National Fish and Wildlife Foundation

Southwest Rivers Business Plan

October 2018

Purpose of a Business Plan

The purpose of a NFWF business plan is to provide a concise blueprint of the strategies and resources required to achieve the desired conservation outcomes. The strategies discussed in this plan do not represent solely the foundation's view of the actions necessary to achieve the identified conservation goals, but instead reflect the view of the many federal, state, academic, and organizational experts that consulted during plan development. This plan is not meant to duplicate ongoing efforts but rather to invest in areas where gaps might exist so as to support the efforts of the larger conservation community. Revisions to this plan may be considered over time, subject to the identification and securing of additional funding.

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About NFWF

The National Fish and Wildlife Foundation protects and restores our nation's wildlife and habitats. Chartered by Congress in 1984, NFWF directs public conservation dollars to the most pressing environmental needs and matches those investments with private contributions. NFWF works with government, nonprofit and corporate partners to find solutions for the most complex conservation challenges. Over the last three decades, NFWF has funded more than 4,000 organizations and committed more than $2.9 billion to conservation projects. Learn more at *www.nfwf.org*.

Cover photo credit: *Pecos River* ([iStock] Anton Foltin); *Sprague's pipit* ([National Audubon Society] Glenn Bartley); and *Pecos pupfish* ([Arkive] Paddy Ryan).

Background

The Southwest Rivers Program was formed through partnerships by the National Fish and Wildlife Foundation (NFWF), public agencies, and corporations to develop new strategies and provide additional resources to address the pressing conservation needs of the region. The Program and this Business Plan are currently focused on two watersheds: the Pecos Watershed Conservation Initiative, which addresses conservation in the Pecos watershed of New Mexico and West Texas, and the Rio Grande Program, which focuses on the Middle Rio Grande Valley of New Mexico and the Rio Grande headwaters region in northern New Mexico and the San Luis Valley of southern Colorado (Figure 1).

In the Pecos watershed several energy companies have partnered with NFWF and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) to form the Pecos Watershed Conservation Initiative which will address wildlife and habitat conservation issues. In the Rio Grande, NFWF and the Bureau of Reclamation (USBR) are partnering to implement innovative water leasing strategies to support endangered species and historical agricultural uses. Higher in the Rio Grande watershed, State and non-profit partners are coming together to address water and habitat issues around streams in northern New Mexico and southern Colorado.

The Southwest Rivers Program was approved by the NFWF Board of Directors in August 2017. An initial slate of grants for the Pecos Watershed Conservation Initiative was made in March 2018. This Business Plan will guide future investments to achieve targeted conservation goals.

Figure 1. Southwest Rivers Landscape

Conservation Need

In the southwestern United States, iconic desert rivers begin their journey on high mountain peaks and wind their way through a stark and arid landscape. These rivers are the lifeblood of the region, providing critical resources for local communities and wildlife.

Streams and their associated riparian habitats in the desert southwest have a disproportionate impact on wildlife, with 70 percent of threatened and endangered vertebrate species dependent upon riparian zones for at least a part of their life cycle (Johnson 1989). These rivers represent biodiversity hotspots, as wildlife and aquatic species in the desert southwest are uniquely adapted to this harsh but beautiful landscape, and many are endemic to the region. Many native species are now found only in small portions of their historic ranges.

Species such as Rio Grande silvery minnow, Pecos gambusia, and most recently Texas hornshell, have been listed as federally endangered species, while others are state-listed as endanged, like Pecos pupfish and Rio Grande sucker. The life cycles of these native species are intimately tied to the flood-dominated hydrology characteristic of rivers in the desert southwest, which has been altered by human development, particularly dam building (Dearen 2016). Rivers that once spread wide across floodplains during flood events, supporting dynamic side channels and shallow rearing habitat for fish and nourishing native riparian vegetation, are now limited by dam releases and water diversions and have become narrow channels disconnected from their historic floodplain.

Upstream, the headwaters of many of the southwest's desert rivers occur in high elevation alpine environments, where conifer forests surround cold-water streams fed by snowmelt. The headwaters regions of desert rivers contribute significantly to the landscape's biodiversity, including a variety of native cutthroat trout species. As temperatures increase across the region and more precipitation occurs as rain rather than snow, these headwaters species are at greater risk.

The rivers of the desert southwest are intertwined with the working human landscapes that have grown up around them. Ranching and farming, energy development and mining all play major economic roles in the region, and utilize large areas of land and much of the available water in these systems. As development increases, the demands on these watersheds also increase, altering habitats and resources for wildlife.

Currently there are two focal geographies within the Southwest Rivers Business Plan: the Pecos River watershed in southeast New Mexico and West Texas, and the middle and upper Rio Grande watershed in southern Colorado and northern New Mexico.

Pecos River Watershed

The Pecos River winds more than 900 miles from its headwaters in the ponderosa pine forests of northern New Mexico through the Chihuahuan Desert grasslands of southeastern New Mexico and West Texas, meeting the Rio Grande on the Mexican border. Historic agricultural use and grazing practices have increased sediment transport into river channels, reducing water quality and paving the way for woody brush encroachment and grassland habitat loss (Dearen 2016). In its lower elevations, the Pecos River travels through the Permian Basin, one of the worlds' largest production areas for oil and natural

gas. Although fossil fuel extraction began in the Permian Basin in the 1920s, it is expected to comprise a major component of U.S. oil and gas production for the next 20 to 30 years due to recent technological advances. As the extent and intensity of the energy sector increases in the region, so do the potential impacts to fish and wildlife.

Riparian Habitat

The Pecos River and its tributaries support one of the most biodiverse semiarid ecosystems in the world, playing host to fish and other aquatic species found nowhere else in the world such as the Pecos pupfish, Pecos gambusia, Rio Grande cooter and Texas hornshell. The riparian corridors of the Pecos also provide specialized habitat to riparian birds like Bell's vireo.

In New Mexico and across the border in Texas, there are several mainstem impoundments which serve to provide both irrigation and flood control, but which have altered the natural hydrologic flow regime. The river and its some of its major tributaries also support significant agricultural irrigation demands that stress water resources on the river. In many areas, the riparian habitat and the stream or tributary itself are just a few feet across, and even the main river channel can run dry. There are also significant impairments from invasive species such as tamarisk that threaten conservation outcomes if not addressed (Gregory *et al.* 2013).

Grassland Habitat

Just as the floodplain has been altered by human activity, so have the formerly vast Chihuahuan grasslands once found throughout the Pecos watershed. Migratory grassland birds like the chestnut-collared longspur fly up to 1,500 miles from their summer range on the Northern Great Plains to restricted wintering grounds in the southwestern U.S. and northern Mexico, while the iconic pronghorn are year-round residents (Ellison *et al*. 2017). These native grasslands have dwindled to just a fraction of their former extent and productivity. This puts pressure not only on the wildlife that inhabit these areas, but also on working ranches that need high-quality forage for livestock production. During a pronounced drought in 2012, the Trans-Pecos pronghorn population decreased to less than 2,700 individuals, an 80-year low (Gann *et al.* 2017).

Rio Grande Watershed

The Rio Grande is one of the iconic rivers of the American Southwest, flowing from high peaks in the Colorado Rockies through a rift valley. Today, the Rio Grande supports agriculture, industry, the cities of Albuquerque and El Paso, and many unique species.

In the Middle Rio Grande Valley, agricultural communities have relied on the river for irrigation for centuries, but increased demand and more frequent drought have caused stretches of the river to regularly run dry in recent decades. This poses a threat to species such as the silvery minnow, which depends on side channels and overbanking flows during flooding, and southwestern willow flycatchers, which inhabit the cottonwood-willow forest canopy supported by the river and shallow groundwater.

