LANDOWNER Incentive Program

L.I.P. Bulletin

ANNUAL NEWSLETTER

TEXAS PARKS & WILDLIFE

TRANS PECOS SPECIAL EDITION

Highlighting the Trans Pecos ecoregion with a sampling of the conservation work and partnerships that have grown over the past decade

The Landowner Incentive Program (LIP) is administered by the Private Lands and Public Hunting Program of the Texas Parks and Wildlife Department Wildlife Division. In partnership with the TPWD Inland Fisheries Habitat Conservation Branch, LIP strives to meet the needs of private landowners wishing to enact good conservation practices on their lands for the benefit of healthy terrestrial and aquatic ecosystems. The LIP Bulletin is the venue for showcasing the great work of our landowner partners as well as providing program information and opportunities to get involved.

GARY GARRETT, UNIVERSITY OF TEXAS AT AUSTIN
RETIRED WATERSHED CONSERVATION PROGRAM DIRECTOR AT TPWD

A History of Cooperative Conservation in West Texas Watersheds

The Texas Parks and Wildlife Department has a long history of working with both governmental and private landowner partners on natural resource conservation in West Texas. With 97% of the land in Texas privately owned, involvement with the private landowners is not only sensible, but often the only way to achieve long-term conservation goals.

Conservation of our state's aquatic resources is particularly daunting and is exemplified by the fact that approximately 47% of the 190 native freshwater Texas fishes are now of conservation concern. In the Chihuahuan Desert region of Texas, 55% of the native fishes are of conservation concern or already lost to extirpation or extinction. Although there are numerous contributing factors, habitat degradation and loss are the primary culprits.

The Chihuahuan Desert of Texas contains some of the most remote watersheds in the state and a wide variety of habitats with many uniquely adapted plants and animals. These desert ecosystems are fragile and slow to recover, if ever, from disturbance. Deep downcutting of streams by erosion from overgrazing, reduced stream flow, non-native species, and extinction of native species may cause irreversible damage to these ecosystems. Under such conditions, droughts are even more devastating and amplify anthropogenic impacts. Droughts not only reduce rainfall magnitude and frequency, but also cause an increase in groundwater pumping for agricultural and municipal uses as surface waters abate. Such extreme conditions put stress on fish community equilibrium with more tolerant species gaining a competitive and numerical advantage. Tributary creeks tend to be impacted more severely yet are critical to the breeding and rearing of young of many of the indigenous species. These changes have been gradual and long-term, taking place since the mid-1800s, but their effects have been compounded over time and are now becoming dramatic.

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A fragile ciénega (desert wetland) in West Texas. These oases in the desert are associated with springs and have rapidly diminished in size over the last 100 years due to groundwater pumping. Photo by Megan Bean.

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Although the streams of our Chihuahuan Desert have suffered, some of the most heavily impacted habitats are spring-fed wetlands, known as ciénegas. They have been important not only to wildlife as a source of water and habitat, but also to man throughout his history. Unfortunately, these ecosystems are probably some of the most abused and damaged. It has seldom been intentional. Simply, water is rare in the desert and people want it for a variety of uses. The ways in which ciénegas have been destroyed include: 1) grazing and watering livestock, 2) draining to move water more efficiently to agricultural fields, and 3) overpumping aquifers. Of the more than 100 moderate (45–450 gallons/minute) and major (>450 gpm) historical springs, 50% no longer exist. Early records, some as far back as 1583, mention expansive ciénegas and abundant fishes. Exploitation of limited resources, particularly groundwater pumping, has degraded that environment, caused extirpation and extinction of species, and ultimately perpetuated the loss of habitats and ecosystems. The few relatively natural faunas and reasonably intact ecosystems that remain need careful management if they are to be preserved.

Effective partnerships to achieve this goal have going on for decades in Texas and two from the 1990s provide good examples of how long we have been at it and how effective they can be.

BALMORHEA CIÉNEGAS

In 1996, a cooperative effort among private, state, and federal entities enabled the creation of ciénega habitat for two federally endangered fishes, Comanche Springs Pupfish (*Cyprinodon elegans*) and Pecos Gambusia (*Gambusia nobilis*). The primary benefit to the fishes was a "natural" habitat critical to their survival, that had been eliminated through human modifications for agriculture and recreation. Benefits to area residents included: 1) relaxation of some pesticide regulations for farmers, 2) protection of the water supply, and 3) increased tourism.

Prior to human alterations, Comanche Springs Pupfish and Pecos Gambusia inhabited two large ciénega systems separated by approximately 50 miles, one fed by the Balmorhea springs complex (Phantom Lake, San Solomon, Giffin, and Sandia springs), and one by Comanche Springs in Fort Stockton. San Solomon Springs is the largest spring in the Balmorhea springs complex; it used to flow at about 23 million gallons per day, but flows are now reduced by more than 30%. The even larger Comanche Springs, in Fort Stockton, once flowed at more than 28 million gallons per day, but its perennial flows totally ceased by 1961 due to groundwater pumping.

More than 100 farmers depended on surface irrigation waters flowing out of Comanche Springs and the ciénega. Groundwater pumping by 18 landowners in an area west of Fort Stockton severely diminished the flows from the spring. The local water district sued these pumpers in 1952 in an attempt to establish its water rights. The pumpers prevailed in the lawsuit by basing their defense on a 1904 case from which had emerged the concept of "rule of capture." This concept established that a well owner could pump as much water as desired, regardless of the impact on the aquifer. This was also the case in which the Texas Supreme Court had determined that the intricacies of aquifers were so "secret, occult, and concealed" that it would be impossible to administer a set of protective rules. Ultimately, the flows of Comanche Springs ceased, the ciénega dried up, the native flora and fauna disappeared, the surface irrigators lost their farms, and their land reverted to desert.

Similarly, farmers also diverted water for agriculture from the Balmorhea springs complex and have been doing so since the mid-1870s. In 1915, the Reeves County Water Improvement District No. 1 was established and, with water from San Solomon and other associated springs, administered irrigation water

San Solomon Ciénega (left) and Clark Hubbs Ciénega (right) Photos provided by Gary Garrett

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Civilian Conservation Corps workers build the swimming pool at Balmorhea State Park.

for 12,000 acres of farmland. Ciénegas presumed to have supported large numbers of Comanche Springs Pupfish and Pecos Gambusia were drained and spring flows were diverted into an irrigation network of concrete-lined canals with swiftly flowing water and dredged, earthen laterals. This habitat is highly unnatural, ephemeral and wholly dependent upon local irrigation practices and other water-use patterns.

In the 1930s, the Civilian Conservation Corps modified San Solomon Springs into a large swimming pool at Balmorhea State Park. The work of this New Deal program enhanced the park's visitor services, but further disrupted the natural ciénega. Ciénegas, and their associated springs, provide habitat for a wide variety of plants and animals, some of which are endemic to these systems. Not only can ciénegas harbor unique species, but an entire community of interacting organisms also depends on these fragile habitats for survival.

When the original San Solomon ciénega was modified, and for the most part destroyed, the only "aquatic habitat" remaining was in the irrigation canals. Although better than no habitat at all, the irrigation canals provided a tenuous existence for some life forms. Some indigenous species, such as the Pecos River Muskrat (*Ondatra zibethicus ripensis*), did not adapt and were extirpated. The Comanche Springs Pupfish and Pecos Gambusia managed to survive in the canals, but their numbers were greatly reduced. Because of the loss of most of their natural habitat, both fishes are rare and on the federal and state Endangered Species lists.

People also suffer when their water sources vanish. Farmers who depended on surface irrigation water from Comanche Springs lost their livelihood when the springs went dry. Farmers in the Balmorhea area also rely on surface irrigation from springs, and if the aquifer was further diminished, local agriculture would certainly suffer. The effects on the rest of the community of Balmorhea would be devastating since they depend on the aquifer and the spring flows for everything from domestic water to tourism. Although state law would allow unrestricted pumping from the aquifer that supports the Balmorhea springs complex, one thing that can prevent over-pumping is the Federal Endangered Species Act. The Endangered Species Act protects the fish, the fish need the water, and as long as the water is flowing from the springs it also is available to humans. Through a pragmatic understanding of the basic relationship between the natural and human communities, biologists and Balmorhea community leaders chose to work together on a solution that would benefit all concerned rather than adopt adversarial roles. While the farmers had previously viewed the fishes as something that hampered and perhaps threatened their livelihood, they realized the fishes could be their best insurance for sustained spring flows.

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A plan was formulated to create a ciénega to look and function like a natural ecosystem. The agricultural community agreed to provide the essential water needed to create a secure environment for the endangered fishes. Water is a rare and precious commodity in West Texas, particularly for farmers, but by each of the users giving up a small amount, they would provide insurance for future water supplies. An additional benefit for the farmers was that, because of their help in creating preferred habitat for the endangered fishes, the Texas Department of Agriculture (TDA), U.S. Fish and Wildlife Service (USFWS), and U.S. Environmental Protection Agency (EPA) proposed a plan to allow benefits of the ciénega to offset any potential effects from pesticide use on farms that could impact endangered species in the irrigation canals. The fishes would have a better place to live and the farmers could continue to apply pesticides necessary to raise their crops. Biologists, engineers and resource managers from universities and government agencies joined forces to make the project work. The USDA Natural Resource Conservation Service provided soil analysis and, along with staff from TPWD, Texas Agricultural Extension Service, TDA, and the University of Texas, gave expert advice on some of the intricacies of the project. The expertise of the Texas Department of Transportation also was crucial. Their surveyors, design engineers and equipment operators transformed biological concepts into reality. The Texas Department of Criminal Justice provided inmates to build the Observation Deck and retaining walls as well as install plant materials selected for initial ciénega vegetation restoration. Botanists at Sul Ross State University provided native plants typical of desert wetland communities for the project. The one-of-a-kind window wall was designed, built, transported and installed by a beneficent concrete fabrication company located 300 miles away. Funding for San Solomon Ciénega was provided by grants from the Educational Foundation of America and National Fish and Wildlife Foundation. Additionally, fabrication costs for the window wall were provided by a TDA grant from the EPA and with contributions from the Texas Organization for Endangered Species.

In 1996, construction of the 2½-acre San Solomon Ciénega was completed. This wetland is situated on Balmorhea State Park land within the boundaries of the original, natural ciénega. As a result, the native fish fauna, including Comanche Springs Pupfish and Pecos Gambusia, have flourished. This location now provides a naturally-functioning habitat and contains the largest known concentration of Comanche Springs Pupfish.

Aquatic plants indigenous to ciénegas, as well as grasses and shrubs characteristic of the drier aspects of these desert wetland communities, were planted at the ciénega and now are well established. Many species of birds, reptiles and mammals began to use the new wetland almost immediately. These include Belted Kingfisher (*Megaceryle alcyon*), Black Phoebe (*Sayornis nigricans*), Swallows (*Petrochelidon* spp.), White-throated Swift (*Aeronautes saxatalis*), Green Heron (*Butorides virescens*), Swamp Sparrow (*Melospiza georgiana*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), Sora (*Porzana carolina*), Yellowthroat (*Geothlypis trichas*), Blotched Watersnake (*Nerodia erythrogaster transversa*), Spiny Softshell Turtle (*Trionyx spiniferus*), Slider (*Trachemys scripta*), Javelina (*Pecari angulatus*), and Desert Cottontail (*Sylvilagus audubonii*).

People of the local and regional community as well as state park visitors benefit from a living exhibit that shows the importance of the springs and their wetlands for fishes and other wildlife of West Texas. Because the primary purpose of the ciénega is to provide desert wetland habitat, visitor access is limited to only a small portion of the total restoration. However, TPWD has tried to maximize the aesthetic and educational experiences available at locations accessible to the public. The observation deck provides an unobstructed view of most of the above-water portion of the ciénega, and the clear water allows viewing of much of its underwater life. The window wall was custom designed for San Solomon Ciénega so that visitors would have a view that few have seen – life in the ciénega as its aquatic residents see it.

Creation of the San Solomon Ciénega was accomplished through willing participation of diverse entities with a common goal of mutual benefit. The project was so successful that TPWD created an additional ciénega, Clark Hubbs Ciénega, in 2011.

DEVILS RIVER MINNOW CONSERVATION AGREEMENT

A Conservation Agreement among the city of Del Rio, TPWD, and USFWS was implemented in 1998. Due to the cooperative efforts outlined in the Agreement, Devils River Minnow (*Dionda diaboli*) was listed as threatened rather than endangered in 1999. The Agreement detailed a five-year plan of research and conservation actions designed to resolve the threats to the Devils River Minnow and lead to its ultimate recovery and de-listing. Benefits included protection of water quality and quantity in the Devils River and adjacent streams for both fish and people, and creation of a

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greenbelt/stream corridor along San Felipe Creek in the city of Del Rio that would not only provide quality habitat for fishes, but also a nature-friendly, city park and potential for increased tourism.

The Devils River is one of the most pristine rivers in southwestern North America and San Felipe Springs is one of the largest spring systems in the state. Due to the geographic location and historical stability, the Devils River and San Felipe Creek sustain many endemic organisms. In addition to numerous species of conservation concern, the area is home to seven federally and/or state listed species of fish: Proserpine Shiner (*Cyprinella proserpina*), Devils River Minnow, Mexican Blindcat (*Prietella phreatophila*), Blotched Gambusia (*Gambusia senilis*), Spotfin Gambusia (*Gambusia krumholzi*), Conchos Pupfish (*Cyprinodon eximius*), and Rio Grande Darter (*Etheostoma grahami*).

The Devils River Minnow is known to occur in the Devils River, San Felipe Creek, and Sycamore Creek in Val Verde County, and Pinto Creek in Kinney County. Historically it also occurred in nearby Las Moras Creek, Kinney County, but was eliminated from that locality sometime before 1980.

A survey in 1953 showed Devils River Minnow was the fifth-most abundant fish species at Baker's Crossing and the sixth-most abundant fish in the upper Devils River. In the mid-1970s, it remained the sixth-most abundant fish in the Devils River. During 1988 to 1989, a survey of 25 locations throughout the historical range in the United States yielded a total of only seven individuals: Devils River = 2; San Felipe Creek = 3; Sycamore Creek = 2. Numbers had declined such that it was rare where it occurred at all and was probably the least abundant of the approximately 30 species that occurred in these streams. In 1979, Devils River Minnow was relatively abundant at the Head Spring area of San Felipe Creek. In 1989, there were none.

