Grande River Basin, New Mexico relative to projections of housing density for the period from 2000 through 2100. Habitat models developed from the Southwest Regional Gap Analysis Project were invoked to examine changes in wildlife habitat and biodiversity metrics using five ICLUS scenarios. The scenarios represent a US Census base-case and four modifications that were consistent with the different assumptions underlying the A1, A2, B1, and B2 Intergovernmental Panel on Climate Change global greenhouse gas emission storylines. Habitat models for terrestrial vertebrate species were used to derive metrics reflecting ecosystem services or biodiversity aspects valued by humans that could be quantified and mapped. Example metrics included total terrestrial vertebrate species richness, bird species richness, threatened and endangered species, and harvestable species (e.g., waterfowl, big game). Overall, the defined scenarios indicated that the housing density and extent of developed lands will increase throughout the century with a resultant decrease in area for all species richness categories. The A2 Scenario, in general, showed greatest effect on area by species richness category. The integration of the land use scenarios with biodiversity metrics derived from deductive habitat models may prove to be an important tool for decision makers involved in impact assessments and adaptive planning processes.

**DOI:** 10.3390/environments5080091

**Schofield, L., H. Loffland, R. Siegel, C. Stermer, and H. Mathewson. 2018. Using conspecific broadcast for Willow Flycatcher restoration. *Avian Conservation and Ecology* 13.**

**Key words**: colonization; conservation; conspecific attraction; *Empidonax traillii*; habitat selection; social cues

**Abstract:** Willow Flycatcher (*Empidonax traillii*) populations have been in decline across the western United States for decades. California populations are especially vulnerable with fewer than 500 pairs remaining in the state. Declines and local extirpations continue despite extensive habitat restoration and improved management designed to help conserve Willow Flycatchers. Such efforts may have failed to help reverse these trends in part because Willow Flycatchers rarely recolonize habitat after extirpation, regardless of present habitat suitability. Failure to recolonize habitat may be because prospecting Willow Flycatchers, like many other songbird species, assess habitat suitability based on the presence of conspecifics, making them unlikely to consider unoccupied habitat as potential breeding grounds. If true, broadcasting conspecific vocalizations in suitable but unoccupied habitat could help facilitate recolonization. During the 2016 and 2017 breeding seasons, we assessed the effectiveness of providing artificial social cues as a means of restoring Willow Flycatchers to suitable but unoccupied restored meadows in the Sierra Nevada mountains of California. We selected 14 experimental meadows where conspecific songs were broadcast during the settlement and breeding periods and 19 control meadows where no broadcasts took place. All the meadows were recently restored, contain high-quality habitat with hydrological characteristics and vegetation similar to meadows where Sierra Willow Flycatchers successfully breed, and were confirmed to be unoccupied in the year prior to their inclusion in the study. We observed Willow Flycatchers at five of 14 experimental meadows (35.75%) during the breeding season and at one of 19 control meadows (5.3%). We found that habitat characteristics also play a role in the efficacy of this technique, as Willow Flycatcher presence was highly significantly related to the combination of both the experimental treatment and meadow size. These results demonstrate that within large, restored meadows, conspecific broadcasts may be an effective strategy for restoring Willow Flycatchers.

**DOI:** 10.5751/ACE-01216-130123

**Schorr, R. A., and B. S. Mihlbachler. 2018. Understanding Habitat Quality for Preble’s Meadow Jumping Mouse: How Survival Responds to Vegetation Structure and Composition. *Journal of Fish and Wildlife Management* 9:545–553.**

**Key words**: grass cover; habitat; Preble’s meadow jumping mouse; shrub density; survival; *Zapus hudsonius preblei*

**Abstract:** Habitat loss is the primary conservation concern for many rare species; yet, it is unclear what habitat components are vital for the persistence of many rare species. The Preble’s meadow jumping mouse *Zapus hudsonius preblei* (PMJM) was listed as Threatened under the Endangered Species Act because of habitat loss in Colorado and Wyoming. The PMJM is restricted to dense shrub cover and dense herbaceous vegetation along wetland and riverine systems. Although it is well established by researchers that PMJM infrequently leave these habitat types, it is unclear what riparian vegetation structure and composition is important to PMJM survival. We collected and analyzed a 14-y PMJM vegetation-monitoring data set and a PMJM mark–recapture data set to assess the influence of vegetation structure and composition on PMJM annual survival. Using individual, group, and site-specific covariates we estimated survival and evaluated the influence of such covariates on annual survival. Annual survival for PMJM was low (, 10%), increasing with body mass, grass cover, and shrub cover, and decreasing with meadow vole *Microtus pennsylvanicus* captures. The PMJM use of and occupation of dense riparian habitats may increase individual survival, and likely increases population persistence. Thus, habitat modifications that reduce grass cover and shrub regeneration, such as grazing, suburban development, and development-altered hydrology, will be detrimental to PMJM populations. Given the low annual survival of PMJM, it is important for conserving PMJM populations to minimize disturbances to the vegetation structure, composition, and density, and the hydrologic processes that support them.

**DOI:** 10.3996/052018-JFWM-040

**Schwartz, M. W., C. N. Cook, R. L. Pressey, A. S. Pullin, M. C. Runge, N. Salafsky, W. J. Sutherland, and M. A. Williamson. 2018. Decision Support Frameworks and Tools for Conservation. *Conservation Letters* 11:e12385.**

**Key words**: Adaptive management; planning; decision analysis; evidence based; futures research; structured decision making ;systematic conservation planning; project management

**Abstract:** The practice of conservation occurs within complex socioecological systems fraught with challenges that require transparent, defensible, and often socially engaged project planning and management. Planning and decision support frameworks are designed to help conservation practitioners increase planning rigor, project accountability, stakeholder participation, transparency in decisions, and learning. We describe and contrast five common frameworks within the context of six fundamental questions (why, who, what, where, when, how) at each of three planning stages of adaptive management (project scoping, operational planning, learning). We demonstrate that decision support frameworks provide varied and extensive tools for conservation planning and management. However, using any framework in isolation risks diminishing potential benefits since no one framework covers the full spectrum of potential conservation planning and decision challenges. We describe two case studies that have effectively deployed tools from across conservation frameworks to improve conservation actions and outcomes. Attention to the critical questions for conservation project planning should allow practitioners to operate within any framework and adapt tools to suit their specific management context. We call on conservation researchers and practitioners to regularly use decision support tools as standard practice for framing both practice and research.