Upstream in the headwaters, the Rio Grande cutthroat trout require clear, cold water and intact stream corridors to thrive. Other native fish species, including the Rio Grande chub and Rio Grande sucker, also inhabit these tributaries. Efforts to improve and maintain riparian zones in headwater streams can support these important species, and their habitat benefits from the dam-building efforts of North

American beaver, whose numbers were dramatically reduced due to trapping, but which are now reentering parts of their former range. Maintaining healthy headwater streams can help store water upstream and provide security for water users, fish, and wildlife downstream.

Current Conservation Context

Despite the small human population of the region, there are a number of viable public and non-profit conservation entities committed to working here. In many cases, significant planning has occurred and local entities are seeking funds to implement their vision. For example, conservation priority documents have been produced for Chihuahuan Desert fishes (Desert Fish Habitat Partnership Workgroup 2008), pronghorn in Texas (Gray 2017), Texas hornshell in New Mexico (Carman 2007), silvery minnow (USFWS 2016), southwestern willow flycatcher (USFWS 2002), and Rio Grande cutthroat trout (Rio Grande Cutthroat Trout Conservation Team 2017). Conservation priority documents for still more focal species are in development (e.g. migratory grassland birds, Rio Grande chub and Rio Grande sucker).

Pecos River Watershed

State wildlife agencies in New Mexico and Texas are active and interested in pursuing conservation efforts in the Pecos watershed, but have had limited resources to implement conservation measures there. The region has been sparsely studied, and outside of a few species, much is yet to be learned about the region's fish and wildlife.

The U.S. Fish and Wildlife Service (USFWS) is active in the region, but like the state agencies, have not spent as much time and resources relative to other parts of New Mexico and Texas. Farm Bill programs administered through NRCS have supported extensive collaborations with private landowners, but which do not always have a wildlife focus. These conservation programs, such as the Environmental Quality Incentive Program (EQIP), have been used to protect perennial grass cover and incentivize better management. NRCS programs have also addressed water efficiency on agricultural lands. The Bureau of Land Management (BLM) has a significant presence in New Mexico, but less so in Texas, where there is relatively more private land. Since 2005, BLM has partnered with NRCS, conservation districts, local land managers, non-profits and the State of New Mexico to restore grasslands in southeast New Mexico.

Several non-profit conservation organizations are also active in the region, including Rio Grande Joint Venture, Borderlands Research Institute at Sul Ross State University, Bird Conservancy of the Rockies, and the Nature Conservancy.

Rio Grande Watershed

Substantial conservation investments, along with species research, have been made in the Rio Grande watershed in Colorado and New Mexico, where outdoor recreation, hunting and angling contribute significantly to local economies. Species like the Rio Grande cutthroat trout are a centerpiece of the region's fly fishing industry, while the riparian bosque forest in the Middle Rio Grande Valley is a highlight of local recreation.

In the Middle Rio Grande, species impacts due to water management actions are governed by the 2016 Biological Opinion on the silvery minnow, southwestern willow flycatcher and yellow-billed cuckoo (USFWS 2016). The need to provide adequate spawning habitat for silvery minnow, and to keep critical reaches of the Rio Grande wetted through the Middle Rio Grande Valley, have led to extensive

collaboration between the Middle Rio Grande Conservancy District (MRGCD) and federal, state, municipal, and non-profit partners, both in managing water resources and in planning for conservation measures. In a proactive attempt to understand how Middle Rio Grande flows are impacted by the Upper Rio Grande Basin, USBR, MRGCD, and U.S. Geological Survey are also partnering to produce the Upper Rio Grande Basin Study.

Partnerships like The Nature Conservancy's Rio Grande Water Fund and U.S. Forest Service partnerships with the private sector and non-profits have demonstrated promising new approaches that fund water quantity and quality investments in the headwaters region by proactively managing upland forests for water runoff and fire protection. This partnership has focused less on riparian habitat areas, but there are planning processes in place in both northern New Mexico and Colorado's San Luis Valley that prioritize aquatic and riparian conservation needs. Plans have been developed by a suite of partners including federal agencies (U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Bureau of Reclamation), state agencies (Colorado Parks and Wildlife, New Mexico Department of Game and Fish), and non-profit organizations (Trout Unlimited, The Nature Conservancy). The planning efforts of these partners have made the region ripe for investment in conservation projects on-the-ground.

In summary, significant planning on an individual species basis has already taken place in this landscape and many of the strategies for successful conservation activities are well known and tested. However, they generally lack the funding and conservation capacity to be implemented. With strategic funding focused on achieving measurable conservation outcomes, the Southwest Rivers Business Plan will fund conservation projects that reinvigorate degraded habitats and benefit wildlife.

Conservation Outcomes

The ultimate goal of this program is to benefit the focal species and overall ecosystem health of the habitat along the Pecos River and associated Chihuahuan grasslands and riparian and aquatic habitats in the Rio Grande. The focal species identified in this business plan were chosen in part to represent a number of important habitat types within the broader landscape, including: 1) headwaters (in the Rio Grande with North American beaver, Rio Grande chub, Rio Grande sucker, and Rio Grande trout); 2) tributaries, wetlands and associated sinkholes (Pecos River with Pecos gambusia, Pecos pupfish, and Texas hornshell); 3) mainstem river (Rio Grande with silvery minnow and Pecos with Texas hornshell); 4) riparian vegetation (Rio Grande with Southwestern willow flycatcher and Pecos with Bell's Vireo); and 5) Chihuahuan grasslands (Pecos with chestnut-collared longspur, Sprague's pipit, and pronghorn). Expansion to additional habitats and species within the watersheds may be considered as outcomes are achieved, lessons are learned, and additional funding arises.

Table 1. Species conservation Goals by focal geography and focal area

Pecos Watershed	
Pecos Riparian Habitat[+]	
Pecos gambusia	Establish 2 additional populations and secure 4 existing populations.*[‡]
Pecos pupfish	Establish 2 additional populations and secure 4 existing populations.*[‡]
Texas hornshell	Re-establish and expand 3 Texas hornshell populations within the Pecos River watershed.[‡]
Bell's vireo	Double the number of breeding pairs of Bell's vireo at Pecos riparian restoration sites.
[+]Two potential focal species (desert massasauga and Rio Grande cooter) are discussed in Appendix A. *A baseline survey of conservation needs at each site will be conducted where access is permitted. Sites will be "secured" by reducing the threat of the site drying up, and by either reducing the risk and/or impact of invasive fish. In addition to monitoring the focal species, monitoring of water quantity and quality and for the presence of invasive species will be needed. Other site-specific threats will be addressed on a case by case basis. The goals for these two fish species were informed using a 3-R approach (Appendix B). [‡]For more information about the populations and our anticipated approach to them, see Appendix C.	
Pecos Grassland Habitat	
Chestnut-collared longspur	Increase the mean bird density of chestnut-collared longspur at NFWF-funded project sites to greater than the baseline of 52.6 birds/100 acres.
Sprague's pipit	Increase the mean bird density of Sprague's pipit at NFWF-funded project sites to greater than the baseline of 1.17 birds/100 acres.

Pronghorn	Increase pronghorn populations in focal areas 20% over the regional baselines. Increase the acreage of grasslands occupied by pronghorn by 100,000 acres.
Rio Grande Watershed	
Rio Grande Headwaters	
Rio Grande chub and Rio Grande sucker	Increase by 10 the stream miles in which Rio Grande chub and/or Rio Grande sucker are present.
Rio Grande cutthroat trout	Increase the number of highly resilient[1] Rio Grande cutthroat populations in stream reaches where they are already present by 5. Secure 5 additional existing Rio Grande Cutthroat cutthroat populations from invasives.
North American beaver	Introduce beaver into 50 new stream miles.
Middle Rio Grande	
Silvery minnow	Increase recruitment and survivability of silvery minnow to achieve a population of greater than 1 fish per 100 m^2 of river. Increase the days of continuous flow in the Isleta and San Acacia reaches of the Middle Rio Grande in the summer by 10 days over the preceding 5-year average. Create 100 acres of silvery minnow spawning habitat to support the silvery minnow population.
Southwestern willow flycatcher	Achieve a 3-year moving average nest success rate for southwestern willow flycatcher of 30% or more at Middle Rio Grande riparian sites restored as part of this program.