Many springs in the area have diminished flows and some have totally stopped (e.g., Beaver Springs, Juno Springs, and Dead Man's Hole), thus reducing the overall length of the Devils River as well as the quantity of water flowing in it. Many of the area streams that were perennial in the early 1900s, no longer flow. In the Devils River, U.S. Geological Survey data from the Pafford Crossing gaging station revealed a general decrease in daily mean discharge for the period between the mid-1970s fish survey and that of the late 1980s. The Devils River Minnow may have suffered from biological threats as well. Numerous non-native fishes had become established in the area, including Common Carp (*Cyprinus carpio*), Redbreast Sunfish (*Lepomis auritus*), Smallmouth Bass (*Micropterus dolomieu*), and Blue Tilapia (*Oreochromis aureus*).

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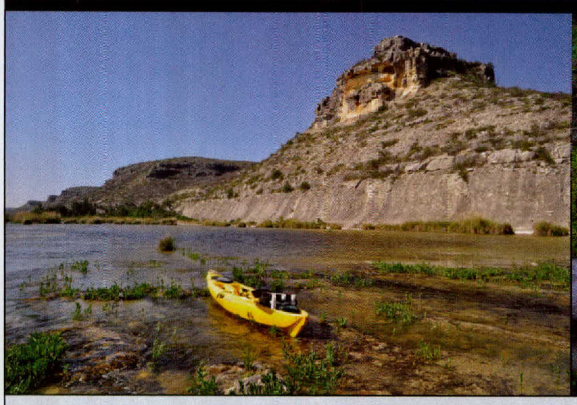
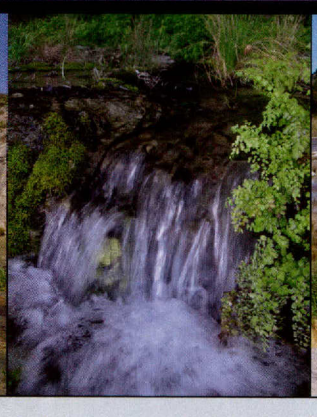


The Devils River is one of the most remote watersheds in Texas. This region is threatened by groundwater withdrawals which reduce spring flow and the amount of water in the river.



Spring on the Devils River (left). Springs provide baseflow to rivers across the state but are especially important in desert environments. Dolan Falls on the Devils River (right). Photos by Megan Bean.

Much of the water for San Felipe Creek comes from two large springs (San Felipe Springs) within the city of Del Rio. The city also gets its municipal water supply from San Felipe Springs. Conserving the quantity and quality of water from the springs is critical for both the Devils River Minnow and citizens of Del Rio. The USFWS had originally proposed the Devils River Minnow for listing as threatened in 1978 with critical habitat proposed for portions of San Felipe Creek and the Devils River but withdrew the proposal in 1980 and retained its designation as a candidate species. The USFWS published a new proposal to list the Devils River Minnow as endangered in March 1998. During the period 1997 to 1998, TPWD worked with USFWS, Del Rio, and private landowners to develop ways to protect the minnow. Landowners and city officials feared repercussions of listing the fish as endangered and came to understand that a cooperative approach to restoring and protecting the ecosystem would be the best for all concerned.

The Devils River Minnow Conservation Agreement was signed by the USFWS, TPWD, and the city of Del Rio in September 1998. TPWD worked closely with city officials and local landowners to develop conservation actions that were beneficial to the species. Those actions in the Agreement included determining the current status of the species throughout its range, protection of the San Felipe Creek watershed, providing technical assistance to landowners on riparian protection and management, and revising live bait use regulations in the Devils River area to prevent the further establishment of non-native, aquatic species.

The Conservation Agreement provided a positive incentive for cooperative actions by all parties and yielded improved science on resource conservation needs. The primary motivation for the Conservation Agreement was to remove threats to the Devils River Minnow to the degree that protection under federal law was not necessary. The USFWS carefully considered the Agreement and to what extent it had been implemented at the time the listing decision was due. The USFWS concluded that with an accelerated implementation schedule, a listing determination of threatened rather than endangered would be appropriate.

These early partnerships, and the many more that have been developed since, provide a positive, non-contentious means to restore and protect some of the natural resources that are so important to all Texans. Currently, the Texas Parks and Wildlife Department and the University of Texas are working on Native Fish Conservation Areas in the Chihuahuan Desert as part of a statewide network of focal watersheds that represent native fish strongholds and serve as priority areas for conservation of Texas freshwater fish diversity. This is a holistic, multi-species, and habitat-based approach to native fish conservation that generates coordination among land owners, non-governmental organizations, state and federal agencies, universities, and local governments to achieve landscape-scale conservation within focal watersheds. The goal is to restore or protect wild, naturally-produced, self-sustaining populations and functional watersheds that can be maintained by sustainable management.

This approach to native fish conservation not only provides an effective method for addressing the common nature and magnitude of threats facing species and their habitats in freshwater systems, it delivers long-term benefits to all the natural resources of the citizens of Texas.

COLLABORATION

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AIMEE ROBERSON, RÍO GRANDE JOINT VENTURE COORDINATOR
OCTAVIA SANCHEZ, ENVIRONMENTAL CONSULTANT WORKING OUT OF MUZQUIZ, COAHUILA

Habitat Restoration in the Big Bend and Northern Mexico: Success through Binational Collaboration, Partnerships, and Diversity

"The Rio Grande/ Bravo does not divide us, it brings us together."

"The Rio Grande/Bravo does not divide us, it brings us together," noted Carlos Alberto Sifuentes (Comisión Nacional de Áreas Naturales Protegidas (CONANP), Mexico) at an annual binational Rio Grande/Bravo (RGB) planning meetings. Given that his involvement along the river began over 15 years ago, Carlos may be best positioned to talk about the binational collaboration that is taking place in this region. Indeed, the binational region of Big Bend is a star when it comes to binational collaboration. Even if we compare the work taking place in this binational watershed to similar work taking place in our more famous partner binational watershed to the west – the Colorado River watershed, whose binational work gained prominence as a result of the international pulse flow event in 2014 – the depth of collaboration along the RGB is more integrated and intimate, involving a host of Mexican and U.S. public and private agencies,

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Representatives from CONANP, Profauna, U.S. National Park Service, Profauna, RGSSS, and WWF – a small fraction of the agencies, institutes, organizations, and citizens who are collaborating on managing the natural resources of this remarkable binational region. Photo by Days Edge Productions.

organizations, institutes and communities who work hand-in-hand to manage the natural resources of this amazing binational region.

The depth of binational collaboration is underscored by a vision statement for the Big Bend reach of the RGB that came out of a 2008 binational workshop that was attended by 15 state and federal agencies, NGOs, and institutes from Mexico and U.S. The vision statement, which sets the tone for collaboration in this region, affirms:

> **We, the citizens of the two nations that straddle the Rio Grande/Rio Bravo, as well as the participants of the binational BIG BEND RIO GRANDE/RIO BRAVO WORKSHOP pledge to form a binational task force whose goal is to preserve, enhance and restore the riverine ecosystem and freshwater biodiversity of the Rio Bravo/Grande, from the Rio Conchos to Lake Amistad, for the benefit of humans and nature.**

Since the 2008 workshop, the strength and diversity of binational collaboration has only increased. Consider the partnerships involved in managing exotic vegetation along the river and restoring native riparian vegetation along local tributaries (this work is highlighted in complementary articles in this newsletter). On the Mexican side of the river in the states of Chihuahua and Coahuila, work is led by CONANP, Profauna and Pronatura Noreste (both national Mexican-based NGOs), consultants working with CONANP, World Wildlife Fund-Mexico, and work crews consisting of citizens from such riverside towns as San Vicente, Paseo de San Antonio, Boquillas de Carmen. On the U.S. side in Texas, we have personnel from Big Bend National Park, Texas Parks and Wildlife Department, Natural Resources Conservation Service, Texas A&M Forest Service, Rio Grande Joint Venture staff employed by the American Bird Conservancy, Rio Grande Science Support Services (Terlingua-based consultant), and Fred Phillips consulting, Inc. (based in Flagstaff, Arizona) with work crews of local citizens from Alpine and Terlingua. Work on both sides of the river is supported by funding from a variety of sources, including the National Park Service, CONANP, the National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, Natural Resources Conservation Service, the National Fish and Wildlife Foundation, as well as such private foundations as Fundación de Carlos Slim, the Dorris Duke Foundation, Dixon Water Foundation, and the Coca-Cola Foundation. This work is highly coordinated and integrated. Binational team members meet regularly to identify priority needs, develop and review work plans, and schedule the implementation of management actions. Personnel from Mexico working hand-in-hand with personnel from the U.S. has become the standard for managing this treasured binational river.

In 2011, the Commission for Environmental Cooperation selected the binational partnership for funding support. The trilateral organization established under NAFTA injected more than a million dollars into the partnership, funding Rio Grande monitoring, park organizational studies for Mexican protected areas, a binational conservation assessment, and finally a

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binational stream restoration project. The paired stream restoration projects, one in Terlingua Creek and one in San Carlos creek, led to other projects in the area, including San Antonio Creek in Mexico and Alamito Creek in Presidio.

Significant conservation work is taking place along such tributaries as Terlingua Creek, San Antonio Creek among others, through collaboration with private partners such as the O2 Ranch, 3 Bar Ranch, John Morlock, and the communities of San Antonio, San Vicente, Norias de Boquillas, and Boquillas del Carmen, underscoring further the public-private nature of the binational collaboration picture. From a private lands perspective, this diversity of federal, state, and non-profit organizations gives private landowners multiple options to choose from when exploring opportunities to restore their property. The landowners and organizations all agree that this collaboration of players is a major strength and one of the keys to our success in implementing a wide array restoration projects across the region.

From a private lands perspective, this diversity of federal, state, and non-profit organizations gives private landowners multiple options to choose from when exploring opportunities to restore their property.

The science and monitoring efforts taking place in this region are equally diverse and binational. Sul Ross State University (Alpine, Texas) and Utah State University (Logan, Utah) have been involved for years in a variety of investigations regarding the biophysical conditions and trends of the river and its tributaries. Professors from La Universidad Autónoma Agraria de Antonio Narro (Saltillo, Coahuila) have conducted studies on the distribution and extent of key plants in this binational region as well as the spread of the salt cedar leaf beetle in northern Mexico, and the Universidad Autónoma de Chihuahua (Ciudad Chihuahua, Chihuahua) has conducted a variety of hydrologic studies in the Rio Conchos, which is the Rio Grande/Bravo's largest tributary. Researchers from Texas Tech University are currently studying raptors and yellow-billed cuckoos that live in the riparian habitat along the tributaries of the Rio Grande/Bravo and are working with the Texas Parks and Wildlife Department to develop monitoring protocols to help us understand the response of birds to restoration projects. (Please see accompanying article in this newsletter on monitoring).

Finally, the completion of several recent initiatives shows great promise for continued strong binational collaboration in the years to come:

- **Binational Monitoring:** In 2017, a collaborative Sister Park effort led by Big Bend National Park, White Sands National Park, protected areas managed by CONANP, and WWF strengthened collaboration between NPS and CONANP on monitoring the status and trends of this region's natural resources.
- **Basin-Wide Water and Natural Resource Conservation Priorities:** In November 2017, a binational Forum in El Paso that was organized by personnel from the Coca-Cola Foundation, Desert Landscape Conservation Cooperative, Instituto Mexicano de Tecnología del Agua, Rio Grande Joint Venture, Tecnológico y de Estudios Superiores de Monterrey, South Central Climate Science center and WWF identified water and natural resource conservation priorities basin-wide.
- **Bird Conservation:** Finally, the Rio Grande Joint Venture, a binational, public-private partnership conserving bird habitats has identified riparian areas as a priority in the Big Bend region and is working with partners on both sides of the border to increase knowledge and capacity to implement restoration projects.
- **Community-Based Work:** Work led by CONANP, Mexican-based consultants like Octavia Sanchez (one of the authors of this article), and local citizens, with support from WWF and the Coca-Cola Foundation, have installed over 23 water catchment systems in the riverside towns of El Paseo de San Antonio, San Carlos, Nuevo Lajitas, Jaboncillos Grande, San Vicente, Los Lirios, El Jardín, Norias de Boquillas and Boquillas del Carmen where the development of water infrastructure in response to water scarcity is a high priority.

As we consider the level of collaboration on this region's precious natural resources, it is a fair statement that there may not be a comparable example in the world of such strong integrated binational collaboration of a shared resource. This is collaboration built on strong personal relationships that is making a real difference in the conservation of this region's natural resources and the lives of its citizens.

TERLINGUA CREEK

SUE HARVISON, OWNER OF THE 3 BAR RANCH

My Landowner Incentive Program Project on Terlingua Creek

What a wonderful experience it has been working with the collaborative efforts of Texas Parks and Wildlife (TPWD), World Wildlife Fund (WWF), USFWS Partners Program and Rio Grande Scientific Support Services (RGSSS) at our ranch in Terlingua, part of the Big Bend area of Texas.

Being involved with these folks that are so knowledgeable and passionate about their mission has been an extraordinary journey. The love of nature and conservation was apparent with the staff and all that worked with the LIP project, which includes Russell Martin, Arlene Kalmbach, Mark Briggs, Jeff Renfro and many others.

I fell in love with the Big Bend the first time I laid eyes on it back in the early seventies. My husband had purchased the 3 Bar Ranch property back then but didn't think that I would like to go there particularly. As luck would have it, I accompanied him on a trip there and it was love at first sight. The beauty of all the things that nature provides in the desert along with the backdrop of the mountains was glorious. I have been going there as often as I can since that first trip in the 1970s.

I first learned about TPWD conservation efforts while taking a river trip down the Rio Grande to Santa Elena Canyon. Our guide explained that the work being done along the river was part of a collaborative project including multiple federal and state agencies as well as non-profit organizations. I expressed an interest in learning more about what all was being done in the Big Bend area. I was later contacted by the staff about the Landowner Incentive Program which I became involved with on my ranch.