**DOI:** 10.1111/conl.12385

**Scianna, J., R. Kilian, J. Muscha, and J. Jacobs. 2018. Effect of Container Size on the Survival and Growth of Plains Cottonwood *Populus deltoides* ssp. *monilifera* Seedlings in a Riparian Planting in Eastern Montana. Final Study Report, U.S. Department of Agriculture, Bridger, MT.**

**Key words**: cottonwood, seedling survival, riparian, invasive

**Abstract:** Plains cottonwood [*Populus deltoides* W. Bartram ex Marshall ssp. *monilifera* (Aiton) Eckenwalder] is an important component of many riparian plant communities in the Great Plains and mid-Atlantic states, but natural recruitment is low, and failure rates of conservation plantings are relatively high. Additionally, competition from invasive woody species such as Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix ramosissima*) has significantly reduced cottonwood regeneration in areas where these invasive species have established. The goal of this study was to determine if seedlings propagated in deep pots (tall, narrow containers), and therefore containing long and extensive root systems, survive and grow better than plants propagated in more shallow, conventional pots. Additionally, planting distance and elevation relative to the river, and soil moisture relations, were investigated. Survival and growth of plains cottonwood seedlings propagated in conventional 2.5-inch by 10-inch deep containers, 2.5-inch by 24-inch deep PVC (polyvinyl chloride) tubing, and 2.5-inch by 36-inch deep PVC tubing, were compared. In 2011, a replicated study was installed along the Yellowstone River at the Fort Keogh Livestock and Range Research Laboratory near Miles City, Montana. After four growing seasons, there was a statistical difference in percent survival between the 10-inch containers (80%) and 24- and 36-inch containers (96.7 and 100%, respectively) at the 85% confidence interval. There was no statistical difference in survival with distance from and elevation relative to the river. There was inconsistent but improved height and caliper growth with increasing distance from the river, presumably reflective of soil characteristics. Soil moisture tension data indicated wide differences in tension, and therefore moisture availability, over time. Differences were noted with depth in the soil profile and with distance and elevation from the river. Results suggest a greater likelihood of plant-available soil moisture at all depths from March through July. The longest intervals of optimum plant-available soil moisture (<100 centibars) occurred at the 4-foot depth, whereas the greatest intervals of tension greater than or equal to 200 centibars occurred at the 2-foot depth. Benefits from deep pot plantings are recognized but cost analyses are needed to determine if the additional production and installation expenses associated with deep pots is offset by increased seedling survival and growth.

**DOI:** Report

**Scott, Michael L., L. V. Reynolds, P. B. Shafroth, and J. R. Spence. 2018. The role of a non-native tree in riparian vegetation expansion and channel narrowing along a dryland river. *Ecohydrology* 11:e1988.**

**Key words**: photography, riparian, Colorado River, vegetation, flow, climate

**Management Implications:** 1. Tamarisk was present in Glen, Marble, and Grand Canyons in the pre-dam period (Clover and Jotter 1944). With other native riparian species, it spread rapidly, likely from both tributary sources and existing stands along the Colorado, throughout the Grand Canyon following dam closure. Despite extensive mortality following flooding from 1983–1986, tamarisk is still a dominant riparian species. Based on photographic evidence, it was widespread by 1989–1992 and was found in 71 percent of the views examined by Webb (1996) and in 79.5 percent of the views we examined for the same time period.

2. Woody riparian vegetation has increased throughout the river corridor in Grand Canyon between the 1990s and 2012. In general, total woody riparian vegetation, including tamarisk, showed increased cover and density during this period in 89.3 percent of the matched images in 2010–2012. Recent work shows that vegetation expansion into lower topographic position in the riparian zone occurred during periods when peak flows were lower and base flows higher and when inundation duration fell below about 5 percent (Sankey et al. 2015). There was no evidence that brief, pulsed inundation during HFEs limited vegetation expansion. Gains in riparian vegetation cover over the past two decades were primarily below the maximum stage of post-dam controlled floods (1,274 cms [~45,000 cfs]), especially in near-shore locations for species like tamarisk, seep-willow, and arrow-weed.

3. Whether HFEs have been a factor in the recent expansion of riparian vegetation is unknown and will require careful, real time monitoring of vegetation following HFEs or retrospective analyses examining the age structure of encroaching vegetation. The seasonal timing of HFEs also warrants further study as they could preferentially shift the structure and composition of riparian vegetation.

4. In contrast to observed vegetation increases, 9.4 percent of the rematches in 2010–2012 show no apparent change, and <2 percent of the views show a decrease in woody riparian vegetation cover and density. Under the current flow regime, some narrow canyon settings are likely to remain free of persistent riparian vegetation.

5. Some of the increase in riparian vegetation results from continued spread and growth of tamarisk, but an important component of the increase includes the establishment of native woody riparian species, including old high-water line species, such as catclaw acacia, honey mesquite, and desert broom, in the new high-water zone or below the stage of the 1983 flood (2,747 cms [~97,000 cfs]). 6. In addition to the natural establishment of riparian vegetation in the new high-water zone, nonnative species like tamarisk and Russian olive have been removed and native vegetation planted as part of experiments or restoration efforts in Marble and Grand Canyons. Artificial manipulation of vegetation should be tracked, actions and locations clearly documented, and the information easily accessible, so that cause-and-effect relationships between flow management and vegetation response can be assessed as accurately as possible.

7. Disconnection of the old high-water assemblage from river flows has left species, like honey mesquite, vulnerable to drought stress, and recent evidence suggests that vegetated cover has declined during the period of early 21st century drought, beginning in the early 1990s. The work of Webb (1996) suggests species like catclaw acacia may be less affected. Some stands may be buffered against drought by factors such as aspect and local ground-water sources. 8. The effects of the recently introduced tamarisk leaf beetle on long-term structure and composition of riparian assemblages in Glen, Marble, and Grand Canyons remain uncertain.