[1] Populations with a modeled probability of persistence greater than 90% to the year 2080 are considered highly resilient (Rio Grande Cutthroat Trout Conservation Team 2013).

Geographic Focus

The Southwest Rivers business plan takes a multi-species approach to improve and sustain targeted habitat within the two focal geographies of the Pecos River and Rio Grande watersheds. Focal areas were selected for their importance to focal species within the targeted watersheds.

Table 2. Conservation focal areas by focal geography

Focal Geography	Focal Areas
Pecos Watershed	Riparian Focal Areas Pecos riparian focal areas (Figure 2) were selected for their importance to the four focal species in this plan. Two focal areas on the mainstem of the Pecos River encompass (1) Bitter Lake National Wildlife Refuge, Bottomless Lakes State Park and adjacent areas administered by Bureau of Land Management (northernmost orange polygon), and (2) the lower Pecos River from Independence Creek downstream to its confluence with the Rio Grande. The remaining focal areas are tributaries of the Pecos (in orange and blue). Priority tributaries (from north to south) are the Black River, Delaware River and Salt Creek. Additional priority tributaries in Texas are the Toyah Basin springs (also known as Balmorhea area springs or the San Solomon Springs System) and the Diamond Y Spring system. For more information about these focal areas in relation to aquatic species, see Appendix C. Two potential focal areas are also shown (in green, Figure 2), including tributaries west of the Pecos in New Mexico and Independence Creek in Texas. These areas require further investigation and targeted survey work within these areas to assess conservation potential may be funded. Grassland Focal Area The Pecos grassland focal area (Figure 3) includes the largest largest areas of grasslands in the region, largely defined by the occupied range of pronghorn as mapped by Texas and New Mexico as well as the Otero Mesa focal area identified by the Commission for Environmental Cooperation (2013).
Rio Grande Watershed	Headwaters Focal Area The Rio Grande headwaters focal area (Figure 4) includes headwater streams of the Rio Grande upstream of Cochiti Dam, encompassing parts of northern New Mexico and Colorado's San Luis Valley. Middle Rio Grande Focal Area The Middle Rio Grande focal area (Figure 4) includes the extent of the Middle Rio Grande Conservancy District (MRGCD), with special emphasis on the Isleta and San Acacia reaches of the Rio Grande mainstem.