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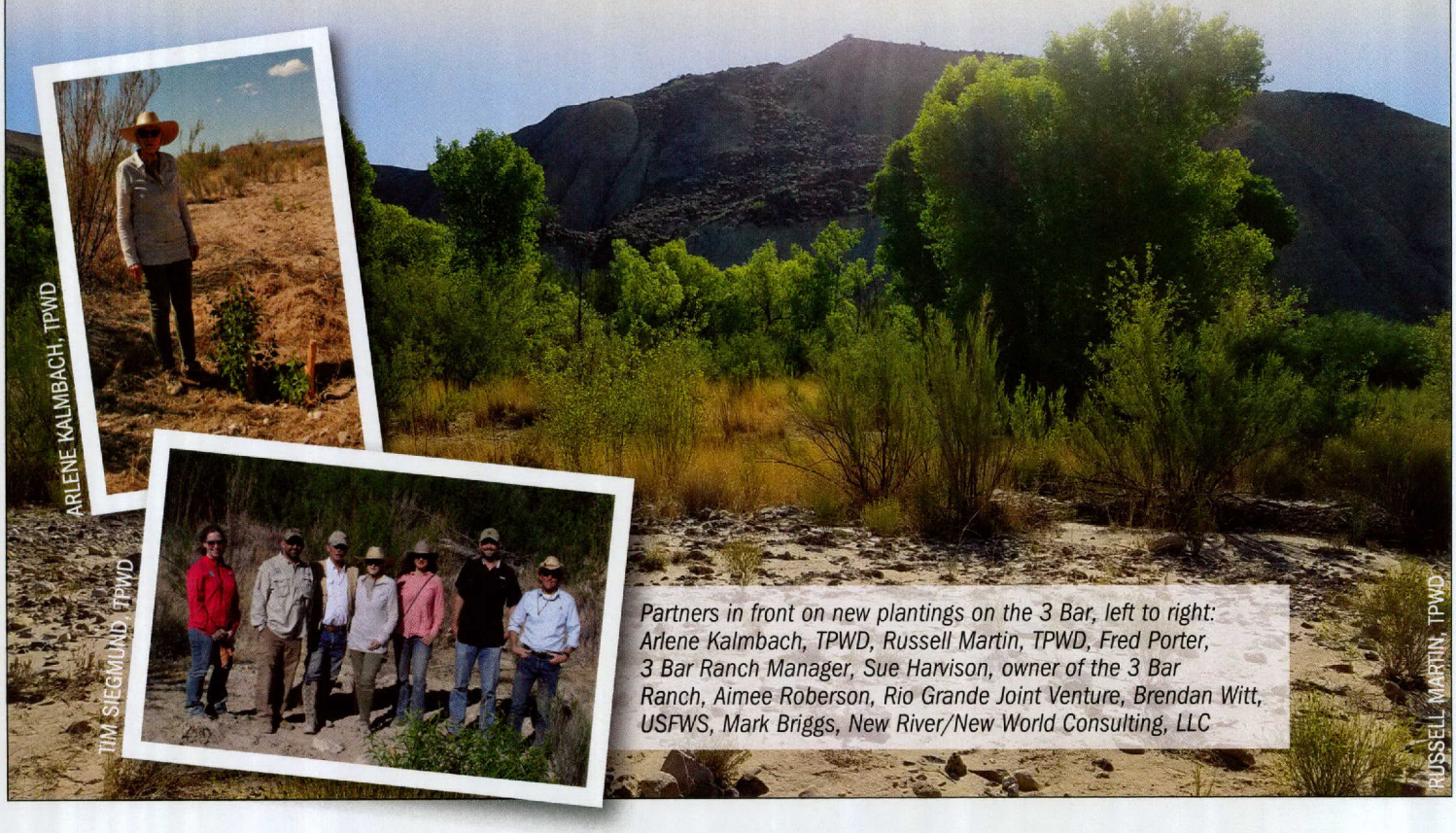

ARLENE KALMBACH, TPWD

TIM SIEGMUND, TPWD

RUSSELL MARTIN, TPWD

Partners in front on new plantings on the 3 Bar, left to right: Arlene Kalmbach, TPWD, Russell Martin, TPWD, Fred Porter, 3 Bar Ranch Manager, Sue Harvison, owner of the 3 Bar Ranch, Aimee Roberson, Rio Grande Joint Venture, Brendan Witt, USFWS, Mark Briggs, New River/New World Consulting, LLC

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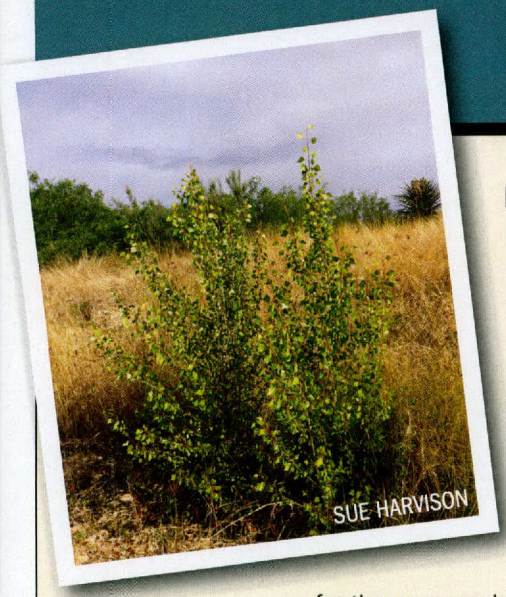

Russell Martin, Trans Pecos Diversity biologist for TPWD, explained to me that the program was involving landowners along Terlingua Creek for the purpose of riparian re-vegetation to enhance habitat for the many varieties of migrating birds and even the federally threatened yellow-billed cuckoo that thrives in the cottonwoods. It would improve the quality of the creek for all the desert wildlife and would involve planting cottonwoods and willows along the banks to help bring it back to its original state before the days of mining. During the early 1900s most of these trees had been cut down to use in the furnaces to melt the ore at the mercury mines in Terlingua.

The process of reestablishing trees to the creek involved cutting branches from our existing cottonwoods and willows, soaking them in water from the creek for a week to take root, and then planting them in strategic places where there would be a reliable supply of water. Test holes had been dug along the creek to determine the locations of the ground water. They ended up planting 1,271 tree branches! There is approximately seven miles of creek on the 3 Bar Ranch so it was an ambitious undertaking!

In addition, they eradicated 2,236 salt cedars to give the new plantings a better chance to survive as well as the existing trees along the creek. Salt cedars are not native and have been a problem because they compete for resources with native trees and plants. All of this has been such an interesting process – particularly seeing that the results have been very successful. The plantings leafed out and began to grow over a period of just a few weeks. It has been fun to watch them progress!

Through the efforts of Texas Parks and Wildlife and their partner organizations, I have learned so much about the value of reestablishing the natural habitat for all the various types of wildlife. More shade for the creek helps to reduce evaporation and means more water will remain in the creek which is so vital in the desert. The LIP project has been important in helping to make the desert a more thriving habitat for all the wildlife that lives and survives in the desert.

I can say that it has been a most meaningful experience working with these conservationists that seem to love what they do to make this part of the world a more vibrant and beautiful place. It was so informative and uplifting to work with all the folks that care so much about conservation and the preservation of a natural habitat for wildlife. Hopefully, generations to come will benefit from these efforts.

In a few years I can't wait to go and sit on the bank of the creek and listen to the birds singing in the newly planted trees and see the results of this great project.

AIMEE ROBERSON, COORDINATOR OF THE RIO GRANDE JOINT VENTURE,
WITH JOHN MORLOCK, LANDOWNER

Partnering to Restore a Bold Running Stream

John Morlock and his family own land around the confluence of Terlingua Creek and Rough Run Creek in Brewster County, Texas. Terlingua Creek is a tributary to the Rio Grande and includes portions of Big Bend National Park as well as private property in its watershed.

Mr. Morlock and his family are conservation-minded landowners: "I have always been concerned with the conservation and management of natural resources, and I have understood that land management efforts applied at a small scale locally will be a step in the improvement or enhancement of larger scale environmental movements. I've researched the historical record of land use for the Rough Run and Terlingua Creek drainages which just added emphasis to my perceived need for restoration efforts."

Based on historical accounts, Terlingua Creek and other tributaries of the Rio Grande in the Big Bend region once supported cottonwood and willow forests that teemed with birds and beaver. Mr. Morlock refers to an historical account of his property at the confluence of Terlingua Creek and Rough Run Creek which describes the area as having a riparian forest large enough to shade 1,000 cattle. That is not what the area looks like today. Riparian communities along Terlingua Creek have been disrupted by agriculture, grazing, mining, and logging of cottonwood and willow trees. Deforestation and fragmentation have decreased the ability of the riparian woodland to slow flood flows, retain sediments and nutrients, and promote aquifer recharge. Flood intensity has increased as recruitment and reestablishment of cottonwoods and other riparian vegetation has decreased, and baseflows, aquifer levels, and aquatic and riparian wildlife habitat quality have declined. However, despite the degraded condition of the riparian zone along Terlingua Creek, it is still considered an area of great ecological significance as its remaining riparian forests provide important ecosystem services for people and habitat for aquatic and riparian wildlife.

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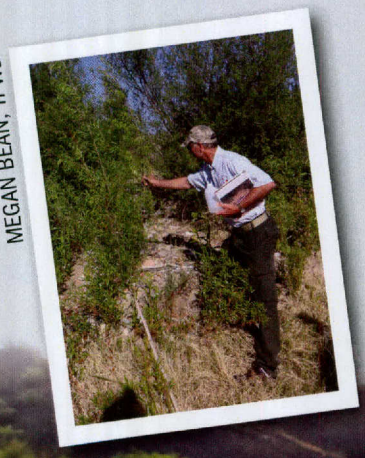
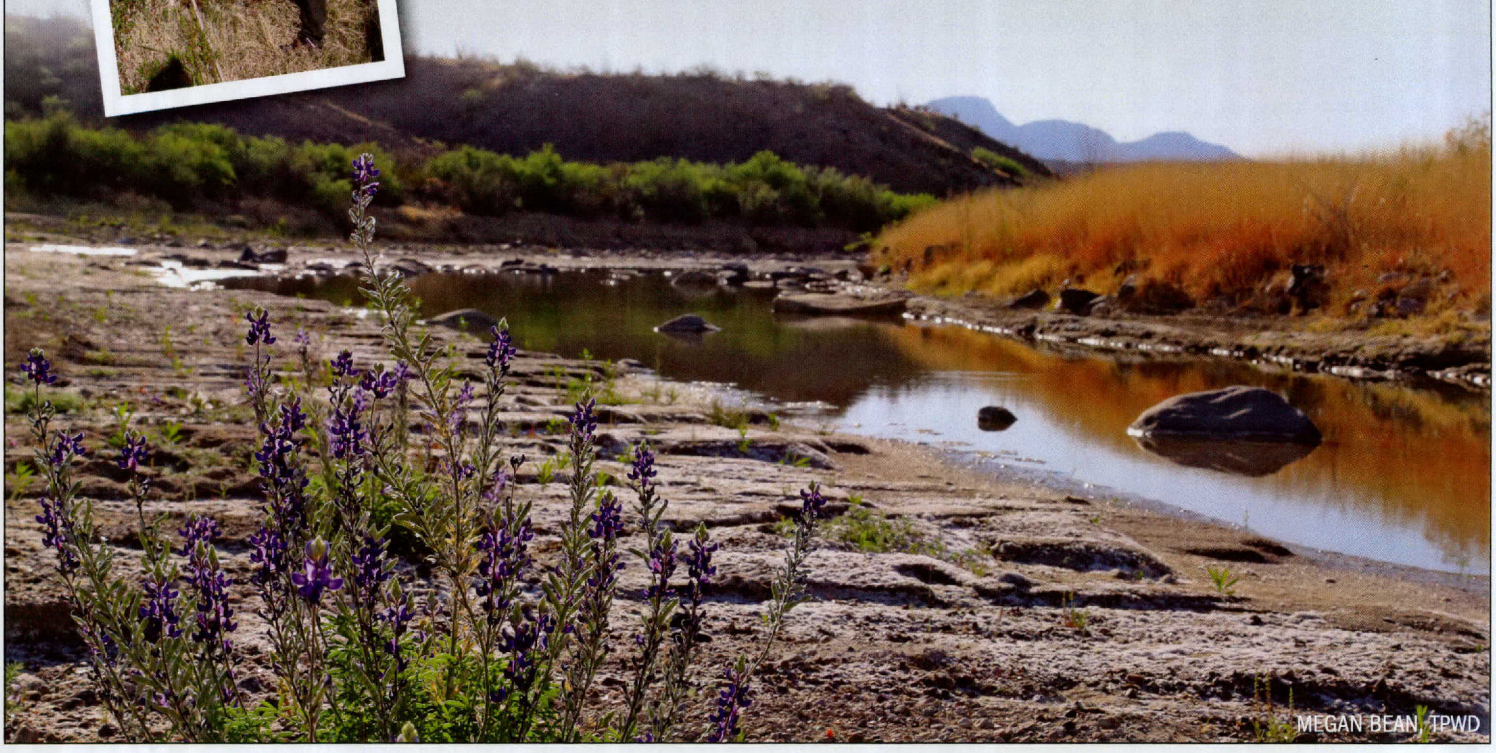


MEGAN BEAN, TPWD



MEGAN BEAN, TPWD

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ARLENE KALMBACH, TPWD

When Mr. Morlock bought the property, he was just starting his career in land management at Big Bend National Park and wanted land to manage himself that would contribute to the conservation of the region. He soon had a family and the property took on new meaning as a place to put down roots and to continue to improve. Mr. Morlock's wife, Adamina, came from a ranching family in South Texas and was teaching school in Terlingua outside of Big Bend National Park when they met. She too felt an immediate connection with this place along Terlingua Creek. These days, Mr. and Mrs. Morlock and their children enjoy spending time there and working together to improve the land.

Mr. Morlock attended two area workshops on riparian restoration and successful land management practices hosted by Texas Agrilife Extension in 2013 and 2016. After participating in these workshops with conservation practitioners from various organizations, Mr. Morlock says they "allowed me to see what efforts would apply to my situation and which agencies to partner with in the process. Following the workshops, I spoke to conservation practitioners in our area and invited them to visit my place on Terlingua Creek. The conversations we had were very informative, and I ended up working with them to develop a well-defined project and find funding to implement it."