**DOI:** Book chapter

**Scott, Michael L, R. H. Webb, R. R. Johnson, R. M. Turner, J. M. Friedman, and H. C. Fairley. 2018. Chapter 9. Evaluating Riparian Vegetation Change in Canyon-Bound Reaches of the Colorado River Using Spatially Extensive Matched Photo Sets. Page 26 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: channel narrowing, cottonwood, *Elaeagnus angustifola*, Escalante River, non-native plant invasion, non-native plants, *Populus fremontii*, Russian olive, south-western United States

**Abstract:** Along rivers, native and invasive species may establish and persist on active channel bedforms as part of channel narrowing. Using historical aerial photography and dendrochronology, we quantified spatial and temporal patterns of narrowing and vegetation expansion, including native Fremont cottonwood (*Populus fremontii*) and non-native Russian olive (*Elaeagnus angustifolia*), along the largely unregulated Escalante River in south-western United States. Russian olive establishment was examined with respect to hydrologic and climate variables. Narrowing along the Escalante River was initiated during a mid-20th century drought. Cottonwood rapidly colonized higher, bar surfaces between the 1950s and 1981. Small numbers of Russian olive established in moist sites during this period as the channel narrowed by nearly 80%. After 1981, there was no obvious cottonwood establishment but low channel bars and banks were rapidly colonized by Russian olive. Hydroclimate predictors were equivocal but exponential growth of this large-seeded, shade-tolerant species lagged its introduction by 30 years, apparently because of delayed reproductive maturity, limited seed availability, and widespread availability of favourable establishment sites following initial channel narrowing. Sediment trapping, levee formation, and modification of channel form by dense, channel-edge bands of Russian olive progressively limited new establishment sites and by 2000, recruitment declined sharply. Our results have implications for management of non-native tree invasions along arid-region rivers, including identification of low, moist, active channel bars where the establishment and physical impacts of Russian olive appear to be most pronounced and where focused management efforts are likely to be most effective.

**DOI:** 10.1002/eco.1988

**Sechler, B. 2018. Biochar as a Soil Amendment for Willow and Cottonwood Plantings in a Riparian Restoration. University of Colorado.**

**Key words**: riparian, trees, plant productivity, restoration, remediation, carbon

**Abstract:** Riparian areas provide some of the most valuable ecosystem services of any habitat type, both for native flora and wildlife, as well as human society. The global degradation of these critical systems makes their restoration imperative for the preservation of overall ecological integrity since depleted riparian corridors will have cascading effects that pervade upland and downstream regions alike. In western river systems there are two key limiting factors that can lead to failures during re-vegetation efforts along riparian stream banks: one is a lack of available soil nutrients, and the other is a lack of soil moisture. Biochar has been promoted as an effective soil amendment that increases both nutrient availability and soil moisture but to my knowledge has not been used in the context of riparian restoration. My experiment tested biochar as an effective addition to the slurry backfill of planted poles and container plants of two essential riparian tree species along Colorado’s Front Range: *Populus deltoides* and *Salix exigua*. Convention dictates that poles planted for restoration purposes should be selected from dormant cuttings and planted in the early spring to ensure that environmental cues for growth do not yield premature budding until spring runoff has achieved an adequate supply of ground water to sustain long term survival. In practice however, early spring plantings can be logistically challenging and the ability to plant non-dormant cuttings later in the summer could make restoration efforts easier for land management agencies to complete. I used non-dormant poles to test whether biochar’s effect on soil characteristics could offset the disadvantages associated with harvesting and planting cuttings in the late summer. My results showed no effects of biochar on the survivorship of either poles or container plants. Container stock of both *P. deltoides* and *S. exigua* survived better than poles of either species with or without a biochar treatment. Anecdotally, there was superior early growth in biochar treated plants, but this growth may have been phenologically maladaptive. Due to logistical constraints early in the planting process this growth could not be quantified.

**DOI:** Thesis

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

**Key words**: Biological control, Riparian restoration, *Tamarix*, *Diorhabda*, Invasive tree removal, Plant community response, Ecological restoration, Integrated pest management, BACI design, RDA multivariate analysis, Field of dreams hypothesis, Disturbance ecology

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

**DOI:** 10.1016/j.ecoleng.2017.11.018

**Smith, D. M., and D. M. Finch. 2018. Chapter 3. Impacts of Interacting Fire, Climate, and Hydrologic Changes on Riparian Forest Ecosystems in the Southwest. Page 15 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words**: disturbances, riparian, flooding, fire, tree, Middle Rio Grande, climate change, aridland, hydrology

**Ecosystem Implications of the Current Disturbance Regime:** Despite its highly regulated state, the Middle Rio Grande supports a unique assemblage of wildlife species. In unburned portions of the bosque, large cottonwoods provide nest sites, shelter, and food for reptiles, birds, and mammals (Finch et al. 2006; Smith and Finch 2014; Smith et al. 2006). Cavities in cottonwood snags and broken branches of live cottonwoods are used for nesting and roosting sites. Smaller woody plants, including Russian olive and saltcedar, provide resources such as nest sites for birds in the shrub and subcanopy nesting guilds (Finch et al. 2006; Smith and Finch 2014; Smith et al. 2009a). Wildfire removes cottonwood canopy, creates snags and fallen debris, and induces resprouting of woody plants, especially saltcedar. These changes to forest structure and composition create habitat features used by many animal species, but make the bosque unsuitable for others (Smith et al. 2007, 2012). As postfire succession occurs, density of canopy-dependent species will decline if cottonwoods do not recover. In addition, cavity-associated species will lose nest and roosting sites if fallen snags are not replaced by mature trees. Under the current disturbance regime, mortality of large riparian trees will continue to increase due to wildfire, drought, and senescence (Smith and Finch 2015). Vegetative and sexual reproduction of cottonwood and other native trees may occur under certain circumstances, such as fire and flood events and management intervention that are limited in spatial scale (Howe and Knopf 1991). Nonnative woody species, such as Russian olive and saltcedar, are present throughout the Middle Rio Grande and will likely increase in abundance as cottonwood declines. With high densities of mesoriparian and xeroriparian growth, postwildfire sites are vulnerable to additional high-severity fires and may enter a positive feedback loop, to the detriment of native hydroriparian species (Drus 2013). Postwildfire replacement of cottonwood by Russian olive and saltcedar will change the structure of the Middle Rio Grande riparian forest by increasing the density of low-stature vegetation and decreasing canopy height, in turn affecting habitat quality for wildlife, including riparian-nesting birds.