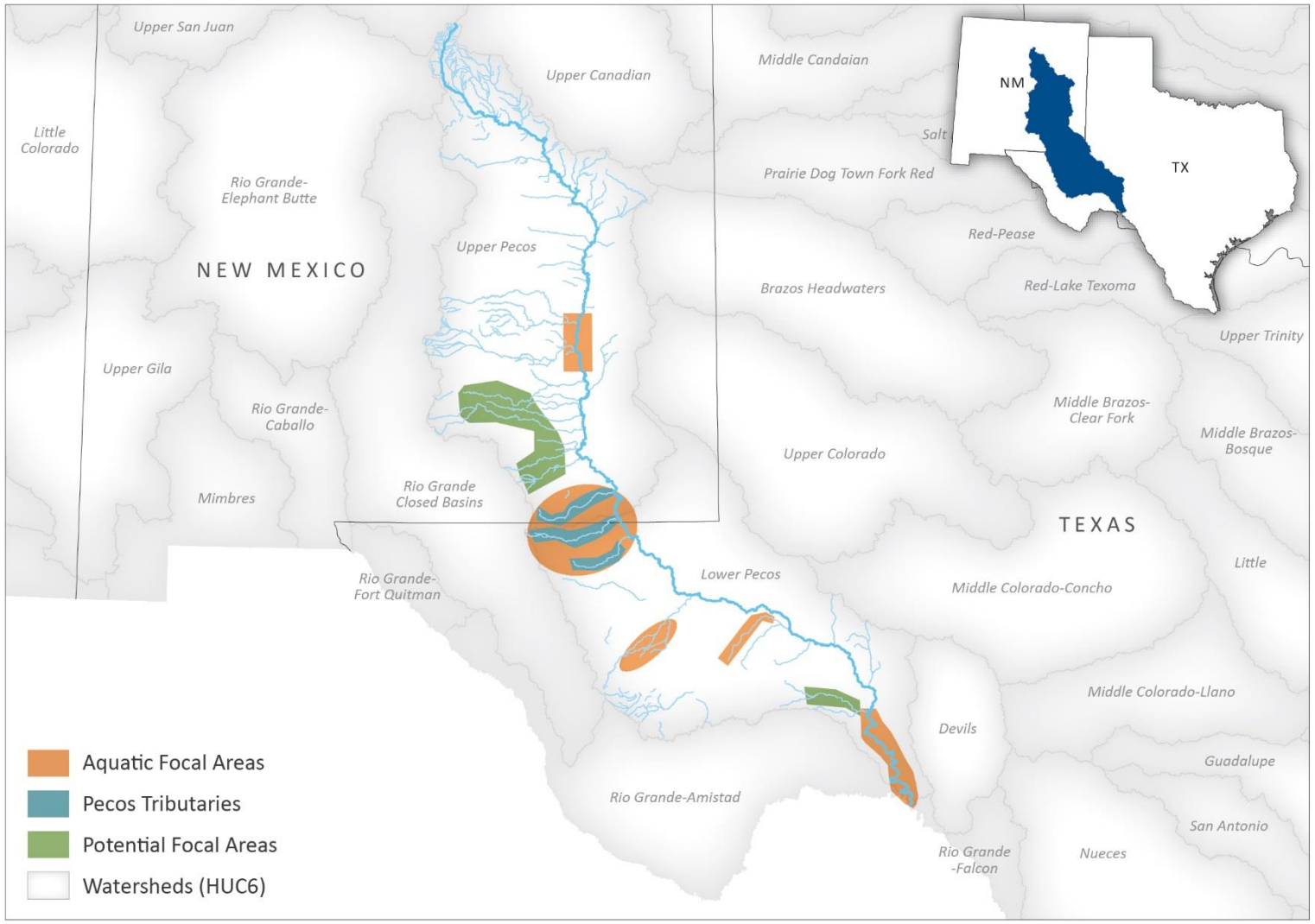

Figure 2. Pecos watershed riparian focal areas

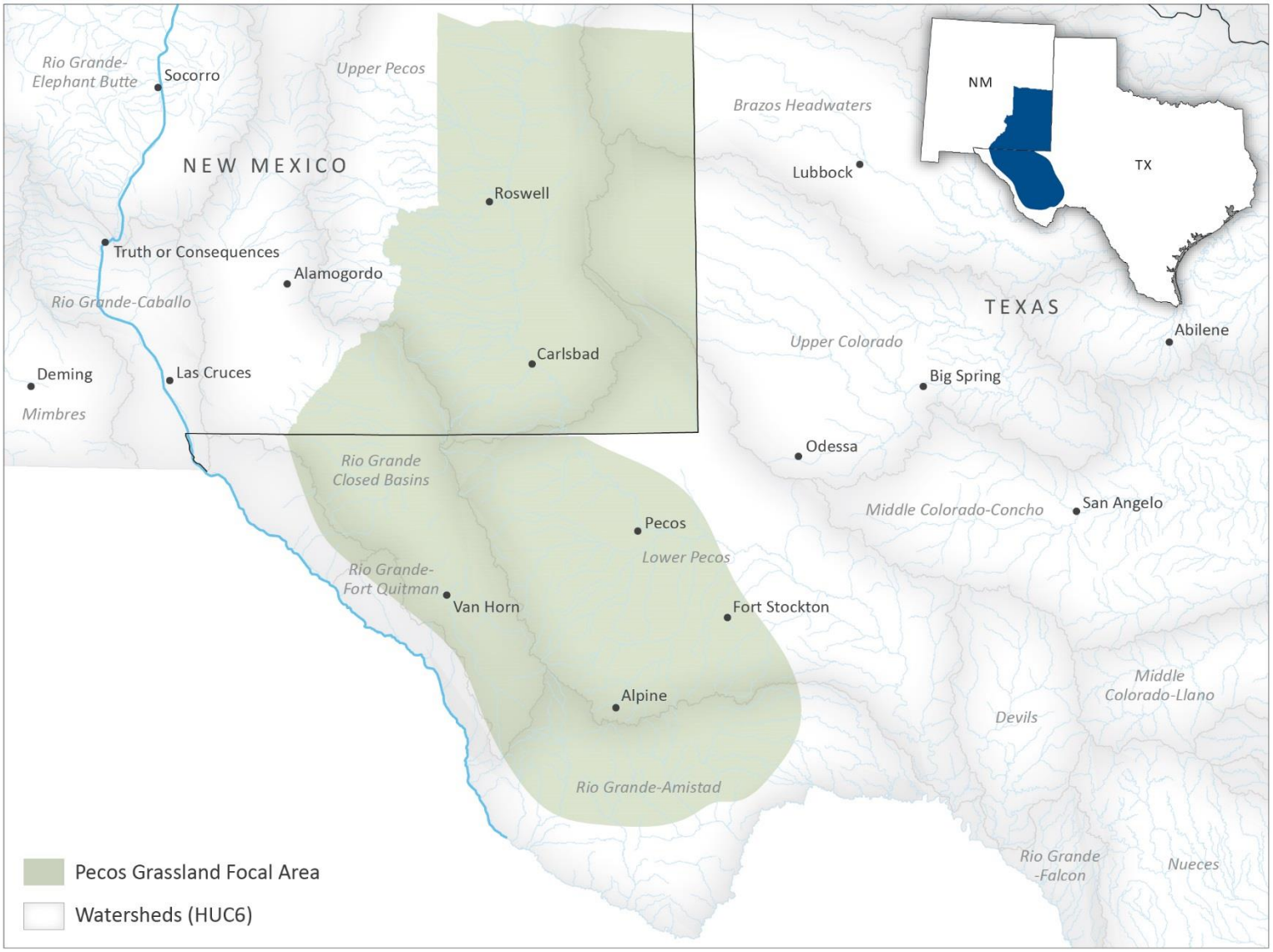

Figure 3. Pecos watershed grassland focal areas

Figure 4. Rio Grande watershed focal areas

Implementation Plan

NFWF will fund the following implementation strategies to support the southwest's terrestrial and freshwater species described in this Plan. The results chain in Figure 5 provides a model for how the collective strategies are anticipated to contribute to the identified conservation outcomes.

Strategy 1. Pecos Riparian Habitat Restoration and Enhancement

1.1 Riparian habitat restoration and enhancement – Restoring stream banks to increase floodplain connectivity and recruitment of native riparian vegetation.

Streambank re-contouring and planting – Where channel entrenchment has occurred, reconnect the floodplain and stream channel to restore and enhance riparian habitat for focal species. Plant native riparian plants where appropriate.

Support engineering design and analysis for riparian restoration projects – Make possible the necessary planning to implement riparian habitat restoration and enhancement projects.

1.2 Improve infrastructure – Road crossings, culverts and dams are often problematic for aquatic species. They can block organism passage, radically alter the hydrology and habitat, as well as be sources of unwanted siltation and contaminants.

Increase habitat connectivity – Removal or improvement to infrastructure at road crossings, culverts and dams that act as barriers to the movement of aquatic species.

Secure infrastructure to reduce unwanted inputs – Secure road crossings through sensitive aquatic habitat to prevent unwanted contaminant spills. Rework culverts and other road crossings when they cause undue siltation. In addition, address persistent point source contaminant inputs from infrastructure.

Support engineering design and analysis for infrastructure improvement projects – Make possible the necessary engineering design and analysis to implement infrastructure improvement projects.

1.3 Increase water quantity and quality for species and their habitats – Make available more water for environmental flows that are necessary to sustain species and their habitats, and improve the quality of that water where it will benefit focal species.

Implement infrastructure projects and improve management practices to limit salinity – Strategies may be employed that reduce salinity in tributaries and the Pecos mainstem to benefit Texas hornshell and other aquatic species.

Support the voluntary leasing or acquisition of water rights – Fund the leasing or acquisition of water rights to increase water availability to riparian species and habitat.

Increase in return flows from the adoption of water efficiency techniques and BMPs on agricultural lands – Support the voluntary shifting of agricultural practices and/or adoption of techniques to reduce water demand in agriculture, making more water available for riparian species and habitat.

Support source switch water use, whereby alternative sources of water supply are identified such that acute surface water reductions are avoided in areas that contain focal species – Strategies may be funded that shift the location of water withdrawal and/or use to increase local water availability to populations of focal species and their habitat.

1.4 Species-specific restoration and management – Restore and manage focal species whose range and population have declined.

Translocation of Pecos pupfish and Pecos gambusia – Translocate Pecos pupfish and Pecos gambusia to appropriate stream reaches with improved habitat or isolated aquatic environments to increase the redundancy of the populations overall (thus safeguarding the future of the species).

Establish Texas hornshell within the Delaware River – Translocate and create the necessary habitat conditions to establish a Texas hornshell population within the Delaware River.

Construct barriers to secure existing populations of Pecos pupfish and Pecos gambusia – Invest in barriers or other strategies to protect existing native fish populations from invasive species to stabilize current populations and prevent further decline.

Support capacity development for implementing species-specific management – Support capacity needed to develop and implement species-specific management projects.

1.5 Research data gaps for species and their conservation needs – Support research on species present in the Pecos River watershed about which not enough is known to implement conservation strategies, from their distribution and current numbers to their habitat needs.

Describe the distribution and current status of Rio Grande cooter throughout the Pecos River watershed, particularly within Texas – Support research to increase our understanding of Rio Grande cooter's habitat needs and distribution and threats so that conservation strategies may be identified (Appendix A).

Obtain a better understanding of the population of Texas hornshell in the Lower Pecos River and assess the feasibility of bolstering it with individuals and habitat improvements – Support research to increase our understanding of the Texas hornshell's distribution in lesser known parts of the Pecos watershed so that conservation strategies may be implemented in suitable areas (Appendix C).

1.6 Improve upland and riparian land management practices – Prevent channel erosion, siltation, and entrenchment by promoting stream-friendly agricultural land management on adjacent lands. This is essential for the health of the Pecos River watershed and is of particular importance for Texas hornshell.

Support implementation of landowner outreach programs – Fund landowner outreach programs to encourage participation in the Pecos watershed conservation strategies described in this plan.

Increase capacity for landowners to participate in best management practices – Provide resources for willing landowners to adopt best management practices to reduce impacts to focal species and their habitat from upland agricultural and ranching activities.

Strategy 2. Pecos Grassland Ecosystem Restoration and Enhancement

2.1 Grassland restoration – Studies and collar data have shown that pronghorn require large uninterrupted areas of grassland to thrive and that above a certain threshold of woody shrub density, pronghorn will not use otherwise suitable habitat. In many areas of the Pecos watershed, woody shrubs, particularly mesquite and creosote, have invaded former grasslands and both pronghorn and migratory grassland birds such as Sprague's pipit and chestnut-collared longspur have stopped using those areas. By focusing on shrub-invaded areas adjacent to existing grasslands occupied by pronghorn, the functional range of the species can be increased by achieving larger grassland patch sizes.