Mr. Morlock worked with the Rio Grande Joint Venture – a public-private, binational bird habitat conservation partnership – to coordinate site visits with experts from American Bird Conservancy, Big Bend National Park, Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service Partners Program, and Texas A&M Forest Service. These

MEGAN BEAN, TPWD

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conservation partners work with an even bigger group of organizations and agencies to rehabilitate riverside forests in the Big Bend region. They worked with the Morlock family to assess the site and develop recommendations for riparian restoration, identify a local source of native riparian plants, and find funding for planting riparian vegetation across about six acres adjacent to Terlingua Creek. Although the majority of the implementation phase of the project was done by contractors, Mr. Morlock was heavily engaged throughout the process. He harvested and planted the first willows, assisted in digging holes to evaluate soil moisture and other characteristics, helped design the planting schematic, improved access to the project site, and worked with his neighbors to remove trespass livestock from the property. He is also working with conservation partners to monitor and evaluate the success of the project. Funding for the project was provided by the National Park Service's Southwest Border Resources Protection Program and the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program. Contractors Fred Phillips Consulting, Inc., based in Flagstaff, Arizona, and Rio Grande Science Support Services, based in Terlingua, Texas, implemented portions of the project.

The project was built on the idea that small areas of riparian restoration can eventually have a large impact both upstream and downstream by creating a protected, nursery environment that will allow natural regeneration of riparian forest to occur. The project complements and resembles riparian restoration work that has been completed in the upper and lower reaches of Terlingua Creek, and included harvesting and then planting 4,500 willow and cottonwood poles in an arrangement that mimics that of natural flood plain vegetation and forms a self-protecting mass. The cumulative effects of this project and similar projects on-going and planned for the Terlingua Creek watershed will create and enhance riparian and aquatic habitat for rare and declining species, such as nesting yellow-billed cuckoos, common black hawks, gray hawks, and fish species such as Mexican stonerollers, and roundnose minnow.

Rio Grande Joint Venture partners have appreciated the opportunity to work with the Morlock family to take important steps toward improved stream function and wildlife habitat. They've also found Mr. Morlock's enthusiasm for and dedication to the project to be inspiring. Mr. Morlock says, "With the completion of this project, I feel we took a major step forward in healing our portion of Terlingua Creek. You can see tangible results with the emergence of the young riparian forest. I am looking forward to working with these conservation partners on future efforts that continue the watershed restoration. I hope the work at our place can return some of the habitat for wildlife that was here historically."

AIMEE ROBERSON, RGJV

MEGAN BEAN, TPWD

JEFF BENNETT, CONSERVATION DELIVERY SPECIALIST, RIO GRANDE JOINT VENTURE – RETIRED NATIONAL PARK SERVICE

JEFF BENNETT

Grassland and Riparian Restoration in Big Bend National Park

"...at the time this ranch was established in 1885 the Terlingua was a bold running stream, studded with cottonwood timber and was alive with beaver. At the mouth of Rough Run there was a grove of trees, under the shade of which I have seen at least one thousand head of cattle."

So said James B. Gillett of the G-4 Ranch. However, the significant services that the surrounding landscape provided were too fragile to sustain the logging pressure from local mercury mines or the grazing pressure within the stream or on the uplands. Mining and agricultural activities during the late 19th and early 20th centuries required the harvest of many riparian forests for fuel and structural material. Grazing in the uplands exposed fragile soils to the power of the summer monsoon. Once the grass cover was diminished, the ability of the land to soak up summer rains was diminished. Much of the topsoil, especially fine grain topsoil, was eroded away by the increased runoff. Within the streams, the increased runoff combined with the loss of the hydraulic dampening provided by the riparian forest meant that the streams now eroded their banks like never before. This process, known as stream incision, disconnected the annual flows from the floodplains. Thus, the local aquifers suffered significant losses of recharge that once supported gallery forests. Once the forest was gone, normal annual flows were sufficient to scour young plants and the forests were not able to recover. Beginning in the 1990s, the National Park

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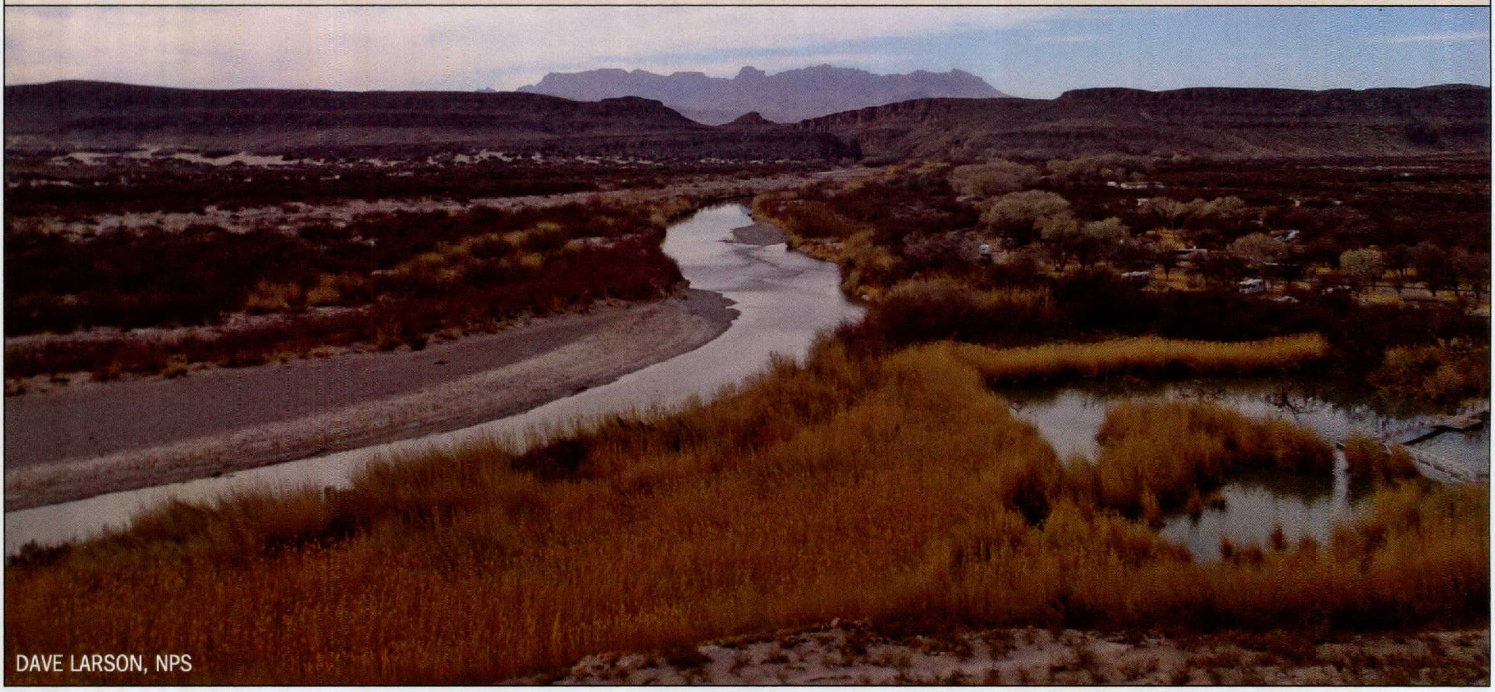
Coyote Willow planting in the dormant season. You can see how debris is stacking up behind each cluster showing how the floodplain is starting to slowly rebuild around stabilizing vegetation. Photos by Jeff Bennett.

Service implemented several reforestation projects along Terlingua Creek, however these efforts to reforest Terlingua Creek were largely unsuccessful and most of the trees were scoured out soon after planting. The most recent reforestation project at Terlingua Abajo generated a great deal of interest and inspired several similar projects on sites further upstream. Placing restoration efforts further upstream reduces the runoff area above and reduces the chance for scouring.

In addition to planting riparian forests, other tools being used for stream restoration are beaver dam analogs, trincheras, and check dams. Beaver dam analogs are structures built within streams or arroyos to mimic the functions of a beaver dam. Namely, they slow down runoff events and retain water, sediment, and nutrients. These structures can be a line of pilings driven across and into a stream bed which are then woven with willow or similar woody material. Trincheras, or loose rock structures, are small leaky dams that are built out of native stone in smaller channels adjacent to main stream channels. These structures have been very successful across the western U.S. Along Alamito Creek, one land owner is considering gravel mulch to slow water and erosion on a highly degraded floodplain.

The waterways of the Chihuahuan Desert support not only riparian and aquatic environs, but are connected to the



DAVE LARSON, NPS

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surrounding grasslands. In Big Bend National Park (BBNP), restoration of degraded grassland began soon after the establishment of the park. With assistance from the then Soil and Water conservation service, several thousand acres of Tornillo Flats were treated. Treatments included planting grass seed with a focus on tobosa seed, pitting, contouring and digging earth tanks. This suite of techniques was selected to improve hydrology and improve microclimates for the establishment of grass. Unfortunately, the project began near the beginning of what would become the drought of record. Consequently, much of the effort was not successful and little grass was established. With the loss of vegetation cover, the highly fragile soils were no longer shaded or protected from the intense summer sun and monsoons. Soil temperatures in bare areas can reach 145 degrees in summer. Rainfall beats the soil, knocking fine particles into pore spaces until a physical crust forms. Once this condition is set up, infiltration is virtually stopped. The end result is increased runoff that erodes the landscape. In Tornillo Flats and in the Hart Ranch area, this erosion has led to several large gully systems. This sets up a situation that can only be improved through direct manipulation. BBNP responded by establishing a restoration program for severely degraded grasslands in the early 2000s that involves plowing strips along the contour, then hydroseeding, and finally covering the strips with brush. The plowing breaks up the physical crust. The hydroseeding puts out seed with mulch and tackifier that prevents harvesting by ants and birds, and finally, the brush shades the soil and prevents reestablishment of the physical crust. The strips are set out to mimic banded vegetation, the natural arrangement of vegetation in arid and hot soils.

To date, nearly 400 acres have been treated this way. The selected acres are chosen so that runoff is decreased, and therefore erosion decreased, on over 1,500 acres of low desert cross-cut by gully systems. For the period of 2005 to 2008, the project was funded through a service-wide disturbed land program of the National Park Service. Since then, the project has relied on volunteers from the Sierra Club and university groups.

Grasslands and waterways of the Chihuahuan desert support significant migratory birds and mostly intact native fish and bird populations. Grasslands are bounded and supported by perennial, ephemeral, and intermittent streams. Landscape level conservation goals are improved when restoration projects link the two ecosystems. Multiple restoration techniques and tools are available for work in both ecosystems, riparian and upland.

DAVE LARSON, NPS

DR. BONNIE WARNOCK, SUL ROSS STATE UNIVERSITY
DEAN OF THE COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
RUSSELL MARTIN, TEXAS PARKS & WILDLIFE DEPARTMENT, WILDLIFE DIVERSITY BIOLOGIST


ARLENE KALMBACH, TPWD

Largescale Restoration Projects Targeting Grasslands and Terlingua Creek at the O2 Ranch

RANCHING AND CONSERVATION HISTORY ON THE O2

In the late 1880s, one of the largest cattle operations in the Trans-Pecos region of West Texas belonged to E.L. Gage. Gage registered the O2 brand in 1888. In 1891 William Turney, an area attorney and cattleman, bought the O2 brand from Gage and began buying the land that now constitutes the O2 Ranch. By the 1930s he had assembled virtually the entire ranch as it exists today. Lykes Brothers Inc. purchased the O2 Ranch in 1941. Founded by Dr. Howell Tyson Lykes and his seven sons in 1900, Lykes Brothers Inc. has been a leading Florida-based agribusiness for more than a hundred years. What began as a 500-acre operation near Brooksville, FL, has grown to more than 610,000 acres in two states.

The O2 Ranch currently encompasses about 272,000 acres of Chihuahuan Desert. Lykes Brothers ran its own cattle operation on the O2 until 1968 and subsequently leased the ranch for others to graze and hunt. In 1998, they withdrew the ranch from leasing and began a long-term program to restore the land to its native condition with focus on wildlife management. In the ensuing years, Charles P. Lykes, Jr. and ranch foreman Homer Mills partnered with Sul Ross State University, Natural Resources Conservation Service, Texas Parks and Wildlife Department, and U.S. Fish and Wildlife Service to help meet their goals. In 2011 their efforts were recognized with a Lone Star Land Steward award (Watch the video at www.youtube.com/watch?v=sW75IRxMkHY).

TERLINGUA CREEK

Terlingua Creek runs from its headwaters on the O2 Ranch and continues south through Big Bend National Park where it connects to the Río Grande at the famous Santa Elena Canyon. Terlingua Creek was historically a large tributary of the Rio Grande contributing year round flows and providing habitats for fish, turtles, birds, and mammals. Due to declines in local groundwater levels, many miles of Terlingua Creek are now intermittent and only connect during large rain events. Historical accounts of perennial and intermittent streams across the Big Bend region indicate many were lined with large stands of cottonwood and willow trees creating riparian forests. Prior to widespread mining and agricultural activities in the area, Terlingua Creek was described as a "bold running stream, studded with cottonwood timber and ... alive with beaver." The riparian forest has not regenerated after mining and agricultural activities during the late 19th and early 20th centuries which harvested timber for fuel and structural material. A healthy, mature riparian forest contains different ages of trees which provides habitats for different species and provides protective cover for cottonwood and willow seedlings during large floods. Once the forests were decimated, even the small floods were enough to uproot young plants and prevent reestablishment of the riparian trees. Now Terlingua Creek shows little evidence of beavers, few cottonwoods or native bunch grasses like alkalai sacaton, and is abundant with exotic and invasive salt cedar. Recovery efforts for the creek have taken a large group of people from many organizations contributing knowledge and resources.

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PARTNERSHIPS

To work on a watershed scale requires participation by multiple partners. Private landonwers, the National Park Service, the Texas State Park system, the USFWS Partners Program, Texas Parks and Wildlife Landowner Incentive Program, TPWD Diversity and Technical Guidance Programs, Sul Ross University, Rio Grande Joint Venture, World Wildlife Fund, and many other partners have been very active along Terlingua Creek over the past decade and have all contributed to these efforts to reestablish a hea thy riparian forest along the creek.

Well over half a million dollars of private and public funds have been strategically spent on landscape habitat restoration projects within the Terlingua Creek watershed. This decade-long restoration effort began with the completion of several riparian and aquatic pilot restoration projects in the Big Bend National Park section of Terlingua Creek where practitioners learned many valuable lessons about the ecologically delicate, yet hydrologically powerful desert stream. Some of those early projects were successful and there are new stands of willow in places where they haven't been for decades. Some of those early projects were "unsuccessful" in establishing new plants but taught valuable lessons like finding a balance between planting too close to the active channel where powerful floods uproot seedling trees and planting too far away from the channel where roots wither while waiting for summer rains to restore underground flows.