**Conclusions: Disturbance Change and the Future of Aridland Riparian Forests:** Studies of woody riparian plants show that effects of disturbances on survival and reproduction vary among species. As our Middle Rio Grande study shows, native hydroriparian pioneer species are vulnerable to changes in streamflow, which, coupled with wildfire effects, could open doors to invasion by xeroriparian and upland species. As with other aridland rivers, the Middle Rio Grande has created an extensive riparian corridor critical to the successful migration, reproduction, and overwintering of myriad wildlife species (Carothers et al. 1974; Knopf and Sampson 1994; Bateman et al. 2008). Maintaining the composition of these corridors is necessary to preserve both regional and continental biodiversity. During the previous decades of riparian research, ecologists have highlighted the importance of woody riparian vegetation to wildlife and have described the response to changes in hydrology. For most riparian taxa, however, response to wildfire, especially in combination with drought, is poorly known or has been examined in only a few locations. As climate changes and wildfire becomes more frequent than flooding, information on how fire, drought, and climate change affect riparian vegetation will be critical for managers in maintaining ecosystem structure and stability, wildlife habitat, and the associated animal populations and communities. Because riparian dynamics, including recovery from wildfire, are coupled with hydrology of regulated streams, we need hydrological projections that incorporate future water use and climate change scenarios. With this information, we can determine which species of plants will naturally sustain themselves and which will require adaptive management in an increasingly arid Southwest.

**DOI:** Book chapter

**Steele, C., J. Reyes, E. Elias, S. Aney, and A. Rango. 2018. Cascading impacts of climate change on southwestern US cropland agriculture. *Climatic Change* 148:437–450.**

**Key words:** agriculture, conceptual framework, climate change, vulnerabilities, arid, cropland

**Abstract:** The interior southwest United States is one of the hottest, driest regions on the planet, yet irrigated cropland agriculture is successfully practiced where there is access to surface water and/or groundwater. Through climate change, the southwest is projected to become even hotter and drier, increasing the challenges faced by farmers across the region. We can assess the vulnerability of cropland agriculture, to assist in developing potential solutions to these challenges of warming temperatures and water scarcity. However, these types of biophysical vulnerability assessment usually generate technological or policy-level solutions that do not necessarily account for farmers’ ability to respond to climate change impacts. Further, there are non-climatic factors that also threaten the future of agriculture in the region, such as population increase, loss of agricultural land, and increasing competition for depleting water resources. In this paper, we assert that to fully address how southwestern farmers may respond to climate change impacts, we must consider both biophysical outcome and contextual vulnerabilities. Future research on individual localities and/or specific commodities and including cross-disciplinary analysis of socio-economic, institutional, cultural, and political factors alongside biophysical factors will help to develop more substantive understanding of system vulnerabilities and feasible adaptive solutions.

**DOI:** 10.1007/s10584-018-2220-4

**Stein, E. D., J. Taylor, A. Sengupta, and S. M. Yarnell. 2018. Evaluating the effects of changes in flow and water temperature on stream habitats and communities in the Los Angeles/Ventura region: Conceptual approach and summary of available data. SCCWRP Technical Report, Southern California Coastal Water Research Project.**

**Key words:** riparian, climate change, modeling, management, flow

**Introduction and Objectives:** Flow regime changes have been shown to affect a broad suite of ecological processes and biological communities (Bunn and Arthington 2002, Naiman et al. 2002, Poff and Zimmerman 2010, Novak et al. 2015). Much of the worldwide focus on assessing ecological effects of hydrologic change has been focused on long-standing human activities that can affect flow, such as conversion of natural lands to urban or agricultural landscapes, infrastructure development, and water management through dams and diversions. These activities alter the flow regime through changes in flow magnitude, duration, timing, frequency, and rate of change (Poff et al. 1997).

In addition to direct human impacts on waterways, there is a growing recognition of the impact of global climate change on stream flow. These changes impact the relative abundance of species globally (McLaughlin et al. 2002) by altering the extent and condition of habitat necessary to support aquatic biodiversity (Jetz et al. 2007, Bellard et al. 2012). When aquatic species experience a change in hydraulic regime or water temperature, it is likely that specialist species (often natives) will lose out to other more generalist (often exotic) species. This was shown by Poloczanska et al. (2008) with a two-taxa population model and climate envelope model, which were used to investigate the responses of populations of competing species to climate change. Poloczanska et al. (2008) noted the complete extinction of one taxa and a rapid increase in the second taxa under future climate scenarios.

For species that rely on freshwater aquatic habitats for all or part of their life cycles, climate change may degrade needed aquatic habitat through changes in seasonal or annual temperature, increases in extreme heat events, changing precipitation patterns (including the proportion of snow vs. rain), and subsequent magnitude and timing of runoff and sediment yield. These changes cumulatively impact channel morphology and water temperature, which ultimately harm aquatic dependent species (Figure 1).

The freshwater habitat impacts of these climatic changes are difficult to assess and model in general, and especially in regions like Southern California with complex topography that creates microclimates that may result in complex localized responses. However, recent efforts to downscale global climate change prediction (ca. 2100) to high spatial resolution projections for the greater Los Angeles region provide a unique opportunity to explore the impacts of climate change on aquatic species important to the ecology of the region. Using these downscaled climate predictions, we can model riverine systems to begin to understand how streamflow will

be impacted and, more importantly, whether these changes in streamflow will put sensitive aquatic species at increased risk of population decline.