Increase the extent of grasslands that have been encroached upon by woody shrubs – Addressing woody shrub encroachment is analogous to restoration in other landscapes. In most areas, the best return from reversing encroachment will occur by reclaiming areas from woody shrubs, through chemical treatments, mechanical treatments or in some areas controlled burns. This restoration may be sustained through sound grassland management of grazing following restoration.

Support implementation of landowner outreach programs – Fund landowner outreach programs to encourage participation in the Pecos watershed conservation strategies described in this plan.

2.2 Increase grassland connectivity – Improvements in the connectivity of grasslands to allow for the seasonal movements of resident pronghorn within the species' range that are important for their survival.

Fence modification – Fence modification, removal and measures that allow for increased ability to cross bottlenecks such as road crossings are relatively simple solutions that can be instituted at scale. Often the simple removal of woven wire fences or the installation of a smooth bottom wire can allow safe passage for pronghorn (Jones *et al.* 2018). In many cases, the location of bottlenecks or problematic fences are well known and will be addressed. In other areas, the movements of pronghorn are not well understood and some research on pronghorn movement will inform strategic investment of future funding.

Support implementation of landowner outreach programs – Fund landowner outreach programs to encourage participation in the Pecos watershed conservation strategies described in this plan.

2.3 Improve grazing and range management practices – In large grasslands, management alterations and improved pasture infrastructure can yield impressive results on a landscape scale. Studies have shown that once behaviors are changed and positive results achieved, managers are likely to maintain those practices, even after financial incentives are removed (Ramsdell *et al.* 2015). Practices may include the introduction of rotational grazing, changed intensity and duration of grazing, and adoption of technology to deliver water, monitor range health and account for the impact such changes on livestock production.

Support implementation of landowner outreach programs – Support landowner outreach programs to encourage participation in the Pecos watershed conservation strategies described in this plan.

Increase capacity for landowners to participate in best management practices – Provide resources for willing landowners to adopt best management practices to reduce impacts to focal species and their habitat in upland grasslands.

2.4 Research data gaps for species and their conservation needs – Research species present in the Pecos watershed about which not enough is known to implement conservation strategies, including abundance and density estimates, demographics and habitat requirements.

Establish baseline population and demographic values for Sprague's pipit and chestnut-collared longspur – Fill targeted research gaps on species distribution, abundance and densities, measures of productivity, movements and habitat preferences, including restored lands and those where management prescriptions have been introduced.

Determine the taxonomic validity of desert massasauga – If confirmed, further work may be needed regarding its distribution, habitat needs and conservation status within the business plan footprint (Appendix A).

Strategy 3. Rio Grande Riparian Ecosystem Restoration and Enhancement

3.1 Increase water availability for species and their habitats – Make available more water for environmental flows that are necessary to sustain species and their habitats.

Implement a pilot water leasing program in the Middle Rio Grande – In order to recruit and sustain populations of silvery minnow, water for environmental use must be identified and deployed to stretches of the Rio Grande that now frequently go dry.

Support leasing or acquisition of water in the headwaters upstream of the Middle Rio Grande Pilot Water Leasing Program area – Fund the voluntary leasing or acquisition of water rights in Rio Grande headwaters and the mainstem upstream of Cochiti Dam to increase water availability to riparian species and habitat.

3.2 Riparian habitat restoration and enhancement – Restore stream banks to increase floodplain connectivity and recruitment of native riparian vegetation.

Streambank re-contouring and planting – Reconnect the floodplain and stream channel to restore and enhance riparian habitat for focal species. Plant native riparian plants where appropriate.

North American beaver reintroduction – By reintroducing beaver in headwater streams of the Rio Grande in a manner compatible with ongoing agricultural use and irrigation, both beaver populations and populations of Rio Grande chub, Rio Grande sucker and Rio Grande cutthroat trout dependent on the habitat created by beaver ponds will benefit.

Support engineering design and analysis for riparian restoration projects – Make possible the necessary planning to implement riparian habitat restoration and enhancement projects.

3.3 Water delivery infrastructure development – To deliver transacted water to riparian restoration sites, it may be necessary to design and construct new water delivery infrastructure, or improve existing infrastructure, within the MRGCD system.

3.4 Stream geomorphology restoration and enhancement – Restore and enhance stream channels that have suffered from channelization, thereby restoring the natural variety of stream substrate and flow patterns that benefit aquatic species life cycles. Specific activities may include stream channel engineering and bank re-shaping.

Instream restoration – Improve stream substrate and flow patterns through engineering to benefit Rio Grande chub, Rio Grande sucker and Rio Grande cutthroat trout throughout their lifecycle.

Removal of barriers to flow – Remove or improve infrastructure at road crossings, culverts and check dams that act as barriers to the movement of aquatic species to ensure habitat connectivity.

3.5 Species-specific restoration and management – Restore and manage focal species whose range and population have declined.

Introduction of Rio Grande chub and Rio Grande sucker – Translocation of Rio Grande chub and Rio Grande sucker to stream reaches with improved habitat will increase the number of stream miles in which they are present.

Introduction of Rio Grande cutthroat trout – Translocation of Rio Grande cutthroat trout to stream reaches with improved habitat will increase the number of stream miles in which they are present.