Important lessons learned from these initial riparian planting projects, include: 1) although we can't immediately restore Terlingua Creek to its historic condition, we can accelerate the natural recovery process; 2) the importance of concentrating our planting efforts in the watershed's headwaters where large floods are less frequent and intense; 3) revegetation results are greatly enhanced by carefully selecting sites that have sufficient water availabi ity, yet provide protection from floods; and 4) the most effective overall response will be to use a "stepping stone-approach" that establishes "islands" of riparian habitat along the middle and lower reaches of the creek to help accelerate the natural recovery of the entire system.

CONSERVATION WORK IN THE RIPARIAN CORRIDOR ON THE O2

With the above referenced lessons learned in hand, several riparian and aquatic restoration projects have been completed in the headwaters of Terlingua Creek on the O2 Ranch. In the riparian areas, the main restoration focus has been on controlling grazing and planting trees to reestablish the woody species of the riparian areas. Cottonwoods are once again producing viable seedlings in the upper Terlingua Creek watershed. The oldest planted cottonwoods are over 13 years old and the first seedling from natural recruitment was produced in 2012.

Cottonwoods of different ages from 8+ years to pole cuttings less than 2 months old. Photo by Bonnie Warnock.

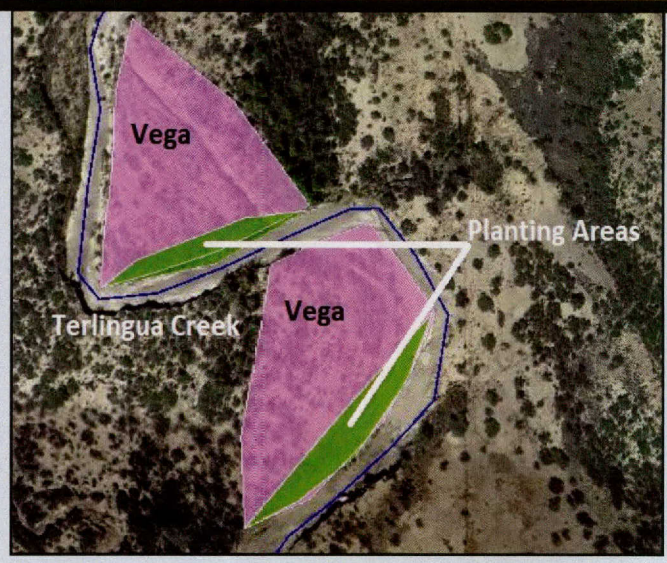
One of the earliest restoration projects was a project conducted in the early 2000s by Professor Dr. Bonnie Warnock, Sul Ross State University (now the Dean of the College of Agriculture and Natural Resources). In this project, Dr. Warnock and her students planted locally harvested cottonwood poles along the banks of Terlingua Creek. Most of these trees survived and can be seen today after nearly

20 years of growth providing an ever-growing seed source for additional cottonwood seedlings along the creek.

In 2011, a grassland/riparian restoration Landowner Incentive Program project was led by TPWD biologist, Jonah Evans, that involved mechanically clearing 307 acres of mesquite and planting the cleared area with native grasses and cottonwoods to help improve infiltration and ground water recharge from outflows at Duff Spring (see article on this project in Spring 2011 edition of the L.I.P. Bulletin). Project results continue to provide valuable riparian habitat and improved ground water recharge around the spring. Specifically, this project site is located near the confluence of Duff Creek and an unnamed creek which, when combined, drain an estimated 10,000 acres on the O2 Ranch.

Duff Springs. Photo by Ryan McGillicuddy, TPWD.

The largest project to date was initiated in 2015 and funded by private donations through the World Wildlife Fund and the Coca-Cola Foundation. In addition to planting over 8,200 coyote willow and cottonwood poles along a three and a half mile stretch of the creek, this project also brought in some the best minds in riparian restoration to advise on the restoration design. While there were several different planting designs tested in this project, the ultimate consensus of the experts was to focus on dense plantings of willow and cottonwood in selected sites that offered water availability for roots and protection from floods. In this regard, planting efforts focused on sites that were outside of the stream bed, sandy areas on the inside of a creek bend (commonly referred to as 'vegas' (Fig. X)), side channels, and slightly higher elevated creek banks where flood velocities are lower. All planting sites had to be connected to the water table so roots could become established. This project led to the successful establishment of dozens of new willow and cottonwood stands along Terlingua Creek at the O2 Ranch.



The most recent project, which was funded by USFWS Partner's Program through the TPWD LIP program expanded on the 2015 project by planting 1,500 willows and cottonwoods along the 3-mile stretch immediately downstream of the World Wildlife Func restoration site.

FIXING THE GRASSLANDS TO HELP THE CREEK

Where to begin on such a huge and diverse ranch? The O2 Ranch has diverse geology including tuff, basalt and limestone with 58 different soils types. Some soils (like the sodic/zeolitic soils found around the headwaters of Terlingua Creek) complicate many restoration practices. With that in mind, a long-term plan was developed using soil survey data. Soils on the ranch were grouped by restoration potential to achieve the best "bang for the buck." GIS maps were created to quantify the acreage and location of potential restoration sites. Small watersheds were delineated for the ranch to further guide restoration efforts. This broke things down into more manageable projects.

While efforts were being made to quantify and map the diversity of habitats, the O2 Ranch also considered changes in ranch management practices and considered grassland restoration practices to improve habitat conditions. The ranch temporarily removed all livestock to allow the grasslands time to recover and reestablish. Unfortunately, with the shrub encroachment that had occurred, rest alone did not always result in improvement. An extensive forage inventory of the ranch was conducted to establish a baseline and to see how much room for improvement existed. It was decided that treatment of shrub-encroached uplands would become a core practice for the ranch.

The primary methods of grassland restoration on the O2 Ranch include prescribed grazing, mechanical brush control, prescribed fire, and herbicide. Stocking rates are carefully set to prevent overgrazing. Mesquite had come to dominate

many of the deeper soils on the ranch, limiting grass production. Large scale attempts at herbicide treatment on the ranch had been unsuccessful. Instead, close to one thousand acres of mesquite have been grubbed out using a root plow attached to an excavator. Prescribed fire has become a routine, economical component of the management plan. Established mesquite readily resprouts after being top-killed with fire but fire is effective at suppressing new mesquite plants. This helps maintain the open grasslands in previously grubbed areas, particularly on the ranch's broad tobosa/sacaton flats and brushy draws.

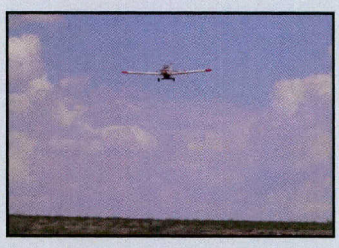
Excavator grubbing western honey mesquite. Photo provided by Bonnie Warnock, Sul Ross University.

Western honey mesquite skeletons. Photo provided by Bonnie Warnock, Sul Ross University.

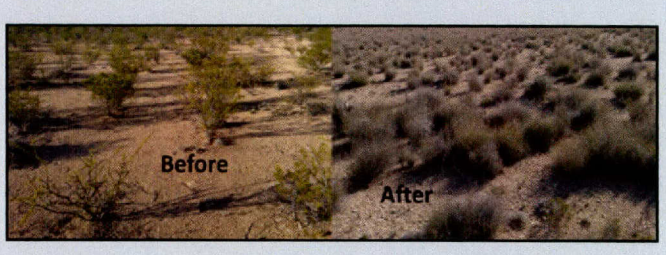
Prescribed burning of brushy draws. Photo provided by Bonnie Warnock, Sul Ross University.

Another effective restoration tool has been the aerial application of Spike 20p (tebuthiuron pellets) on thousands of acres. Spike is an herbicide that kills woody plants (not including mesquite) and does not harm grasses. This is the only practical treatment for many of the creosote/mariola/tarbush encroached areas of the ranch. An important drawback is that Spike also can suppress forb production for many years, referred to as "forb shock." Because forbs are a critical component for wildlife management, the ranch has experimented with techniques to address forb shock. One method was to apply the herbicide in strips. This created large amounts of "edge" between the treated and untreated areas, which is a favorite habitat for quail. Another method was to burn several years after the treatment had had time to affect the target species. The fire neutralized the herbicide in the soil and allowed the forbs to return. Another practice on the ranch is to treat small areas of different soil types to determine how effective the herbicide will be, before making a large investment in that area.

Air Tractor applying Spike 20p (tebuthiuron pellets). Photo provided by Bonnie Warnock, Sul Ross University.



Results of Spike 20p applied in strip patterns on gravelly soil. Photo provided by Bonnie Warnock, Sul Ross University.



Test plot for Spike application for Chino grama grassland restoration. Photo provided by Bonnie Warnock, Sul Ross University.

The benefits of thinking on a large scale with multiple restoration techniques are paying dividends. The ranch foreman, Homer Mills, has noted the improvements in water infiltration and less erosion on the uplands. It takes more rain for the channels to run now because the new grasses help retain water where it falls. That goes for the dirt tanks, as well. He observed that less water reaches the tanks now, however, the water that makes it is no longer sediment laden. This clear water keeps the tanks from filling with sediment as fast. Mills has also noted increased wildlife utilization in areas that have been treated for brush, particularly mule deer and pronghorn antelope.

RESEARCH EFFORTS ON THE O2

The O2 Ranch also supports numerous restoration research studies with Sul Ross State University and the Borderlands Research Institute. These benefit the ranch and the region as a whole:

- Study of the effects of ripping and a combination of ripping and herbicide (Figure 1)
- Study fire effects on tobosa flats (Figure 2)
- Study of the effects of combinations of fire and herbicide on whitebrush (*Aloysia gratissima*)
- Study of restoration of degraded sodic soils using cotton bur/burlap wattles (Figure 3)
- Study of the effects of Spike followed by prescribed fire
- Study on different reseeding mechanisms
- Prairie dog re-introduction for controlling mesquite (Figure 4)

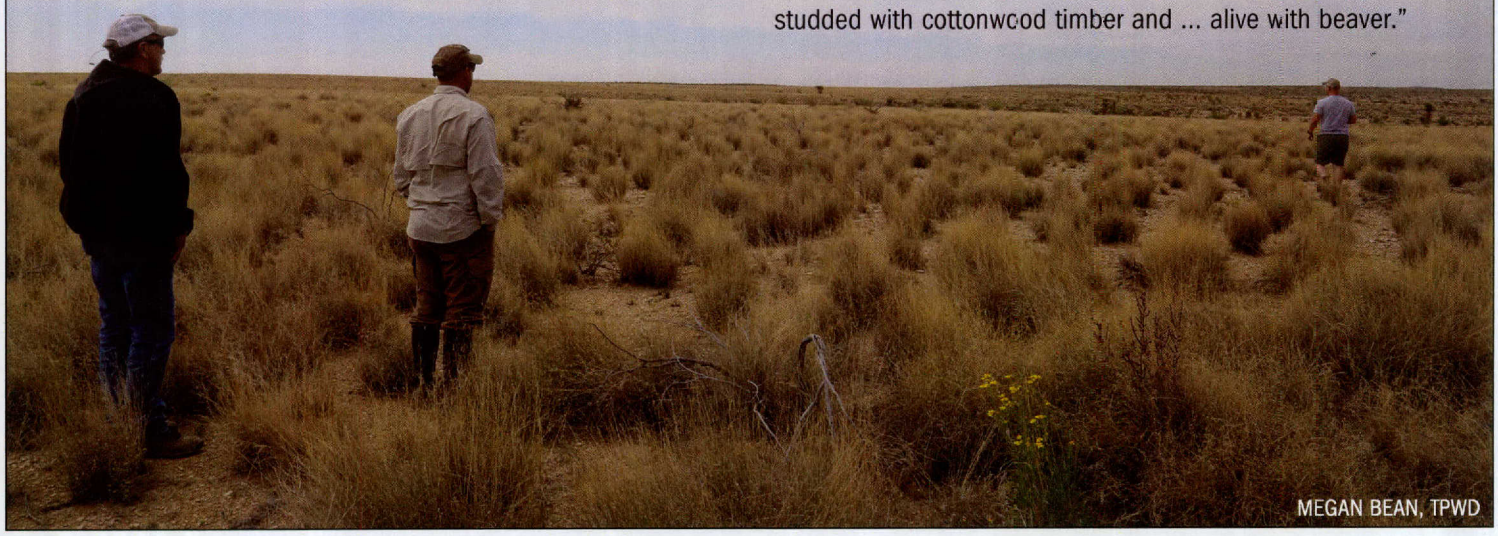
Figure 1. Restoration study of mechanical ripping. Photo provided by Bonnie Warnock, Sul Ross University.

Figure 2. Prescribed burning study on tobosa flats. Photo provided by Bonnie Warnock, Sul Ross University.

Figure 3. Restoration experiment of a sodic soil using cotton bur filled wattles. Photo provided by Bonnie Warnock, Sul Ross University.

Figure 4. Black-tailed prairie dogs reintroduced to the O2 flats to help control mesquite. Photo provided by Bonnie Warnock, Sul Ross University.

These projects have laid the foundation for landscape restoration practices that benefit aquatic, riparian, and upland habitats. Thinking about connecting habitats across the landscape is more holistic and further enhances the area and its recovery. Partners hope that combined grassland and riparian restoration efforts will help Terlingua Creek heal to once again become a "bold running stream, studded with cottonwood timber and ... alive with beaver."



ARTIFICIAL WETLANDS

FRED PHILLIPS, FRED PHILLIPS CONSULTING

BJ Bishop Wetlands Restoration, Presidio Texas

In 2009 Presidio Texas had a problem. The city needed an easement to construct a pipeline that would transport treated effluent from their wastewater plant into the Rio Grande River. Terry Bishop, a local farmer whose family has farmed the Presidio Valley for decades, had the solution. The city offered the Bishops reuse of the effluent (as much or as little as they liked) in exchange for an easement for constructing the pipeline. They shook hands on it and the project was underway.

The vision for the BJ Bishop Wetlands Restoration Project (BBWP) was to reestablish wetland and riparian vegetation within a 12-acre fallow farm field using treated effluent and also learn from this effort to help guide future restoration projects along the Rio Grande River. The need for riparian habitat restoration along the Rio Grande is vital. There are over 300 species of birds occurring in the area and over 80% of the riparian areas have been destroyed by water storage projects, mining and agricultural practices in the region.