Working with the Los Angeles Regional Water Quality Control Board, we propose to develop a framework for relating climate change-induced alterations in streamflow to changes in key ecologically and recreationally important biological communities. This work will augment past efforts to develop assessment tools for benthic invertebrates by focusing on development of tools for higher-level taxa, such as fish, amphibians, birds, and/or riparian communities. This document serves as a first step in this process. In this document, we: 1) summarize the ecologically and recreationally important aquatic communities known to occur in the Los Angeles Regional Board’s jurisdiction; 2) outline a process for prioritizing which communities should be the focus of analysis of climate change effects; 3) summarize available modeling approaches to relate changes in temperature, flow and physical habitat to changes in habitat suitability or the likelihood of occurrence of priority biological communities; 4) evaluate the strengths and limitations of available modeling tools at helping to achieve the overall project objective

**DOI:** Report

**Swanson, F. J., and S. V. Gregory. 2018. Chapter 2. Development of Riparian Perspectives in the Wet Pacific Northwest Since the 1970s. Page 7 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words:** riparian, management, forest

**Introduction:** Streams and riparian zones have been fertile ground for ecosystem science and a battleground for forest policy and management in the wet Pacific Northwest west of the crest of the Cascade Range for many decades. Competing, high-value resources of salmon and big Douglas-fir timber and their iconic places in cultures of the region sharpened the clash of values. Landslides from forestry operations and roads and elevated water temperature in streams where forest cover had been removed were points of physical connection between steep slope forestry and cold-water fishes. Logging slash from harvest operations had dammed streams and depleted dissolved oxygen, leading fisheries agencies and advocates to call for removal of wood from streams in the 1950s and 1960s. In the decades since, science has played important roles in characterizing ecosystem components and dynamics and in identifying issues and management options. Social conflicts have propelled the science forward. In this essay, we offer a brief historical overview of steps in the development of concepts about riparian zones in this region and societal context from the perspective of the large, interdisciplinary science team—the Stream Team—based on the Oregon State University campus in Corvallis and at the H.J. Andrews Experimental Forest in the Willamette National Forest east of Eugene. Team members come from the University, Forest Service research and land management branches, and other institutions; and the participants have roots in stream ecology, fisheries and forest science, geomorphology, and other fields. The nucleus of the Stream Team has been large research programs—the International Biological Program in the 1970s and the Long-Term Ecological Research program since 1980, both supported by the National Science Foundation and the Forest Service, and based in Oregon State University. Important work occurred elsewhere in the region, most notably based in Seattle in fisheries and forestry research, and outreach programs based at the University of Washington (e.g., Naiman et al. 2005), but we do not attempt to cover that work in this chapter.

**DOI:** Book chapter

**Switalski, A. 2018. Off-highway vehicle recreation in drylands: A literature review and recommendations for best management practices. *Journal of Outdoor Recreation and Tourism* 21:87–96.**

**Key words:** Travel planning, OHV recreation, Natural resources, Use conflict, Cultural resources, Arid lands

**Abstract:** Around the world the rapid expansion of off-highway vehicle (OHV) recreation into arid and semi-arid lands has resulted in significant environmental and [social costs](https://www.sciencedirect.com/topics/social-sciences/social-costs). This paper reviews our current understanding on the ecological and [social effects](https://www.sciencedirect.com/topics/social-sciences/social-effects) of OHVs on [dryland](https://www.sciencedirect.com/topics/social-sciences/arid-zones) environments. Based on research and existing management guidelines, the paper compiles a set of [best management practices](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/best-management-practice) to minimize impacts during [system design](https://www.sciencedirect.com/topics/social-sciences/systems-design), and provides [management strategies](https://www.sciencedirect.com/topics/social-sciences/strategy-management) to further reduce impacts after route designation. The review found that OHVs have impacts to multiple resources that include [soil compaction and erosion](https://www.sciencedirect.com/topics/social-sciences/soil-erosion), trampling of vegetation, as well as [wildlife habitat](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/wildlife-habitats) loss, disturbance, and direct mortality. Conflict among user groups has also been identified as occurring with non-motorized user groups being displaced. [Vandalism](https://www.sciencedirect.com/topics/social-sciences/vandalism) of archaeological and [cultural resources](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/cultural-resource) along OHV routes has also been documented. Gaps in our understanding still exist, and [research needs](https://www.sciencedirect.com/topics/social-sciences/research-priorities) are also presented. Knowledge of the most current research and the use of best management practices can help guide land managers to minimize conflict and resource damage.

**DOI:** 10.1016/j.jort.2018.01.001

**Tave, D., L. A. Toya, and A. M. Hutson. 2018. Behavioral observations of the endangered Rio Grande Silvery Minnow in a conservation aquaculture facility. *Croatian Journal of Fisheries* 76:7–26.**

**Key words:** Conservation aquaculture Fish behavior Rio Grande silvery minnow *Hybognathus* amarus Endangered species

**Abstract:** A major reason why conservation aquaculture is needed to improve the success of aquaculture-assisted ﬁsheries is that traditional production aquaculture produces ﬁsh with mal-adaptive behaviors. These behaviors can be produced via domestication and culture techniques, and preventing these mal-adaptive behaviors requires integrating improvements in genetic management and culture protocols. The genetic protocols needed to minimize hatchery-induced genetic changes have received considerable attention, but changing the way ﬁsh are raised has received less effort. Conservation aquaculture cultures ﬁsh in environments that resemble their native habitats so that when stocked, they behave like wild ﬁsh rather than hatchery ﬁsh. A purpose built-conservation aquaculture facility can also be used to learn about a species’ behavior and how it reacts to changes in the environment, something which can be difﬁcult or expensive to study in the wild. These observations can then be used to help direct both propagation and recovery management. This paper provides the rationale for why genetic management, culture systems, and management practices need to be altered to produce ﬁsh that are behaviorally similar to wild ﬁsh for aquaculture-assisted ﬁsheries programs. It then provides a description of some of the behaviors of the endangered Rio Grande silvery minnow *Hybognathus* amarus that were observed at the Los Lunas Silvery Minnow Refugium, a purpose-built conservation aquaculture facility, and explains how some of these behaviors can be used in culture and recovery management. Behaviors described are: schooling; predator avoidance; feeding behavior; use of vegetation for cover and predator avoidance; habitat use by bottom substrate; location in the water column; upstream movement via a ﬁsh ladder; movement upstream in a high-velocity channel; response to changes in water level; spawning behavior; seine avoidance; and Kaah-chee-nyee Srkaash, a behavior described for the ﬁrst time.