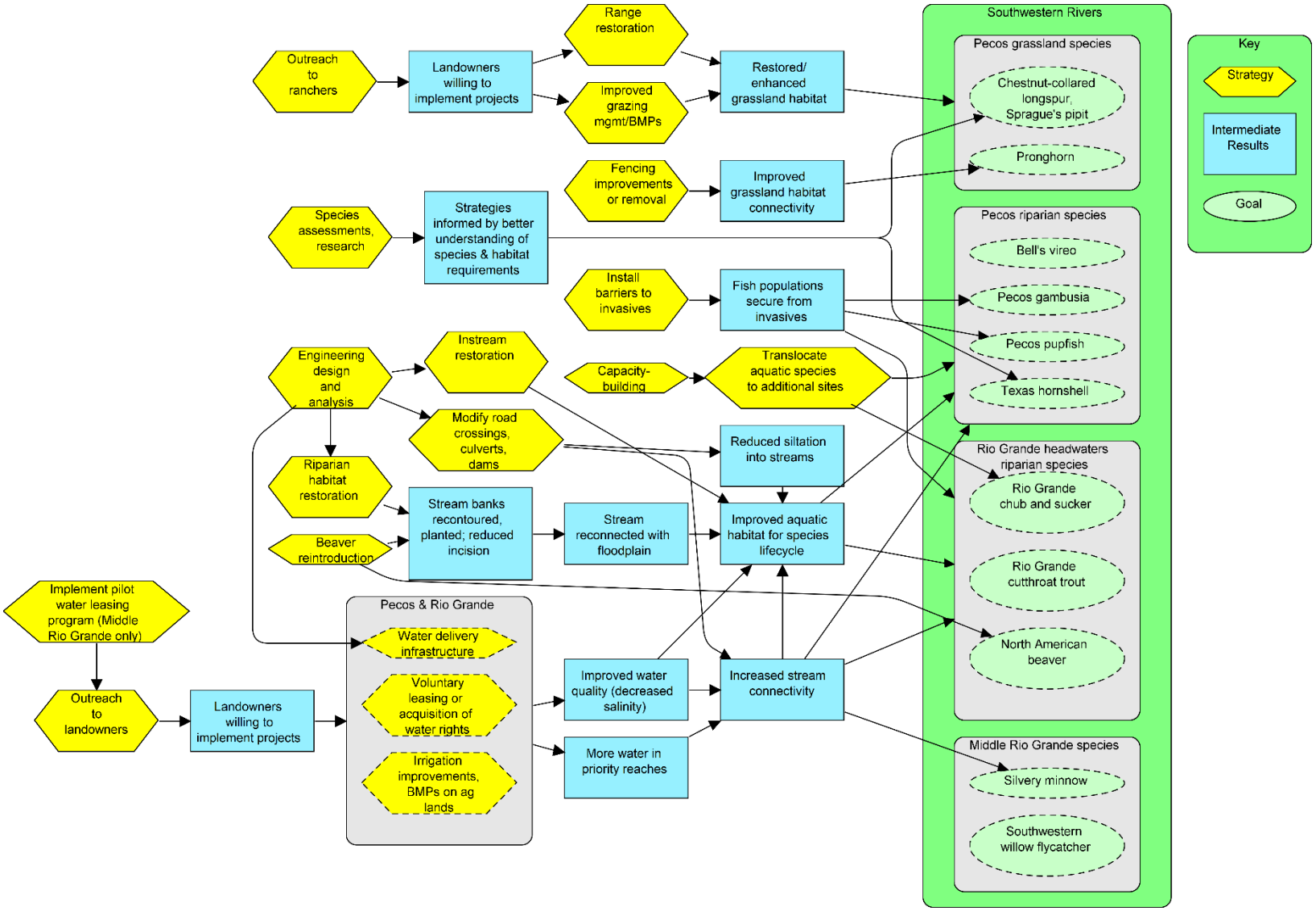

Figure 5. Results chain depicting the relationship of various strategies (yellow hexagons) within the business plan to each other, to the intermediate results (blue boxes) and ultimately to a goal for the target species (green ovals).

Risk Assessment

Risk is an uncertain event or condition which, if it occurs, could have a negative effect on a program's desired outcome. We assessed seven risk event categories to determine the extent to which they could impede progress towards our stated business plan strategies and goals during the next 10 years. Below, we identify potential risks and describe strategies to minimize or avoid those risks, where applicable.

CATEGORY	RATING	RISK DESCRIPTION	MITIGATING STRATEGIES
Regulatory Risks	**Low**	Ag policies in Northern Great Plains (NGP) and Mexico, where grassland birds spend parts of their lifecycle, may be the driving force behind conversion of grassland habitat. Changes to ESA and its implementation may impact motivation/ strategies of program partners. State water law regulating transactions to benefit habitat and species varies between states and can be onerous.	Plan goals take into account threats to migratory species outside of region. Habitat work in NGP program addresses grassland conversion there. Diverse portfolio of species in the plan include ones that are listed, of concern, and common. Fostering strong partner relations is an important aspect of program. Plan discusses need to work within existing state water law frameworks.
Financial Risks	**Moderate**	Funding, particularly from oil and gas companies, may not be stable, in part due to price volatility of fossil fuels.	Program will continue to maintain a diverse set of private and public partners, to minimize dependence on any one funder.
Environ-mental Risks	**High**	Prolonged and more frequent drought can negatively impact aquatic and grassland systems and delay implementation of strategies. A shift toward less snowfall in headwaters of these river systems will shift peak flow to earlier in the spring. Increased temperatures would threaten cold-water aquatic species, increase evaporative demand and decrease water availability.	Drought and water scarcity are major drivers of this program and inform the chosen strategies. Species metrics will work to compare to regional trends so that large scale drought events will be taken into account. Aquatic strategy is being applied in distinct focus areas, so any impact that does occur at one watershed may not impact the other watersheds.
Scientific Risks	**Low**	The genetics and life histories of some species in the plan are not well known.	Program will fund targeted research to address key information gaps.
Social Risks	**Low**	Landowners may be reluctant to engage in conservation actions, and gaining their trust and participation can take time. Pool of landowners for aquatic strategies is small; a few unwilling ones could pose a risk.	NFWF and implementation partners are making a deliberate effort to reach out to and include landowner-led groups in the program. NFWF will build upon experiences in other programs to accomplish this.
Economic Risks	**Moderate**	Expansion of oil and gas production into new areas may affect ongoing conservation efforts. Landscape fragmentation & habitat loss due to energy industry development may impact areas considered for funding.	Collaboration with energy industry partners can help direct conservation investments to areas with less development potential.
Institutional Risks	**Moderate**	Institutional support and technical capacity for conservation actions in Pecos watershed is constrained by other conservation priorities in New Mexico and Texas.	The business plan includes investment in greater organizational capacity, including personnel, to achieve the program goals.

Monitoring & Evaluating Performance

To track program performance and conservation outcomes, NFWF will monitor progress at the project and program scales. Table 3Table 3. Metrics for measuring progress towards conservation goals summarizes the core metrics for tracking progress towards stated conservation goals. A detailed description of monitoring and evaluation plans by focal geography and habitat type, including strategy-based metrics, is in Appendix D. Where possible, monitoring efforts will be coordinated across species and within each habitat category.

At a key stage in the program's lifecycle, NFWF will conduct an assessment or commission a third-party evaluation to examine the factors that have facilitated and hindered successful program implementation to inform future decision-making and adaptively manage. In some cases these course corrections may warrant increased investment; however, it is also possible that NFWF would reduce or eliminate support if periodic evaluation indicates that further investments are unlikely to achieve intended outcomes or conversely if goals are met ahead of schedule.

Table 3. Metrics for measuring progress towards conservation goals

	Goals	Metrics	Baseline (2018)	Target (2028)	Data source(s)
Strategy 1. Pecos Riparian Habitat Restoration and Enhancement					
Bell's vireo	*Double the number of breeding pairs*	# of breeding pairs	10	20	Grantee reporting
Pecos gambusia	*Secure existing populations*	# of populations secured	0	4	State, federal and university data with supplemental monitoring as needed
	Establish new populations	# of populations established	0	2	State, federal and university data with supplemental monitoring as needed
Pecos pupfish	*Secure existing populations*	# of populations secured	0	4	State, federal and university data with supplemental monitoring as needed
	Establish new populations	# of populations established	0	2	State, federal and university data with supplemental monitoring as needed
Texas hornshell	*Re-establish and expand populations*	# of populations	0	3	State, federal and university data with supplemental monitoring as needed

	Goals	Metrics	Baseline (2018)	Target (2028)	Data source(s)
Riparian habitat restoration	*Reconnect floodplain and reestablish native riparian vegetation*	# acres restored	0	50	Grantee reporting
Infrastructure improvements	*Reduce risk of point-source water quality impairment*	# projects executed	0	3	Grantee reporting
	Remove barriers to connectivity	# of stream miles opened	0	5	Grantee reporting
	Construct barriers to secure native fish populations from invasives	# barriers constructed	0	2	Grantee reporting
Improve upstream land management	*Expand implementation of BMPs upstream*	# of acres under improved BMPs	0	1,000	Grantee reporting
Environmental water availability	*Water acquisitions or leases*	Acre feet of water leased	0	500	Grantee reporting
	Water delivery infrastructure construction or modification	# projects executed	0	1	Grantee reporting
Species research	*Describe the distribution and current status of Rio Grande cooter throughout the Pecos River watershed, particularly within Texas*	# studies completed whose findings are reported to management	0	1	Grantee reporting
Outreach	*Communicate water leasing opportunities*	# individuals reached by outreach	0	50	Grantee reporting
	Engage volunteers in riparian restoration	# volunteers participating in projects	0	50	Grantee reporting
Strategy 2. Pecos Grassland Ecosystem Restoration and Enhancement					
Chestnut-collared longspur	*Increase the mean bird density to more than baseline for 5 years at project sites*	# of individuals/ 100 ac	52.6/ 100 ac	>52.6 /100 ac	Bird Conservancy of the Rockies
Sprague's pipit	*Increase the mean bird density to more than baseline for 5 years at project sites*	# of individuals/ 100 ac	1.17 /100 ac	>1.17 /100 ac	Bird Conservancy of the Rockies
Pronghorn	*Increase population*	% population increase over regional baseline	0%	20%	New Mexico Department of Game and Fish, Texas Parks and Wildlife Department
	Increased habitat usage	# of acres over baseline	0	100,000 acres	New Mexico Department of Game and Fish, Texas Parks and Wildlife Department
Increase landscape connectivity	*Fence barrier removal or modification*	Miles of fence removed or modified	0	50 miles	Grantee reporting
Grassland restoration and conservation	*Treat brush encroachment*	Acres restored	0	250,000 acres	Grantee reporting
	Improve grassland management	Acres under improved management (BMPs)	0	500,000 acres	Grantee reporting