In 2011 David Crum, Executive Director of the Trans-Pecos Land and Water Trust (TPLWT)), Karen Chapman of the Environmental Defense Fund, Terry Bishop and Fred Phillips solidified the vision and wrote a successful grant application to the North American Wetlands Conservation Act (NAWCA). This grant paid for the design, construction and short term maintenance of the BBWP. TPLWT then hired Fred Phillips Consulting (FPC) and Oxbow Ecological Engineering (OEE) to design and construct the project in conjunction with TPWLT and Presidio Valley Farms, the Bishop Family's farming operation. This was one of the most interesting projects of the many environmental restorations FPC had been in charge of the last quarter century.

One of the formidable challenges of the project was getting the permit from The Texas Commission of Environmental Quality (TCEQ) to allow for the reuse of effluent on the 12-acre project site. Mary Kelly, then serving as Executive Director of TPWLT and now a partner in Culp & Kelly, worked through a maze of bureaucracy and meetings to acquire the discharge permit.

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The restored wetlands three months after planting.

FRED PHILLIPS, FRED PHILLIPS CONSULTING

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FPC and OEE worked with the project stakeholders and developed the site grading, planting and water structure plans. The goals of the design included:

1. Create 12 acres of aquatic, wetland and riparian habitat
2. Install a water control structure and levee that would allow for water level management
3. Harvest as much plant material as possible for the project from nearby stands of native wetland and riparian plants
4. Construct an electrical fence and gates to keep feral hogs and dogs out of the wetland area

The final grading plan included excavation of 5,000 cubic yards of dirt to create the different plant terraces within the wetlands. It also included two habitat cells separated by a stoplog water control structure and a levee that allows for water levels to be managed throughout the project. The final planting plan included three acres of deep marsh (bulrush), five acres of shallow marsh (three-square), two acres of transitional grass habitat (sacaton/salt grass) and two acres of riparian habitat (cottonwood/willow/mesquite). A 12-inch pipe from the wastewater plant discharges the effluent into a spillway feeding the wetlands. The estimated discharge of effluent into the wetlands is 50,000 GPD in the summer and over 150,000 GPD in the winter.

In 2015 the grading construction portion of the project brought another set of challenges. As Presidio is located in a remote section of the state, it is hard to acquire the large equipment necessary to excavate 5,000 yards of wet dirt. The team acquired grading bids from regional contractors but the bids all came in at over twice the budgeted amount for the work. To stay within the budget constraints of the project the team needed a new approach. FPC found a 25-ton scraper tractor they could rent and operate on their own. The rental of the tractor and "in house" labor greatly reduced the cost of this work. Because of the remoteness of Presidio this machine would have to be delivered to the site from El Paso, Texas. A specialized machine like this could finish the job in a matter of 3-4 days. The team had high hopes that they had figured out a way to get the grading completed and under budget, but then it started raining. The combination of the wet fields and the weight of a 25-ton machine would surely sink the tractor. Adding insult to injury, there would be no equipment in Presidio that could extract the expensive machine out of the muck. As a result of the multiple rain events in the winter of 2015, delivery of the machine from El Paso was canceled three times. Each time this cost the project money, frustrated the crew and created logistical nightmares.

Texas Conservation Corps crews plant the project.

Furrow ditches made with a tractor made for easier and more efficient planting of the wetland plugs.

BOTH PHOTOS: FRED PHILLIPS, FRED PHILLIPS CONSULTING

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After the third cancelation the team decided to take yet another approach. Bishop summed it up perfectly: "Sometimes you just have to do it the old way." After a couple days of driving around Presidio and talking to fellow small farmers, they managed to find a 1969 D6 bulldozer (that only turned in one direction), a front-end loader with a four-yard bucket and a tractor with a scraper. The team also found a snowbird named Rod Duffy who was staying at Bishop's Loma Paloma RV Park and he knew how to operate the classic bulldozer. With guidance from Civil Engineer George Cathy of OEE, the experienced machine operators and some old-fashioned level work led by FPC the team was able to get the grading completed in six days and under budget. The locals who worked on the project were happy to be doing something positive in their own community.

Sometimes what you need is right beneath your feet. Locating and acquiring local native plant materials needed for the project was nearly impossible. Then we had a look at the wastewater treatment plant ponds located only a hundred yards from the wetlands project. They were a thriving garden! The wetland plants we needed for the project, including giant bulrush, three square bulrush, Baltic rush, Nebraska sedge, inland saltgrass, alkalai sacaton, cottonwood and black willow trees. Through sustainable harvesting methods 90% of the plant material needed for the project came from the wastewater plant. Jesús, treatment plant manager, was ecstatic about getting rid of all the willow and cottonwood trees that were choking his treatment ponds. He even used the city backhoe to excavate the large willows and cottonwoods and transplant them directly into the wetlands. Native seed stock was also generously donated by Jeff Bennett and Big Bend National Park. The Planting crew, led by FPC, was from the American Youth Works Texas Conservation Corps (TXCC) out of Austin. The project was nearly completed, but was still missing something.

After work on a sweltering June afternoon, Terry and Fred took a rest on the back porch overlooking the Rio Grande and Presidio Valley Farms and sipped on Patron tequila. Fred mentioned that the 60-foot-tall dead cottonwood tree in Terry's roping arena would make a perfect perching site for birds in the wetlands. The next morning 60 feet of tree was being hauled two miles down the highway by truck and trailer to the wetlands. Six hours, ten bags of concrete and a lot of maneuvering later the tree snag was balanced and resting in its new aquatic home with plenty of avifauna keeping it company.

Since completion, the BBWP has been thriving. Birders from all over visit the site to explore the diverse and abundant avifauna and invertebrates that utilize the wetlands. The water is flowing and the vegetation is thriving. Healthy willows, sedges and grasses now support a vibrant ecosystem that has cleaner water, air and soil and an abundance of wildlife. Local residents, including the Bishop family, love to walk around the wetlands at sunrise and sunset. Sul Ross University is using it as a research site. The thousands of cars that drive the River Road to Big Bend every month are starting to stop and take notice of this gem in the desert–so many in fact that the Texas Parks and Wildlife Foundation (TPWF) awarded a grant to the project to construct a wildlife observation platform adjacent the highway. Bishop says that his favorite part of the wetlands is looking at all of the new birds that come every day, and the hardest part is not seeing the birds when they migrate on. He finds joy in watching so many people getting excited about the wetlands and all the wildlife occurring there.

Future plans for the BBWP expansion may include a tree farm that will supply regional restoration projects with needed plant material, a native fish nursery and expansion of the existing wetlands. Bishop says that it needs to be done in baby steps as there is a lot of work involved with maintaining the area.

In the spring of 2018 on a tour of the BJ Bishop Wetlands (named after Terry's late father), led by Aimee Roberson of the American Bird Conservancy's (ABC) Rio Grande Joint Venture, our group witnessed over 25 species of birds in under an hour. Species included great blue herons, kingfishers, black-necked stilts, white-faced ibis, red-tailed hawks and red-winged black birds just to name a few. The group–consisting of ABC ,USFWS, Sul Ross, Big Bend National Park, local ranchers, students and interested citizens–was there to explore the wetlands and learn about what this project has taught us. This knowledge will hopefully translate into more large-scale riparian restoration projects, increased awareness on the importance of ecological restoration, positive economic impacts and most importantly the creation of inspiring relationships that give rise to amazing solutions.

GRASSLAND RESTORATION

RUSSELL MARTIN, TPWD

Desert Grassland Habitat Restoration: Reconnecting Disjunct Populations

Historically, most of the Trans-Pecos ecoregion between 3,500 – 5,200' elevation was a grassland ecosystem with scattered shrubs relegated to drainages. Areas like Tornillo Flats in Big Bend National Park were described as having waist-high grass.

However, like much of Texas, intense grazing, the removal of keystone species such as bison and prairie dogs, and fire suppression led to the expansion of shrubs into the grasslands, which eventually caused the system to shift to the shrubland ecosystem that we see over large parts of the state today.

The Lado Ranch, part of the Wexford Ranches, is nestled between the two largest remnant plains grasslands (4,000 – 5,200') in the Trans-Pecos, the Marfa Plateau and the southern extent of the Otero Mesa, amongst a series of low-elevation desert mountains, frequently called Sky Islands, surrounded by a sea of shrubland that was once desert grassland (3,500 – 4,000'). The ranch ranges in elevation from ~3,100' up to 5,627' at High Lonesome Peak at the top of the Van Horn Mountains. This 2,000' of elevation change results in remarkable habitat diversity ranging from Rio Grande river bottom, desert scrub, remnant patches of desert grassland, and low elevation desert mountains.

These diverse habitats and the wildlife-focused management of the ranch have led to thriving populations of desert bighorn sheep, mule deer, scaled quail, and aoudad, species all well-adapted to shrubland ecosystems, however, the populations of the remaining grassland specialists, a small herd of pronghorn, an isolated population of black-tailed

District Biologist, Jose Etchart, programs a trail camera to monitor habitat change over time.

Cristy Burch, GIS Specialist, launches a habitat-mapping drone.

RUSSELL MARTIN, TPWD

KAI BUCKERT

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prairie dogs, and a reintroduced population of endangered Aplomado falcons, have remained stagnant or disappeared over the past three decades due to limited habitat despite the wildlife-focused management. That was a concern for the ranch manager, Kai Buckert.

"We want all of the wildlife on the Lado to thrive," says Buckert. Even the often-loathed prairie dogs. The ranch and conservation partners including the Mule Deer Foundation and the Texas Bighorn Society have invested heavily in a well-planned and executed water system over the past two decades to ensure water is well distributed across the ranch, which is often a limiting factor for wildlife in the arid Trans-Pecos. Despite those efforts, the pronghorn herd has hovered around 12–15 strong, the prairie dog colony was stuck around 20 acres in size, and the reintroduced Aplomado population slowly disappeared while the numbers of all the other big game species soared over the past two decades.

The Wexford Ranches have a strong history of habitat restoration at their ranches on the Texas Gulf Coast. They've completed chemical and mechanical brush management projects, constructed artificial wetlands, and implemented an outstanding prescribed grazing program, which have all led to tremendous wildlife populations. However, the Region 2 Diversity Biologist, Trey Barron, that works with Kai and the Wexford Ranches along the Gulf Cost, recommended that they consider habitat restoration on the Lado when Kai expressed his concerns about the stagnant pronghorn and prairie dog numbers so he put Kai in touch with the Trans-Pecos Wildlife Diversity Biologist, Russell Martin, to explore the idea of restoring desert grasslands on the Lado.

After a group of the Trans-Pecos wildlife biologists met with Kai, all agreed that suitable grassland habitat was the main factor limiting the grassland species on the Lado and a long-term grassland restoration program was the best bet for the ranch to conserve the remaining numbers of pronghorn and prairie dogs with the goal to see both of those species grow in number as more grassland habitat was restored.

Since the Van Horn Mountains occupy most of the ranch, we focused our attention on the northwestern-most 10,000 acres of the ranch where the pronghorn herd spends the majority of its time and a remnant prairie dog town clings to a feeble existence. This corner of the ranch, ranging from 4,100 – 4,400' elevation, is a patchwork of nearly equal parts remnant grassland and creosote-invaded shrubland with a lattice of desert washes dominated by sacaton.

Using the prairie dog town as an anchor, we identified 750 acres of creosote that could be aerially treated with tebuthiuron, which would give the prairie dogs a better opportunity to expand west and south beyond the current boundary of their creosote-bordered town. As a keystone species, prairie dogs help maintain open grasslands by preventing brush from invading grasslands. There are several other species, such as Ferruginous hawk, Swainson's hawk, burrowing owl, mountain plover, and kit fox, highly dependent on the habitat provided by the dogs. They maintain their open grassland by instinctively attacking new shrubs as they sprout up within or on the edges of their town. This critical behavior is self-serving, since it eliminates potential cover and perches for predators, while also providing a tremendous ecosystem service to landowners that graze cattle and the other grassland-dependent species, like pronghorn, that strongly prefer landscapes with a low percentage of shrub cover.

We're also excited about using this ranch and habitat restoration project as a part of our new habitat monitoring program that uses a combination of time lapse photos taken from trail cameras and high-resolution aerial images. In 2016, the West Texas Wildlife Region purchased a small unmanned aerial system (sUAS), also known as a "drone," specifically designed to produce high resolution imagery (<3 sq cm) that will allow us to map and monitor the changes to habitat resulting from specific management actions. The sUAS will only be flown with landowner permission to monitor changing habitat conditions across the region.

There are also numerous research projects showing that pronghorn and cattle will spend a disproportionate amount of time foraging in prairie dog towns compared to other areas without prairie dogs. The theory to explain this behavior is that prairie dogs constant grazing pressure promotes lush, fresh grass production and additional forb production, both of which are desirable to grazers like cattle and pronghorn.

We're looking forward to continuing restoration efforts within this part of the ranch in the future so we can help accomplish the ranch's goal to conserve their remnant pronghorn herd while providing valuable habitat to other desert grassland species.

INVASIVE SPECIES

JEFF BENNETT, CONSERVATION DELIVERY SPECIALIST, RIO GRANDE JOINT VENTURE – RETIRED NATIONAL PARK SERVICE

Exotic Vegetation Management Along the Rio Grande in the Big Bend

The Rio Grande in the Big Bend is the focus for conservation interests in the northern Chihuahuan Desert and is one of the most ecologically significant areas in North America.

Large spring complexes deliver some 200,000 acre-feet of water to the river annually, sustaining native fish and providing recreational opportunities to thousands of visitors each year. Unfortunately, upstream water use diverts surface flows to such an extent that the absence of annual scouring flows has allowed the banks and floodplains to become choked with vegetation, much of it exotic. In particular, the establishment of extensive and dense stands of salt cedar (*Tamarisk* spp.) and the exotic Mediterranean weed, giant reed (*Arundo donax*) are enhancing sediment accumulation that is burying native aquatic habitat as well as increasing flood damage to public infrastructure.