**DOI:** 10.2478/cjf-2018-0002

**Theimer, T. C., M. K. Sogge, S. N. Cardinal, S. L. Durst, and E. H. Paxton. 2018*a*. Extreme drought alters frequency and reproductive success of floaters in Willow Flycatchers. *The Auk* 135:647–656.**

**Key words:** drought, *Empidonax*, floater, flycatcher, non-territorial, territoriality

**Abstract:** Changes in habitat quality, including those caused by extreme events like droughts and floods, could alter costs and benefits of territoriality and thereby the prevalence and reproductive consequences for individuals capable of breeding that do not do so (floaters). We studied floating behavior in a population of Southwestern Willow Flycatchers (*Empidonax traillii extimus*) in central Arizona during one year of extreme drought, one year of lake inundation, and three years of near average precipitation. In all years, most floaters were second year (SY) males, and most subsequently settled outside of the patch where they were detected in the floating year, suggesting that floaters did not “queue” at high-quality territories in order to achieve higher reproductive success in subsequent years. Instead, cohorts that floated in non-drought years had lower apparent survival and lower reproductive success compared to territorial birds. In the extreme drought year, however, the number of floaters was 1.5 times greater than in all other years combined, more females floated, and apparent survival and mean annual productivity in subsequent years was higher for males that floated in that year than for those that were territorial. Inundation of habitat due to rising reservoir levels did not result in an increase in floaters because many birds nested in inundated areas where trees projected above the water so that the relative amount of available habitat was not reduced to the extent habitat models predicted. Overall, our results indicate that the prevalence and reproductive and demographic consequences of floating can change under extreme climatic events like severe drought.

**DOI:** 10.1642/AUK-17-206.1

**Theimer, T. C., M. K. Sogge, and E. H. Paxton. 2018*b*. Patch age since disturbance drives patch dynamics for flycatchers breeding in both reservoir and riverine habitat. *Ecosphere* 9:e02425.**

**Key words:** demography; disturbance; ﬂooding; patch dynamics; reservoir; riparian; stand age

**Abstract:** Species dependent upon early-successional landscapes often occupy patches at different stages of recovery after disturbance. The demographic processes that drive patch dynamics in these systems have rarely been described but are important for developing effective conservation and management plans, especially when humans have modified the timing and intensity of disturbances that drive regeneration. In riparian systems, disturbance by floods historically initiated plant regeneration, but many rivers are now regulated and stream flows disrupted by dams and reservoirs. We studied the demography and patch dynamics of an endangered, neotropical migrant bird dependent on remnant riparian patches for breeding, the southwestern willow flycatcher (*Empidonax traillii extimus*), over 9 yr at both a riverine and reservoir site in central Arizona. We found that at both sites, number of territories/ha within patches increased for 2–4 yr after colonization and then declined, with several patches abandoned after 6–10 yr. Age of birds increased with patch age, with younger birds in colonizing patches and older, site-faithful birds in older patches, while mean per capita reproductive success did not differ with patch age. Natal dispersal and breeding dispersal were primarily from intermediate-aged patches into either young- or other intermediate-aged patches. At both riverine and reservoir sites, both the number of patches and the number of territorial birds increased over time, with the percentage of territories shifting into younger and younger patches. The type of disturbance driving patch regeneration differed between riverine and reservoir sites (seasonal flooding vs. falling lake levels due to drought), but the demographic patterns did not, indicating that reservoirs can generate patch dynamics similar to those on rivers. Managing stream flows and reservoir levels to maintain disturbance cycles sufficient to generate riparian patches at different stages of regeneration through time would benefit succession-dependent species like the endangered flycatcher we studied, whether those disturbances arise from natural flooding events along free-flowing rivers or through changes in reservoir levels.

**DOI:** 10.1002/ecs2.2425

**van Riper III, C., S. L. Puckett, and A. J. Darrah. 2018. Influences of the invasive tamarisk leaf beetle (*Diorhabda carinulata*) on avian diets along the Dolores River in Southwestern Colorado USA. *Biological Invasions* 20:3145–3159.**

**Key words:** Invasive tamarisk, Bird foraging, Diet preference, Arthropods biological control, Riparian habitat, Salt cedar, Passerine birds

**Abstract:** The tamarisk leaf beetle (*Diorhabda carinulata*), introduced from Eurasia in 2001 as a biological control agent for the invasive plant *Tamarix ramosissima*, has spread widely throughout the western USA. With *D. carinulata* now very abundant, scientists and restoration managers have questioned what inﬂuence this introduced arthropod might have upon the avian component of riparian ecosystems. From 2009 through 2012 we studied the consequences of biological invasions of the introduced tamarisk shrub and tamarisk leaf beetles on the diets of native birds along the Dolores River in southwestern Colorado, USA. We examined avian foraging behavior, sampled the arthropod community, documented bird diets and the use of invasive tamarisk shrubs and tamarisk leaf beetles by birds. We documented *D. carinulata* abundance, on what plants the beetles occurred, and to what degree they were consumed by birds as compared to other arthropods. We hypothesized that if *D. carinulata* is an important new avian food source, birds should consume beetles at least in proportion to their abundance. We also hypothesized that birds should forage more in tamarisk in the late summer when tamarisk leaf beetle larvae are more abundant than in early summer, and that birds should select beetle-damaged tamarisk shrubs. We found that *D. carinulata* composed 24.0 percent (± 19.9–27.4%) and 35.4% biomass of all collected arthropods. From the gut contents of 188 birds (25 passerine species), only four species (n = 11 birds) contained tamarisk leaf beetle parts. Although *D. carinulata* comprised one-quarter of total insect abundance, frequency of occurrence in bird gut contents was only 2.1% by abundance and 3.4% biomass. Birds used tamarisk shrubs for foraging in proportion to their availability, but foraging frequency did not increase during the late summer when more tamarisk leaf beetles were present and birds avoided beetle-damaged tamarisk shrubs. Despite *D. carinulata* being the most abundant arthropod in the environment, these invasive beetles were not frequently consumed by birds and seem not to provide a signiﬁcant contribution to avian diets.

