Thornforest Conservation Plan

An ecosystem conservation strategy
for the **Rio Grande Valley of Texas**

Contents

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An ecosystem conservation strategy for the Rio Grande Valley of Texas

Developed by the Thornforest Conservation Partnership

Updated March 2022

Texas' Rio Grande Valley (RGV) is home to a diverse subtropical forest ecosystem that features species and habitat associations common to northeastern Mexico. The region's terrestrial biodiversity is dependent on the remnants of this distinct, localized form of Tamaulipan thornforest, which dominated the Rio Grande delta's landscape from historic times through the early 20th century. In the recent past, agricultural land clearing decimated this woodland in such a way that less than 10% of its pre-1930 extent now remains. Expanding fronts of urbanization, invasive species and a changing climate are quickly adding even greater levels of environmental stress to the remaining forest patches. These realities pose a challenge for maintaining the integrity of this ecosystem into the future unless deeper commitments to its conservation are made. The incentives for such actions cannot be understated as habitat restoration is a multi-dimensional strategy for regional economic growth, community resilience and natural resource conservation.

The recently formed Thornforest Conservation Partnership (TCP) is a stakeholder coalition of agencies, institutions, nonprofits and industry members working to conserve this ecosystem for the benefit of the RGV's unique biodiversity. This document, the Thornforest Conservation Plan, is a collaborative effort among TCP partners to establish a guiding framework for achieving this goal. The plan is based on a green infrastructure approach and employs a landscape analysis to envision the strategic expansion of this ecosystem through reforestation. The results of the analysis indicate that restoration of 81,444 acres [e.g., top potential restoration sites (TPRS)] would be necessary to promote the local survival and/or recovery of a select group of focal species by expanding the remaining forest (core areas) and providing connectivity between patches (potential corridors). About 30% (24,724 acres) of this TPRS acreage is located on protected lands where consistency in management objectives is expected [e.g., U.S. Fish & Wildlife Service (USFWS)]. As such, prioritizing restoration on these lands will provide a high return on investment for long-term biodiversity conservation in the RGV. Further examination of planting potential on protected lands reveals that a demand for more than 12 million trees could be generated, even under low density scenarios (e.g., 500 trees/acre). The analysis' implications for the conservation of this ecosystem point to significant investments in regional capacity (e.g., expanded nursery seedling production, increased staffing and advanced research) as being necessary to realize this vision.

With more than 40 years of experience as the region's pre-eminent reforestation practitioner and oversight of most federal restoration efforts in the RGV, the USFWS's restoration program is a logical focus for much of this investment. However, a significant premium on private lands restoration is also implied by the findings. Upcoming dissemination of a detailed goal set, budget and implementation plan for these activities over the next 10 years by TCP membership (Thornforest Business Plan) will be inclusive of restoration opportunities on both protected and private lands. Ultimately, the plan provides a call to action on deeper engagement over this ecosystem's future, including efforts to expand reforestation, advance forest management practices through research and embrace the multi-functionality of natural landscapes in an urbanizing region of Texas.