Beginning in the early 2000s, the National Park Service (NPS) and their Mexican counterparts implemented several projects designed to limit the extent of exotic vegetation, encourage native plants, and provide benefit to visitors and native wildlife and pollinators. Very soon after, hydrologists and river scientists at Sul Ross State University and Utah State University advocated for a much larger program that might decrease sediment accumulation and improve habitat. At that time, the vegetation management focused largely on controlling salt cedar. However, the release of the salt cedar beetle (*Diorhabda* sp.) by U.S. Department of Agriculture, (USDA) and NPS in 2008 greatly reduced the extent of this invasive plant along the river. In its place the aggressive Mediterranean grass giant reed (*Arundo donax*) and the native coyote willow (*Salix thurberi*) took over long reaches of the Big Bend reach of the Rio Grande. The giant reed was so pervasive that its control became a priority for NPS and the

MEGAN BEAN, TPWD

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MEGAN BEAN, TPWD

Texas Parks and Wildlife Department (TPWD). To date 100 km of both sides of the river below Mariscal Canyon have been treated using techniques that rely on prescribed fire followed by the application of a broad-spectrum EPA approved herbicide (imazapyr).

Simultaneously, the USDA has developed and released biological controls for giant reed which reduced the amount of giant reed such that native plants dominated. This project was of great importance to the Department of Homeland Security because the controls reduced reed enough to improve within stand visibility and access for border patrol agents. Biological controls have value over mechanical and chemical methods in that they do not require ongoing treatments. Initial release sites were below Amistad Reservoir. Recently, TPWD, the NPS, and private landowners have collaborated with the USDA to release the arundo wasp (*Tetramesa romana*) and arundo scale (*Rhizaspidiotus donacis*) at sites between Santa Elena and Heath canyons. The arundo wasps lays eggs in new shoots preventing new growth and the scale feeds on the plant reducing plant vigor. Topping the reed at three feet encourages shoot growth and improves the effectiveness of the control. Recent monitoring indicates that the insect is established near Santa Elena canyon. The National Park Service has plans to continue releasing the arundo wasp with insects purchased from a private insectary.

These efforts to control invasive weeds along the Rio Grande have reduced the extent of exotic vegetation, improved riparian habitat, and increased the prevalence of native plants and pollinators. Monitoring of results continues, with gathered data guiding managers, local citizens, and river advocates to identify appropriate next steps.

JEFF RENFROW, RIO GRANDE SCIENTIFIC SUPPORT SERVICES

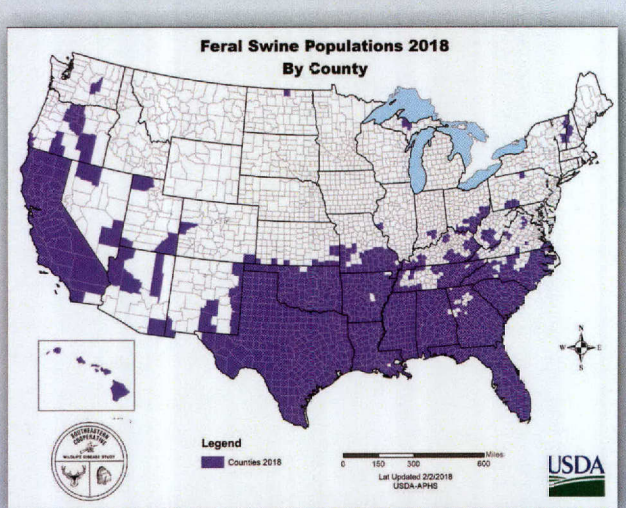
PRICE RUMBELOW, TPWD

Feral Pig Control in the Presidio Valley

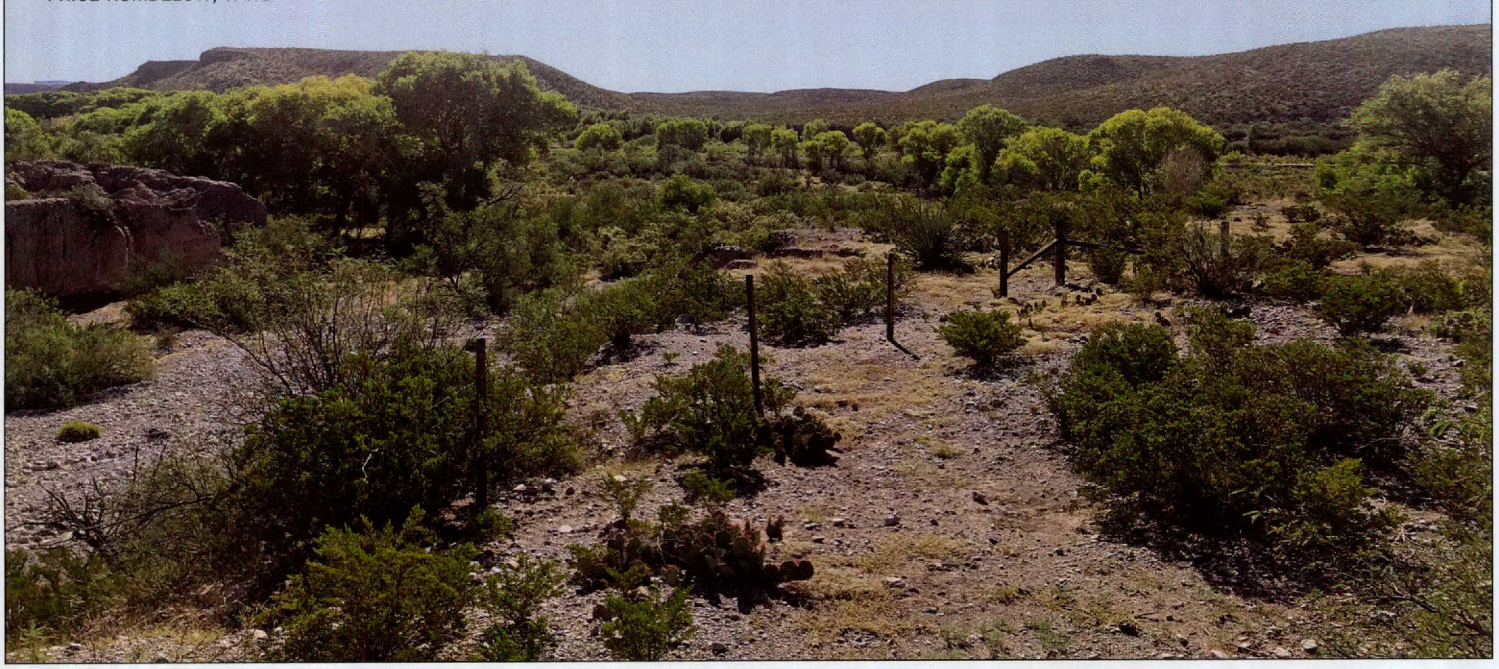
The Rio Grande Joint Venture and Pronatura Noreste joined forces to host an "International Grassland Enhancement and Riparian Rehabilitation Workshop" April 23-27, 2018 in Brewster and Presidio counties, Texas.

At this meeting Miguel Ramón Mendoza Pérez of Comisión Nacional de Áreas Naturales Protegidas (CONANP), subdirector in charge of Canon de Santa Elena and myself, Price Rumbelow (TPWD, Natural Resource Specialist, Region 1 State Parks), began a conversation on conservation goals for the area from Presidio to Lajitas on both the U.S. and Mexican side of the Rio Grande. One of the greatest threats to this region's wildlife and agriculture is the damage done by non-native species. Miguel described feral pigs as a binational riparian conservation issue that could be best addressed through cooperation.

Wild boars and boar analogs evolved in multiple parts of the world. In the Americas we see the collared peccary (*Pecari tejacu*) which arrived at the same body shape but is not the same as the European (*Sus scrofa*) or Asian (*Sus indicus*) wild boar, a process known as convergent evolution. Feral pigs come from domesticated forms of the European and Asian boar that later escaped or were released from captivity and reverted back to a wild-like state (Giuffra et al. 1999). Feral pigs are thought to have been introduced to the United States by European sailors in what is now Florida. Now, feral pigs can be found in at least 35 states and number in the millions.



www.aphis.usda.gov; Dec. 4, 2018: History of Feral Swine in the Americas



Alamito Creek provides a movement corridor for a variety of native and non-native wildlife.

PRICE RUMBELOW, TPWD

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Feral pigs foraging for food will root, or dig up, the ground just beneath surface in search of grubs, seeds, and roots. By doing this they can cause a lot of damage to crops and rangelands. Through their tendency to wallow, feral pigs can fowl water sites and create stagnant pools which allow pests such as mosquitos thrive. In addition to their impact on us, they can have devastating effect on native wildlife through habitat deterioration, competition for food, transmission of disease, and even direct predation for smaller mammals, reptiles, and ground-nesting birds.

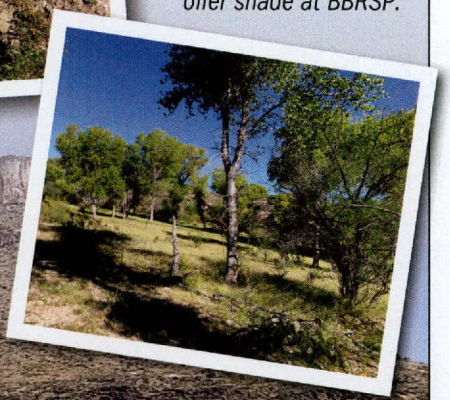
Following the workshop the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) was approached about conducting control efforts in Presidio County including Big Bend Ranch State Park. They were excited to help with the project as their international services branch had recently been tasked with feral pig control along border states with Mexico. To this end, APHIS sent a helicopter to Presidio in early October to begin eradication efforts on state and private lands along the Rio Grande corridor.

The primary target area in the state park included Alamito Creek and Ciénega Gorge in the area known as the Panhandle of Big Bend Ranch. West from the park on private lands, APHIS, as per their agreement with the state of Chihuahua, targeted lands along Rio Grande corridor.

The window for this operation was October 8–11, 2018. During that time 33 feral pigs were removed from the state park and surrounding private lands. Miguel Mendoza working with farmers in Mexico, has been trapping feral pigs for over a year now. This represents the first time that there has been a concerted effort to control pigs between these three groups.

Future projects could be aided by developing more detailed data on feral pig movements in the area. This can be accomplished by deploying GPS satellite linked collars on feral pigs in the area to determine seasonal habitat preferences and identify cross-river movement. In addition to GPS collar data, follow up monitoring, probably in the form of observation reports by local farmers and ranchers, may identify escape refugia where pigs go during heightened periods of pressure. Increasing the collaboration between landowners (private, state, and international) moving forward may be the most crucial aspect for feral pig control to be effective in the Presidio Valley.

Feral pig killed during eradication efforts at BBRSP.



Cottonwood galleries offer shade at BBRSP.

The high desert mountains stand in sharp contrast to riparian (creek-side) habitat at Big Bend Ranch State Park.

ALL PHOTOS:
PRICE RUMBELOW,
TPWD

MONITORING

MARK BRIGGS, ECOLOGIST, NEW RIVER/NEW WORLD CONSULTING, LLC
JOSE JAVIER OCHOA, COMISIÓN NACIONAL DE ÁREAS NATURALES PROTEGIDAS
JEFF BENNETT, CONSERVATION DELIVERY SPECIALIST, RIO GRANDE JOINT VENTURE
JEFF RENFROW, RIO GRANDE SCIENTIFIC SUPPORT SERVICES

What's Changing in Big Bend?

An Overview of Natural Resource Monitoring in the Binational Big Bend Region

Monitoring is the systematic process of observing, tracking, and recording data for the purpose of quantifying change due to the implementation of specific management actions (e.g., eradication of giant cane) and/or as a result of natural occurring processes (e.g., changes in vegetation conditions due to changes in streamflow).

In the context of conservation efforts along the Rio Grande/Bravo (RGB) in Big Bend, monitoring efforts are helping to address two different questions: First, how well are we making progress toward stated management or conservation objectives? Second, what is the status and trend of the river's ecosystems and the natural processes that support those ecosystems? Monitoring to address both of these questions is taking place along the RGB in Big Bend. Let's walk through some monitoring efforts, each of which has its own objectives and cadre of agencies, institutes, and organizations that are involved.

First, it's important to mention that there are several well-established monitoring programs in the region that are part of larger regional efforts and that are collecting climatic and streamflow data fundamental to our understanding of the RGB system and how it works. In Texas, there are a variety of weather stations that are part of the Cooperative Observer Program (COOP), a network of stations that is run by the National Weather Service. For example, the weather station maintained by Big Bend National Park at Panther Junction is part of this network. Data collected by COOP stations can be obtained from the National Climatic Data Center (NCDC). In Chihuahua and Coahuila, the federal agency, Servicio Meteorológico Nacional (SMN), maintains many weather stations in the region and data collected by those stations, along with stations maintained by the states of Chihuahua and Coahuila, can be found at CICESE's website (http://smn.cna.gob.mx/es/climatologia/informacion-climatologica).

Kevin Urbanczyk and students from Sul Ross State University measure discharge on the Lower Canyons reach of the Rio Grande.