**DOI:** 10.1007/s10530-018-1764-6

**Vargas-Acosta, R. A., L. G. Chavira, N. Villanueva-Rosales, and D. Pennington. 2018. Towards SWIM Narratives for Sustainable Water Management. Pages 25–33 *in* D. Garijo, N. V. Rosales, T. Kuhn, T. Kauppinen, and M. Dumontier, editors. ISWC 2018. Volume 2184. CEUR, Monterey, CA.**

**Key words:** Participatory Analysis, SWIM, Narratives, Stakeholders

**Abstract:** The creation of scientific models to understand water availability under different scenarios is an important step towards pursuing a sustainable water future. A wide variety of scientific models have been created for understanding the different elements driving water availability in urban, agricultural and ecological settings. The Sustainable Water through Integrated Modeling Framework (SWIM) enables a wide range of stakeholders to run water-sustainability model scenarios through participatory modeling. Although SWIM is a science-driven platform, it was created with input from diverse stakeholders with the goal of improving how water models can be used and shared. SWIM aims to foster a better understanding on the impact that decisions about water usage can have. This paper describes our efforts towards translating the science behind the models generated in SWIM into English and Spanish explanations, also known as narratives. We anticipate that narratives will better communicate the meaning of specific water-economics scenarios under different perspectives, including urban, agriculture and environmental. Thus, assisting stakeholders in decision making.

**DOI:** Conference paper

**Vorster, A. G., B. D. Woodward, A. M. West, N. E. Young, R. G. Sturtevant, T. J. Mayer, R. K. Girma, and P. H. Evangelista. 2018. Tamarisk and Russian Olive Occurrence and Absence Dataset Collected in Select Tributaries of the Colorado River for 2017. *Data* 3.**

**Key words:** Colorado River Basin; *Diorhabda* spp.; *Elaeagnus angustifolia*; invasive species; riparian; Russian olive; tamarisk; tamarisk beetle; *Tamarix* spp.

**Abstract:** Non-native and invasive tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) are common in riparian areas of the Colorado River Basin and are regarded as problematic by many land and water managers. Widespread location data showing current distribution of these species, especially data suitable for remote sensing analyses, are lacking. This dataset contains 3476 species occurrence and absence point records for tamarisk and Russian olive along rivers within the Colorado River Basin in Arizona, California, Colorado, Nevada, New Mexico, and Utah. Data were collected in the field in the summer of 2017 with high-resolution imagery loaded on computer tablets. This dataset includes status (live, dead, defoliated, etc.) of observed tamarisk to capture variability in tamarisk health across the basin, in part attributable to the tamarisk beetle (*Diorhabda* spp.). For absence points, vegetation or land cover were recorded. These data have a range of applications including serving as a baseline for the current distribution of these species, species distribution modeling, species detection with remote sensing, and invasive species management.

**DOI:** 10.3390/data3040042

**Webb, J. A., R. J. Watts, C. Allan, and J. C. Conallin. 2018. Adaptive Management of Environmental Flows. *Environmental Management* 61:339–346.**

**Key words:** Environmental flows, Adaptive management, Reflection, Researchers, Managers, Local stakeholders, Decision-making, Uncertainty, Learning

**Abstract:** Adaptive management enables managers to work with complexity and uncertainty, and to respond to changing biophysical and social conditions. Amid considerable uncertainty over the beneﬁts of environmental ﬂows, governments are embracing adaptive management as a means to inform decision making. This Special Issue of Environmental Management presents examples of adaptive management of environmental ﬂows and addresses claims that there are few examples of its successful implementation. It arose from a session at the 11th International Symposium on Ecohydraulics held in Australia, and is consequently dominated by papers from Australia. We classiﬁed the papers according to the involvement of researchers, managers and the local community in adaptive management. Five papers report on approaches developed by researchers, and one paper on a community-led program; these case studies currently have little impact on decision making. Six papers provide examples involving water managers and researchers, and two papers provide examples involving water managers and the local community. There are no papers where researchers, managers and local communities all contribute equally to adaptive management. Successful adaptive management of environmental ﬂows occurs more often than is perceived. The ﬁnal paper explores why successes are rarely reported, suggesting a lack of emphasis on reﬂection on management practices. One major challenge is to increase the documentation of successful adaptive management, so that beneﬁts of learning extend beyond the project where it takes place. Finally, moving towards greater involvement of all stakeholders is critical if we are to realize the beneﬁts of adaptive management for improving outcomes from environmental ﬂows.

**DOI:** 10.1007/s00267-017-0981-6

**Werner, W. E. 2018. Chapter 8. Arizona as a Watershed—Then and Now: Case Studies of Changed Management of Rivers and Habitat in the Lower Colorado River System. Page 14 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.**

**Key words:** riparian, Lower Colorado River, tributary, adaptive management, dams

**Discussion:** Riparian ecosystems are dynamic by their nature and riparian habitat is dynamic as stands of vegetation progress through natural succession and mature. Maintaining sufficient habitat on the landscape involves more than simply maintaining stands of vegetation. Maintaining conditions suitable to support an adequate prey base for birds, for example, is an element of maintaining habitat. Doing so may require more water than is needed simply for survival of trees. In some circumstances, our ability to control variables limits our ability to manage for riparian habitat. In other circumstances, we can set the stage, to the best of our ability, within constraints, such as on the Salt River in Phoenix where we can manage the landform and can create baseflows but have little control on high flows. In further circumstances, such as the operation of Alamo Dam, we can manage flow constraint by managing both high flows and baseflows, to a greater or lesser degree, within physical constraints of dam design and available water upstream in the system.

In the case of operating Alamo Dam to benefit riparian habitat on the Bill Williams River, we can develop contingency plans to exploit opportunities, if and when those opportunities arise. On the lower Gila River below Painted Rock Dam, we can set the stage by creating suitable landform but have no control on the frequency of high flows, which were more frequent during our planning efforts than since. On the Lower Colorado River, we can create functional habitat in floodplain settings where it once occurred naturally although our ability to manage river flows and sediment movement is very low. By doing the best we can in a variety of circumstances in managed systems, we can create a patchwork quilt of habitat.