	Goals	Metrics	Baseline (2018)	Target (2028)	Data source(s)
Species research	*Establish baseline population and demographic values for Sprague's pipit and chestnut-collared longspur*	# studies completed whose findings are reported to management	0	1	Grantee reporting
	Determine the taxonomic validity of desert massasauga	# studies completed whose findings are reported to management	0	1	Grantee reporting
Outreach	*Engage with landowners on best management practices*	# individuals reached by outreach, training, or technical assistance activities	0	100	Grantee reporting
	Engage volunteers in grassland restoration	# volunteers participating in projects	0	50	Grantee reporting
Strategy 3. Rio Grande Riparian Ecosystem Restoration and Enhancement					
North American beaver	*New stream miles occupied*	# of stream miles	0	50	Grantee reporting
Rio Grande chub and Rio Grande sucker	*Increase by 10 the stream miles in which Rio Grande chub and/or Rio Grande sucker are present.*	# of additional occupied stream miles	0	10	Colorado Parks and Wildlife, New Mexico Department of Game and Fish
Rio Grande cutthroat trout	*Increase resilient populations*	# of highly resilient populations increased	0	5	Colorado Parks and Wildlife, New Mexico Department of Game and Fish
	Secure populations	# of populations secured	0	5	Colorado Parks and Wildlife, New Mexico Department of Game and Fish
Silvery minnow	*Increase minnow density*	# minnows per m^2	0.16	≥1	Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers
Southwestern willow flycatcher	*Maintain breeding success*	3-year moving average nest success rate	Varies between 20-45% annually	30%	Bureau of Reclamation, U.S. Fish and Wildlife Service
Environmental water availability	*Water acquisions or leases*	New water transactions programs	0	1	Middle Rio Grande Conservancy District
	Water acquisions or leases	Acre feet of water leased	0	7,500	Middle Rio Grande Conservancy District

	Goals	Metrics	Baseline (2018)	Target (2028)	Data source(s)
	Water delivery infrastructure construction or modification	# projects executed	0	1	Middle Rio Grande Conservancy District
	Increase the days of continuous flow in the Isleta and San Acacia reaches	# of days of continuous flow more than preceding 5-year average	0	10	Bureau of Reclamation, Middle Rio Grande Conservancy District
Riparian habitat restoration	*Reconnect floodplain and reestablish native riparian vegetation*	# acres restored	0	10	Grantee reporting
	Riparian habitat restoration in the Middle Rio Grande	# of projects	0	4	Grantee reporting
Instream restoration	*Restore stream geomorphology to increase aquatic species habitat*	# stream miles	0	10	Grantee reporting
	Silvery minnow spawning habitat creation	# of acres over baseline	0	100	Bureau of Reclamation, Grantee
Outreach	*Communicate water leasing pilot program goals*	# individuals reached by outreach	0	200	Grantee reporting
	Engage landowners regarding beaver introduction	# individuals reached by outreach	0	50	Grantee reporting
	Engage volunteers in riparian restoration	# volunteers participating in projects	0	100	Grantee reporting

Budget

The following budget shows the estimated costs to implement the activities identified in this business plan. This budget reflects NFWF's anticipated engagement over the business plan period of performance; however, it is not an annual or even cumulative commitment by NFWF to invest. We acknowledge that in many cases the activities laid out in the plan build upon efforts funded by other organizations. This budget assumes that the current trajectory of funding by those other organizations continues over this program's time frame.

Table 4. Budget for Southwest Rivers Program Business Plan

BUDGET CATEGORY	Years 1-5 ($)	Years 5-10 ($)	Total ($)
Strategy 1. Pecos Riparian Habitat Restoration and Enhancement			
1.1 Riparian habitat restoration and enhancement	$1.25M	$2M	$3.25M
1.2 Improve infrastructure	750K	$1.75M	$2.5M
1.3 Increase water quality and quantity	$500K	$2M	$2.5M
1.4 Species-specific restoration and management	$500K	$1M	$1.5M
1.5 Research data gaps	$1M	$250K	$1.25M
1.6 Improve upland and riparian land management	$500K	$1M	$1.5M
1.7 Monitoring	$500K	$500K	$1M
Strategy 2. Pecos Grassland Ecosystem Restoration and Enhancement			
2.1 Grassland restoration	$1.25M	$2.75M	$4M
2.2 Increase grassland connectivity	$600K	$1.5M	$2.1M
2.3 Improve grazing and range management	$1M	$2M	$3M
2.4 Research data gaps	$750K	$350K	$1.1M
2.5 Monitoring	$400K	$400K	800K
Strategy 3. Rio Grande Riparian Ecosystem Restoration and Enhancement			
3.1 Increased water availability	$9.25M	$9.25M	$18.5M
3.2 Riparian habitat restoration and enhancement	$1.25M	$2M	$3.25M
3.3 Water delivery infrastructure development	500K	$750K	$1.25M
3.4 Stream geomorphology restoration	750K	$1M	$1.75M
3.5 Species-specific restoration and management	$500K	$1M	$1.5M
3.6 Monitoring	$250K	$250K	$500K
Other			
Communications and community relations	$100K	$100K	$200K
TOTAL BUDGET	**$22.6M**	**$31.35M**	**$53.95M**

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Appendix A

Potential Focal Species in the Pecos

For the purposes of this business plan we treat two species as prospective focal species for the Pecos focal geography: desert massasauga and Rio Grande cooter. Prospective focal species warrant funding under the business plan. However, with prospective focal species we recognize there are serious data gaps in terms of their distribution, conservation status, and actions needed to improve their status. Therefore, in the first years of the business plan NFWF will invest in filling data gaps regarding these species and re-assess the possibility of their becoming focal species by year five.

Desert Massasauga

Before NFWF considers desert massasauga a focal species, we need several information gaps to be filled. First and foremost, we would like to be certain of the taxonomic status of desert massasauga. Should it prove to be sufficiently distinct taxonomically, we anticipate funding survey work to further understand its distribution and abundance within the Pecos River watershed. This will likely be followed by research to investigate its conservation status, the relative importance of current / potential threats, as well as possible implementation strategies.

The taxonomic question

The massasauga *Sistrurus catenatus* has traditionally been viewed as being composed of three subspecies: eastern massasauga (*S. c. catenatus*), western massasauga (*S. c. tergeminus*), and desert massasauga (*S. c. edwardsii*) (Holycross *et al.* 2008). In 2010, WildEarth Guardians petitioned to list desert massasauga under the U.S. Endangered Species Act (ESA), where it remains under review. There is some question about the taxonomic validity of desert massasauga as a distinct subspecies eligible for protection under ESA. Kubatko *et al.* (2011) used multiloci data to determine that *S. catenatus* was actually two species: eastern (*S. catenatus*) and western (*S. tergeminus*). These authors also found support for western massasauga being composed of two subspecies (*S. t. tergeminus* and *S. t. edwardsii*). However, with increased sampling of the putative subspecies, Ryberg *et al.* (2015) concluded that *S. t. tergeminus* and *S. t. edwardsii* were genetically indistinguishable and did not warrant being treated as discrete taxonomic entities. The U.S. Fish and Wildlife Service is currently funding a project to settle this question definitively.