JEFF RENFROW, RIO GRANDE SCIENTIFIC SUPPORT SERVICES

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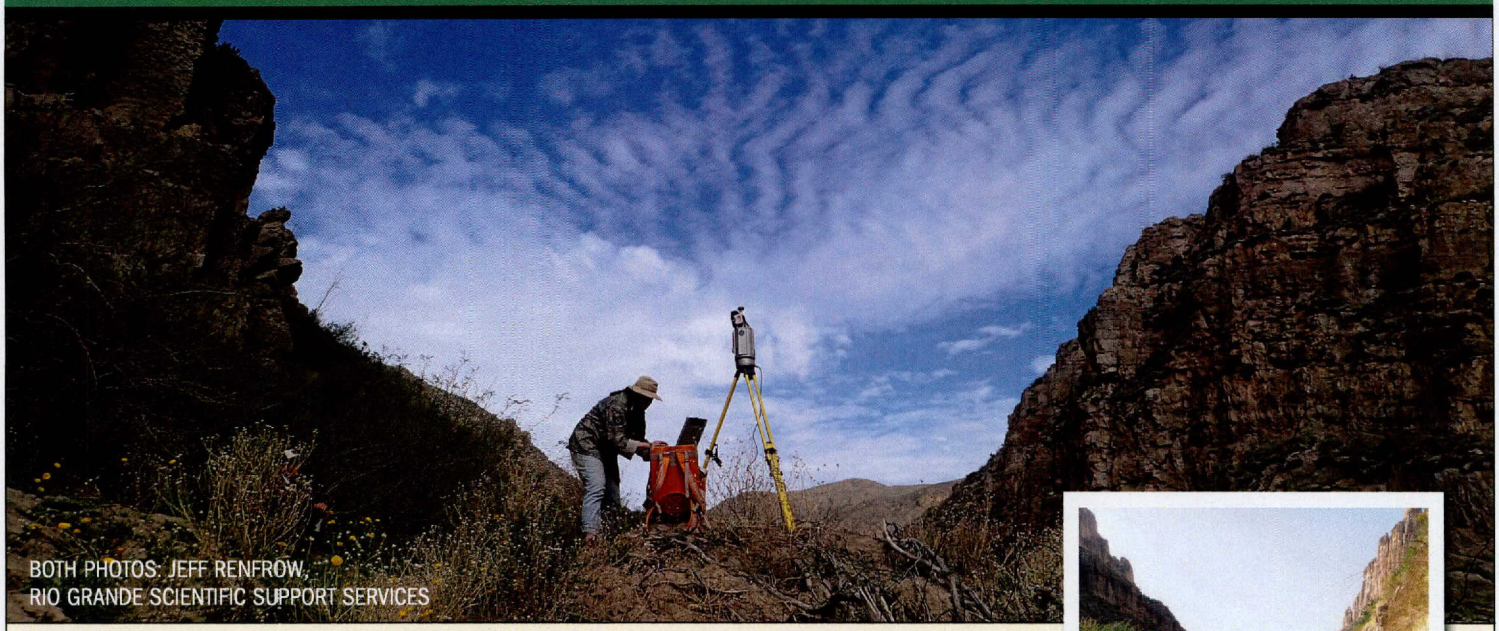
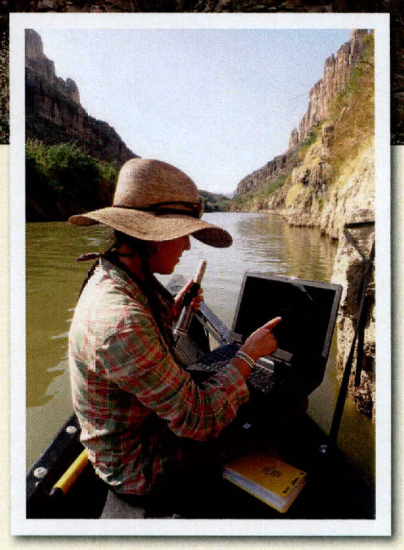


BOTH PHOTOS: JEFF RENFROW, RIO GRANDE SCIENTIFIC SUPPORT SERVICES

Laura Durning (USGS/Grand Canyon Monitoring and Research Center) collects ground based LIDAR to measure topographic changes on the Boquillas Canyon reach of the Rio Grande in Big Bend National Park.



Kelon Crawford of Rio Grande Scientific Support Services downloads transducer data on the Black Gap Wildlife Management Area reach of the Rio Grande.

Along the Big Bend reach of the RGB, streamflow data are collected by a network of gauges maintained by the United States Geological Survey (USGS) and International Boundary and Water Commission (IBWC). The majority of these gauges are real-time (collect data every 15 minutes) and several of these stations have long-term records, though with some interruptions (e.g., several gauges required repair following the high-flow event of late September-early October 2008). Data collected by gauges maintained by USGS can be found at https://waterdata.usgs.gov/tx; data collected by gauges operated by IBWC can be found at https://www.ibwc.gov/Water_Data/histflo1.htm. Also, IBWC's Texas Clean Rivers Program (CRP), in partnership with the Texas Commission on Environmental Quality (TCEQ), is responsible for collecting water quality data throughout the Texas portion of the RGB. Along with all stations that are part of this effort, water quality data collected along the reach of RGB between Presidio/Ojinaga and Amistad (segment 2306) can be found at: https://www.ibwc.gov/CRP/monstats.htm.

In addition to the above, there are several ongoing monitoring efforts in the binational region of Big Bend that are associated with smaller scale, more localized, natural resource conservation efforts. For the past several years, the tag team of Big Bend National Park (BIBE), USGS, Utah State University, Sul Ross State University (SRSU), Rio Grande Scientific Support Services (RGSSS) and Comisión Nacional de Áreas Naturales Protegidas (CONANP), annually conduct an intensive survey of water and sediment flow, channel morphology and aquatic habitat in Boquillas Canyon and the Lower Canyons. The overall goal of this effort is to better understand the status and trends of aquatic and riparian habitat and the processes driving those trends.

In Cuatro Ciénegas – a dune, wetland complex managed in part by CONANP – monitoring of its famous dunes and wetlands is being carried out by CONANP and RGSSS via a combination of ground-based surveys and imagery obtained from repeated drone surveys. The remote monitoring aspect of this program was developed with a big assist from the World Wildlife Fund (WWF) and Kevin Urbanzcyk and his students at Sul Ross State University, with support from the National Park Service's (NPS) Sisters Parks program (there is well-established and mutually beneficial Sister Park relationship between Cuatro Ciénegas and White Sands National Monument).

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Monitoring of riparian vegetation and channel morphology in connection with riparian revegetation efforts along Terlingua Creek at the O2 Ranch, 3 Bar Ranch, and Terlingua Baja (in BIBE) gauges the effectiveness of these planting efforts to meet stated objectives (see accompanying articles on conservation efforts along Terlingua Creek in this newsletter). Monitoring at the O2 Ranch and 3 Bar is being carried out by Rio Grande Scientific Support Services (RGSSS (a natural resource consulting firm located in Terlingua)), SRSU, and WWF. Monitoring at Terlingua Baja is being carried out by BIBE with consultants. Many of these riparian revegetation projects are supported by the Texas Parks and Wildlife Department (TPWD) Landowner Incentive Program (LIP) with funds from the United States Fish and Wildlife Service Partners for Fish and Wildlife Program, state funds, National Fish and Wildlife Foundation Funds, and other funding sources.

Monitoring is also taking place in connection with the exotic vegetation management actions that are taking place along the RGB between Mescal Canyon through Black Gap (see accompanying article on this topic in this newsletter). The objective of this monitoring effort is to understand the effectiveness of binational efforts to manage giant cane as well as how the system responds following treatment. Key questions that are being addressed as part of this effort, include: Does giant cane die back after treatment? What is the response of the riparian vegetation community following treatment – does cane come roaring back or is there a strong native vegetation response? Does treatment of giant cane have a positive impact on streamflow and channel morphology conditions? This monitoring program is being carried out by CONANP, BIBE, WWF, RGSSS, and SRSU. In addition, the USGS, with help from local consultants, routinely surveys channel morphology at several long-term monitoring sites between Solis and Boquillas Canyon, which will be key to understanding correlation between management of giant cane and changes in channel morphology.

Results of the riparian vegetation monitoring part of this program indicate thus far that: (i) treatment of giant cane has dramatically decreased the extent and distribution of this invasive species along the river; (ii) although giant cane does reestablish after treatment, it does so relatively slowly and in a manner that can be managed cost effectively; (iii) there is a strong response of native riparian flora following treatment in some areas. These and other results will be highlighted in forthcoming peer-reviewed reports and journal articles. The results of monitoring to understand the impacts of vegetation management on channel morphology and streamflow is more nuanced and will require additional data collection before conclusions can be drawn with confidence. The majority of data collected as part of this monitoring effort is housed at BIBE.

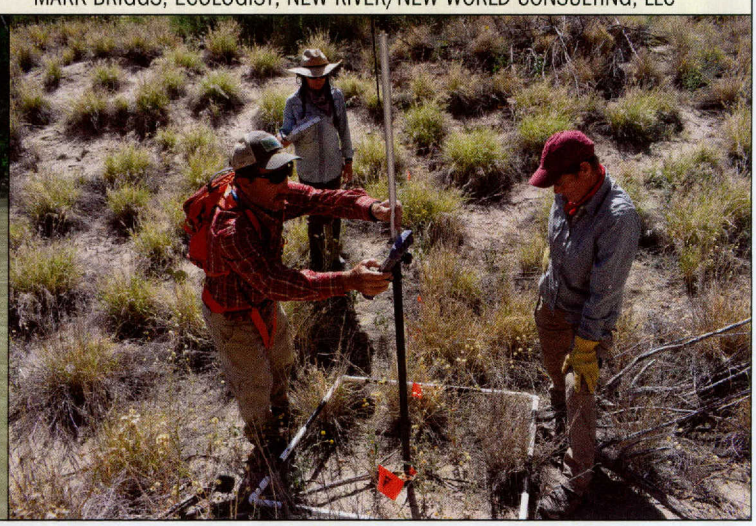
This is not a comprehensive list of monitoring efforts in the Big Bend region, but a good start of the monitoring connected to understanding the RGB system and how well we are progressing toward management objectives.

Biologists from Texas Parks and Wildlife and USFWS sample for fish in San Francisco Creek on the Lower Canyons Reach of the Rio Grande.

JEFF RENFROW, RIO GRANDE SCIENTIFIC SUPPORT SERVICES

Jeff Renfrow, Kelon Crawford, and Patty Manning of Rio Grande Scientific Support Services survey vegetation as part of the Big River Monitoring protocol on the Boquillas Canyon reach of the Rio Grande.

MARK BRIGGS, ECOLOGIST, NEW RIVER/NEW WORLD CONSULTING, LLC



PARTNERSHIPS

BIG BEND CONSERVATION ALLIANCE

Far West Texas is one of the last untouched landscapes still existing in the United States. Any person who visits this area will leave with a greater appreciation for the vast, open spaces and starlit skies. Those who call the area home have a connection with the region's heritage. Growth and development in the Big Bend region is inevitable, but Big Bend Conservation Alliance (BBCA) seeks to promote changes that will enhance existing livelihoods while protecting this delicate, desert landscape in perpetuity.

BBCA is a non-profit, volunteer-driven organization that works to conserve the living heritage and unique natural and cultural resources of the greater Big Bend region of Texas. To accomplish our mission, BBCA has developed programs and strategies that build alliances, educate the public, and promote the heritage and natural resources of the region.

We educate. BBCA is a credible source of unbiased information on issues facing the Big Bend, and on what steps can be taken to protect the natural resources and individual rights of those who live here. For the past two years, BBCA has hosted a West Texas Water Symposium that brought together experts in water policy, land rights, area landowners, and the general public for a candid discussion about the state of water resources in the region. The next Water Symposium is planned for June 2019. BBCA is currently working on developing a regional hydrologic profile with support from the area's groundwater conservation districts to provide better tools for local decision-making.

We promote. Dark Skies are an integral part of what makes Far West Texas the wide, open space it is. BBCA has an ongoing partnership with TPWD's Big Bend Ranch State Park staff, promoting Dark Sky efforts and events. We have supported and participated in numerous Dark Sky workshops held at the state park and around the region, including the "Stars Over Terlingua" event on December 1, 2018. BBCA partners with TPWD and others to work with regional municipalities to become International Dark-Sky Association certified by adopting and implementing light-shielding measures that reduce light pollution in the more populated areas of the Big Bend.

We listen. Big Bend Conservation Alliance serves as a regional convener, acting as a good listener and learning from the broadest range of perspectives to identify, educate, and advocate for the most important issues that face our region's residents, landowners and environment. The BBCA Eminent Domain Town Hall meeting in August 2018 brought together voices from across the region to discuss eminent domain issues facing landowners. Our knowledge of needs and resources in the region grows with every voice we hear, so make your voice heard! BBCA encourages you sign up for our quarterly e-newsletters at www.bigbendconservationalliance.org to stay informed of upcoming events, issues and opportunities throughout the Big Bend.

Please visit our website for additional information about our programs and events: **www.bigbendconservationalliance.org**

Eminent Domain Town Hall meeting in August 2018

West Texas Water Symposium audience

DEVILS RIVER CONSERVANCY

Treasure. Preserve. Protect.

The Devils River watershed is one of the few remaining wild and pristine landscapes in Texas. It encompasses the vibrant biological crossroads of the Texas Hill Country, Chihuahuan Desert, and Tamaulipan Brush Country ecoregions. Steeped in human history and lush with biological diversity it is an outpost of a natural Texas long lost. The Devils River has long been protected by its remote location, rugged landscape and the staunch character of its stewards. However, times are changing in Texas, and as the population grows undue pressure is placed on our already strained natural resources, pushing development into treasured landscapes like the Devils River watershed.

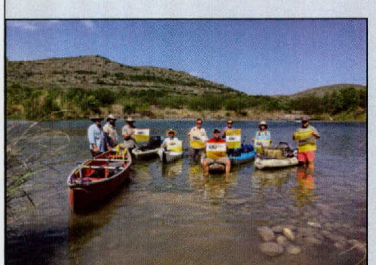
Devils River Conservancy (DRC) is a 501(c)3 non-profit organization lead by landowners, conservation professionals and engaged citizens. The DRC's mission is to protect and preserve the Devils River and the lands within its watershed, the native flora and fauna that call the watershed home and the area's historical heritage. Central to this mission is education of the public on the benefits of the region's natural ecosystem and the need to protect it for future generations. The focal attributes of the Devils River region that the DRC strives to protect are the pristine flowing waters of the Devils River and the groundwater and spring flows that sustain them, numerous endemic species, the star-filled night skies, the natural scenic vistas, and the largely unfragmented landscape.

Some of the most significant challenges facing the Devils River are fragmentation of large private ranches, groundwater resource depletion, recreational abuse, and industrial-scale energy development. The DRC works to address these challenges through:

- Partnerships with conservation organizations such as the Texas Parks and Wildlife Department and The Nature Conservancy
- Education programs designed to engage stakeholders in implementing conservation-driven management and recreation practices
- Outreach events bringing stakeholders together to observe the shared resource and build a common vision for its protection
- Research projects to fill knowledge gaps, develop conservation management tools and provide honest data to guide policy development
- Targeted initiatives to rally stakeholders in addressing significant threats to the region

The DRC has engaged a community of dedicated stakeholders, built a strong network of partners and elevated the profile of the Devils River through these activities. It's Not Easy to Save a River, but the DRC knows it is possible with the continued support of Texans who treasure Texas' last remaining wild places.

For more information about conservation efforts in the Devils River Basin please visit **www.devilsriverconservancy.org**



Stakeholders participate in the DRC lead 'Working Days' outreach event in May of 2018.

CLINT ROBERTSON

Devils River Basin landowners, stakeholders and ranch managers attend a DRC-hosted road building workshop.

FOR MORE INFORMATION

All inquiries: Texas Parks and Wildlife Department, 4200 Smith School Rd., Austin, TX 78744, telephone (800) 792-1112 toll free, or (512) 389-4800 or visit our website for detailed information about TPWD programs:

www.tpwd.texas.gov