**DOI:** Book chapter

**Wonkka, C. L., D. Twidwell, C. H. Bielski, C. R. Allen, and M. C. Stambaugh. 2018. Regeneration and invasion of cottonwood riparian forest following wildfire. *Restoration Ecology* 26:456–465.**

**Key words:** Cimarron River, *Populus deltoides*, resprouting, riparian forest regeneration, tamarisk, wildfire

**Abstract:** *Populus deltoides* is considered to be a weak resprouter and highly susceptible to wildfire, but few post-wildfire studies have tracked *P. deltoides* response and resprouting within the Great Plains of North America. Following a wildfire in southwestern Kansas, U.S.A., we surveyed burned and unburned areas of a cottonwood riparian forest along the Cimarron River that included a major understory invader, tamarisk (*Tamarix ramosissima* Ledeb.). We tested the following hypotheses, which are consistent with the current understanding of P. deltoides response to wildfire in the Great Plains: (1) regeneration of *P. deltoides* will be low in areas burned by the wildfire; (2) the number of dead *P. deltoides* individuals will be greater in the wildfire than unburned areas; and (3) tamarisk regeneration will be higher than *P. deltoides* regeneration in the wildfire areas because tamarisk is considered a stronger resprouter. We found evidence contrary to two of our hypotheses 3 years following the wildfire. (1) *P. deltoides* regeneration was high following the wildfire, averaging 692 individuals/ha. (2) The number of dead mature cottonwood trees was greater in wildfire plots than in unburned plots. (3) There was more *P. deltoides* regeneration than tamarisk regeneration following wildfire. These findings, which diverge from the majority of studies examining *P. deltoides* regeneration in the Great Plains, suggest that differing local environmental and forest stand conditions, coupled with the timing and intensity of the fire, could be important determinants of riparian forest species' responses to wildfire.

**DOI:** 10.1111/rec.12577

**Woodward, B. D., P. H. Evangelista, N. E. Young, A. G. Vorster, A. M. West, S. L. Carroll, R. K. Girma, E. Z. Hatcher, R. Anderson, M. L. Vahsen, A. Vashisht, T. Mayer, D. Carver, and C. Jarnevich. 2018. CO-RIP: A Riparian Vegetation and Corridor Extent Dataset for Colorado River Basin Streams and Rivers. *ISPRS International Journal of Geo-Information* 7:397.**

**Key words:** riparian corridor; valley bottom; V-BET; Landsat; random forests; NAIP

**Abstract:** Here we present “CO-RIP”, a novel spatial dataset delineating riparian corridors and riparian vegetation along large streams and rivers in the United States (US) portion of the Colorado River Basin. The consistent delineation of riparian areas across large areas using remote sensing has been a historically complicated process partially due to differing definitions in the scientific and management communities regarding what a “riparian corridor” or “riparian vegetation” represents. We use valley-bottoms to define the riparian corridor and establish a riparian vegetation definition interpretable from aerial imagery for efficient, consistent, and broad-scale mapping. Riparian vegetation presence and absence data were collected using a systematic, flexible image interpretation process applicable wherever high resolution imagery is available. We implemented a two-step approach using existing valley bottom delineation methods and random forests classification models that integrate Landsat spectral information to delineate riparian corridors and vegetation across the 12 ecoregions of the Colorado River Basin. Riparian vegetation model accuracy was generally strong (median kappa of 0.80), however it varied across ecoregions (kappa range of 0.42–0.90). We offer suggestions for improvement in our current image interpretation and modelling frameworks, particularly encouraging additional research in mapping riparian vegetation in moist coniferous forest and deep canyon environments. The CO-RIP dataset created through this research is publicly available and can be utilized in a wide range of ecological applications.

**DOI:** 10.3390/ijgi7100397

**Worthington, T. A., A. A. Echelle, J. S. Perkin, R. Mollenhauer, N. Farless, J. J. Dyer, D. Logue, and S. K. Brewer. 2018. The emblematic minnows of the North American Great Plains: A synthesis of threats and conservation opportunities. *Fish and Fisheries* 19:271–307.**

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

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

**DOI:** 10.1111/faf.12254

**Yates, K. L., P. J. Bouchet, M. J. Caley, K. Mengersen, C. F. Randin, S. Parnell, A. H. Fielding, A. J. Bamford, S. Ban, A. M. Barbosa, C. F. Dormann, J. Elith, C. B. Embling, G. N. Ervin, R. Fisher, S. Gould, R. F. Graf, E. J. Gregr, P. N. Halpin, R. K. Heikkinen, S. Heinänen, A. R. Jones, P. K. Krishnakumar, V. Lauria, H. Lozano-Montes, L. Mannocci, C. Mellin, M. B. Mesgaran, E. Moreno-Amat, S. Mormede, E. Novaczek, S. Oppel, G. Ortuño Crespo, A. T. Peterson, G. Rapacciuolo, J. J. Roberts, R. E. Ross, K. L. Scales, D. Schoeman, P. Snelgrove, G. Sundblad, W. Thuiller, L. G. Torres, H. Verbruggen, L. Wang, S. Wenger, M. J. Whittingham, Y. Zharikov, D. Zurell, and A. M. M. Sequeira. 2018. Outstanding Challenges in the Transferability of Ecological Models. *Trends in Ecology & Evolution* 33:790–802.**

**Key words:** Predictive modeling, model transfers, species distribution models, habitat models, extrapolation, generality, uncertainty

**Abstract:** Predictive models are central to many scientific disciplines and vital for informing management in a rapidly changing world. However, limited understanding of the accuracy and precision of models transferred to novel conditions (their ‘transferability’) undermines confidence in their predictions. Here, 50 experts identified priority knowledge gaps which, if filled, will most improve model transfers. These are summarized into six technical and six fundamental challenges, which underlie the combined need to intensify research on the determinants of ecological predictability, including species traits and data quality, and develop best practices for transferring models. Of high importance is the identification of a widely applicable set of transferability metrics, with appropriate tools to quantify the sources and impacts of prediction uncertainty under novel conditions.

**DOI:** 10.1016/j.tree.2018.08.001