We plan to assess funding desert massasauga work once the taxonomic question is resolved. Of course, the conservation status and trend of the massasauga within the business plan geography is independent of its taxonomic status. But in a landscape with so many urgent conservation needs, prioritizing research into what may be a wide-ranging species relative to endemic species in peril could be difficult to justify.

Rio Grande Cooter

Rio Grande cooter is a potential focal species for NFWF. At present, the species is thought to be in need of the restoration of riparian vegetation, healthy stream flows, and improved watershed management. However, this is mainly based on common sense and other potential threats abound (e.g., pet trade, fish hooks, fire ants, racoon predation) (Pierce *et al.* 2016). In addition to uncertainty about the threats most limiting the species, there is uncertainty with regard to its current distribution, conservation status, and

methods by which to measure change in populations over time, especially outside the Devils River where water quality allows for effective snorkelling surveys. The species might be present in Bitter Lake National Wildlife Refuge in New Mexico, but this is unconfirmed. Rio Grande cooter is said to be absent from the mainstem of the Pecos River from the New Mexico state line southward into Texas to Independence Creek (Pierce *et al.* 2016). Thus, aside from an indeterminate sized population in Independence Creek there appears to be no record of the species in the Pecos anywhere in Texas.

In order to prioritize conservation efforts for Rio Grande cooter, surveys to determine the distribution of Rio Grande cooter within the Pecos watershed of Texas are needed along with an understanding of the current status of the population within Independence Creek. Further surveys for the species in Bitter Lake National Wildlife Refuge may be warranted, as well as the exploration of translocating individuals to the refuge (Pierce *et al.* 2016). Similarly, establishing a population at William S. Huey Wildlife Area, New Mexico could prove beneficial to the species. As with any conservation actions, including translocation, it would be useful to have an agreed methodology for monitoring populations over time. Mali *et al.* (2018) compared visual surveys with extensive trapping along the Black River. Results showed that even after hundreds of trap hours, new individuals were still being detected each day without any apparent levelling off in terms of captures. Mali *et al.*'s (2018) survey approach was more intense than we typically fund, yet it is not clear that even it would be sufficient (i.e., sensitive enough) to measure our progress towards goals for the species. Therefore, NFWF anticipates funding more work to understand current distribution of the species and to seek a survey approach that meets our needs while still being efficient.

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Appendix B

3-R Approach to Goal Setting for Focal Fish Species in the Pecos River Watershed

Populations of Pecos pupfish and Pecos gambusia are intraspecifically isolated, insecure, and of uncertain taxonomic distinctiveness. Before outlining priorities for these species we put them in the context of a standard planning approach. NFWF has relied on a 3-R approach in other business plans (e.g., Lahontan Cutthroat Trout – developed by Trout Unlimited and based on Shaffer & Stein 2000). Overall we would like to have a portfolio of investments that secures the species with 3-Rs in mind:

- Representation – saving existing elements of diversity;
- Resiliency – having sufficiently large populations and intact habitats to survive large disturbances and rapid environmental change;
- Redundancy – saving enough different populations so that some can be lost without jeopardizing the species.

Representation

No subspecies are known for either Pecos pupfish or Pecos gambusia. Pure Pecos pupfish populations (i.e., those that have not hybridized with sheepshead minnow, *Cyprinodon variegatus*) exist in the wild: in small numbers in the mainstem of the Pecos River in New Mexico from north of Loving to Bitter Lake National Wildlife Refuge, Bottomless Lakes SP and the associated BLM overflow area (NM), and the upper reaches of Salt Creek (TX) (PPCA 2013). None of these populations is known to be genetically distinct, though three morphological types have been shown to be associated with separate habitat types in New Mexico (Collyer *et al.* 2015).

There are four areas where Pecos gambusia exist: Bitter Lake National Wildlife Refuge (NM), Blue Spring (NM), Diamond Y Spring system (TX), and the Toyah Basin springs (also known as Balmorhea area springs or the San Solomon Springs System). Within some of these are small, isolated populations (e.g., several populated springs within a few square miles of each other). Initial studies of the four Pecos gambusia areas found them to be distinct (Echelle & Echelle 1986; Echelle *et al.* 1989), but advances in genetic techniques since these studies were conducted leaves the question of distinctness unresolved.

A better understanding of the degree of taxonomic distinctiveness among populations of both species of fish would be useful.

Resiliency

As mentioned previously, the Pecos River watershed has been highly modified. Through this plan, we aim to secure populations of Pecos pupfish and Pecos gambusia. However, no population of either fish is sufficiently large and secure, and none are likely to become so within the business plan timeframe.

Redundancy

For both Pecos pupfish and Pecos gambusia, we have a goal of adding two sites to increase redundancy. These additions will act as insurance populations within the Pecos River watershed. Previous insurance populations were created that have since vanished, which emphasizes the need to make them as secure as possible.

We also aim to secure existing sites. In the main text, we refer to securing sites as dealing with threats on a case by case basis. This is less ad hoc than it might sound. We are focused on invasive species and making sure suitable water remains for the species to persist. In areas such as the Toyah Basin springs, this may mean securing water flows to all of the local springs from the aquifer that feeds them (a suggested need in USFWS 2018). However, for Pecos pupfish in Bottomless Lakes State Park a more local effort might be required to keep a single pool from disappearing. In terms of invasive species, securing the pure strains of the two fish will require putting barriers in place. We have a goal of securing four sites for each fish species.

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Appendix C

Expanded Description of Pecos River Watershed Focal Areas for Aquatic Species

Pecos Gambusia

There are four areas where Pecos gambusia exist: Bitter Lake National Wildlife Refuge (NM), Blue Spring (NM), Diamond Y Spring system (TX), and the Toyah Basin springs (also known as Balmorhea area springs or the San Solomon Springs System, USFWS 2018a) (TX). Within some of these are small, isolated populations (e.g., several populated springs within a few square miles of each other). The Bitter Lake NWR is also important for Pecos pupfish and Blue Spring is in the headwaters of the Black River, which is important to Texas hornshell.

Pecos Pupfish

Roswell area public lands (NM): Pecos pupfish reside in springs and sinkholes of Bitter Lake National Wildlife Refuge, Bottomless Lakes State Park, and the Bureau of Land Management Overflow Area.

Salt Creek (TX): The only wild population of Pecos pupfish in Texas occur within Salt Creek, with pure stain individuals near the headwaters. Work to secure this population from invasive species, habitat restoration, and securing flows is needed.

Insurance populations: Additional sites for Pecos pupfish should be established (PPCA 2013). Some of the best opportunities for these are on private lands and still need to be identified.

Texas Hornshell

Black River (NM): Expand the range of Texas hornshell along the Black River. The section of the Black River containing Texas hornshell is confined to 8.7 miles between two lowhead dams (USFWS 2018b). Establish Texas hornshell within the Black River beyond this portion of the river and work towards safeguarding the population from further siltation.

Delaware River (TX, NM): Restore Texas hornshell to the Delaware River. Reintroduction of Texas hornshell to the New Mexico portion of the river has taken place, but a catastrophic event may have eliminated these individuals. Further translocation to the Delaware River as well as water quality improvements are needed.

Lower Pecos River (TX): Assess the population of Texas hornshell along the Lower Pecos River. Until recently, the last known report of a live specimen here dated from 1973 (Metcalf 1974). Indeed, Texas hornshell was thought to be extirpated from the Lower Pecos River (Karatayev *et al.* 2015).[2] However, three individuals were recently found (Bosman *et al.* 2016) and more survey effort is needed (Randklev *et al.* 2016). Work to restore this population, possibly with genetically-appropriate translocated individuals and water quality improvements.

[2] After describing what is known of the historical distribution of Texas hornshell in the Lower Pecos River, Karatayev *et al.* (2015) considered the species extirpated, but noted that there is a possibility that it still occurs based on a recently dead shell they found in 2010.

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