KENNY BRAUN / AMERICAN FORESTS

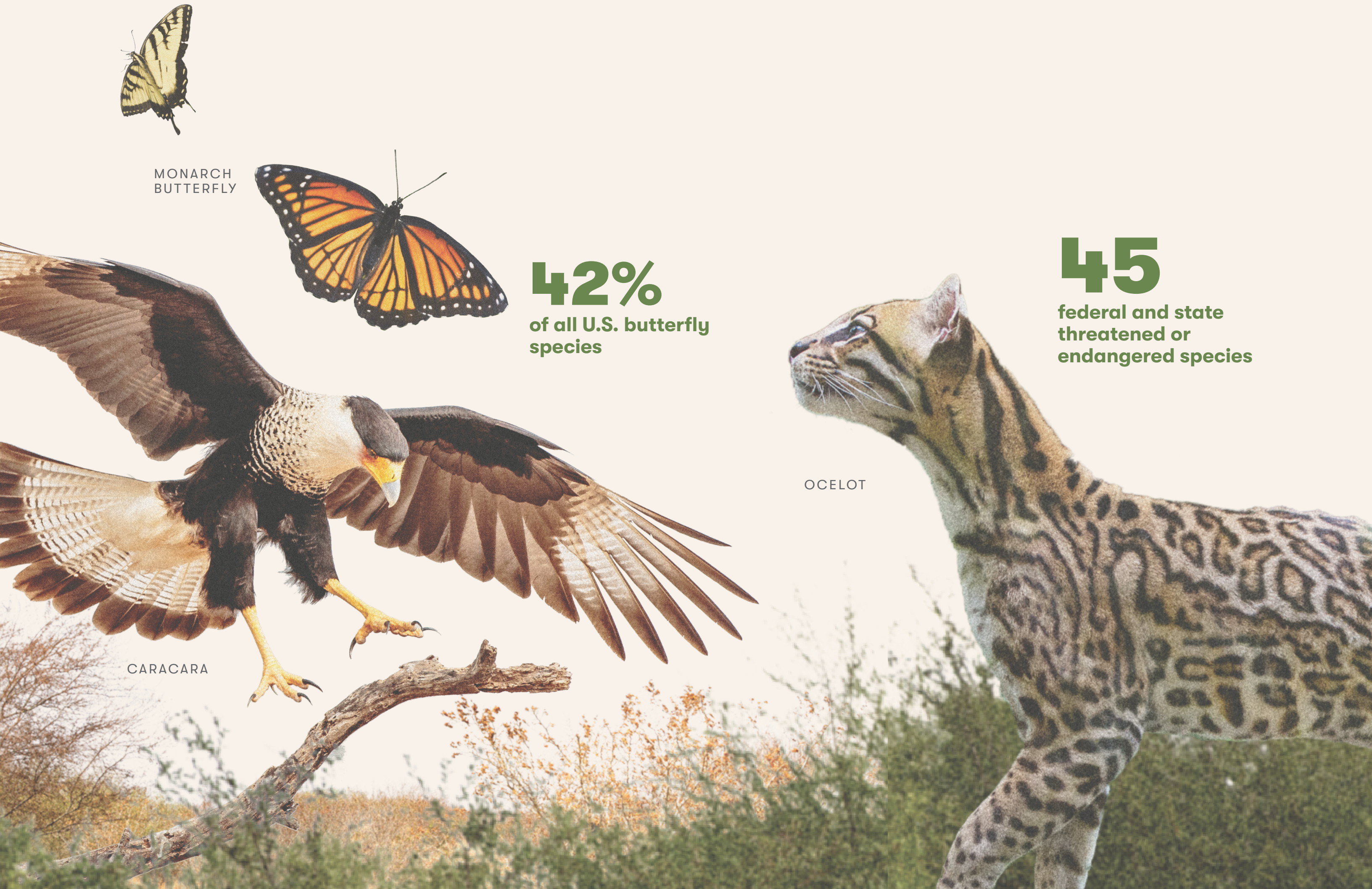
El valle del Río Grande de Texas (VRG) alberga un ecosistema de bosque subtropical diverso que presenta asociaciones de especies y hábitats comunes al noreste de México. La biodiversidad terrestre de la región depende de los remanentes de esta forma distinta y localizada del llamado bosque espinoso tamaulipeco, que dominó el paisaje delta del Río Grande desde tiempos históricos hasta principios del siglo XX. En el pasado reciente, el desmonte de tierras agrícolas destruyó este bosque de tal manera que ahora queda menos del 10% de la extensión que tenía antes de 1930. La expansión urbana, las especies invasoras y un clima cambiante están añadiendo rápidamente niveles aún mayores de estrés ambiental a los parches forestales restantes. Estas realidades presentan un desafío para mantener la integridad de este ecosistema en el futuro a menos de que se hagan compromisos más profundos para su conservación. Los incentivos para tales acciones no pueden subestimarse, ya que la restauración del hábitat es una estrategia multidimensional para el crecimiento económico regional, la resiliencia de la comunidad y la conservación natural.

La Coalición para la Conservación del Bosque Espinoso (Thornforest Conservation Partnership o TCP por sus siglas en inglés), recientemente formada, es una asociación integrada por agencias, instituciones, organizaciones sin fines de lucro y miembros de la industria que trabajan para conservar este ecosistema en beneficio de la biodiversidad única del VRG. Este documento, el Plan de Conservación del Bosque Espinoso, es el resultado del esfuerzo de colaboración entre los socios del TCP para establecer un marco de referencia para lograr este objetivo. El plan se basa en un enfoque de infraestructura verde y emplea un análisis del paisaje para visualizar la expansión estratégica de este ecosistema a través de la reforestación. Los resultados del análisis indican que sería necesaria la restauración de 81 444 acres [p. ej., sitios de restauración de alto potencial (TPRS, por sus siglas en inglés)] para promover la supervivencia local y/o la recuperación de un grupo selecto de especies focales mediante la expansión del bosque restante (áreas núcleo) y proporcionando conectividad entre parches (corredores potenciales). Aproximadamente 30% (24,724 acres) de esta superficie en acres de TPRS se encuentra en tierras protegidas donde se espera coherencia en los objetivos de gestión [p. ej., Servicio de Pesca y Vida Silvestre de EE. UU. (USFWS). Como tal, priorizar la restauración en estas tierras es una gran inversión para la conservación de la biodiversidad a largo plazo en el VRG. Un estudio más detallado del potencial de plantación en tierras protegidas revela que se podría generar una demanda de más de 12 millones de árboles, incluso en escenarios de baja densidad (por ejemplo, 500 árboles/acre). Las implicaciones del análisis para la conservación de este ecosistema apuntan a inversiones significativas en la capacidad regional (p. ej., mayor producción de plántulas de vivero, mayor dotación de personal e investigación avanzada) como necesarias para hacer realidad esta visión.

Con más de 40 años de experiencia como el principal practicante de reforestación de la región y la supervisión de la mayoría de los esfuerzos federales de restauración en el VRG, el programa de restauración del USFWS es un enfoque lógico para gran parte de esta inversión. No obstante, nuestros hallazgos también encontraron que la restauración en tierras privadas es primordial. La próxima y posterior difusión de un conjunto detallado de objetivos, presupuesto y plan de implementación para estas actividades durante los próximos 10 años por parte de los miembros del TPC (Plan Económico para el Bosque Espinoso) incluirá oportunidades de restauración tanto en áreas protegidas como privadas. En última instancia, este plan proporciona un llamado a la acción sobre un compromiso más profundo sobre el futuro de este ecosistema, incluyendo los esfuerzos para expandir la reforestación, promover las prácticas de manejo forestal a través de la investigación y adoptar la multifuncionalidad de los paisajes naturales en una región urbanizada de Texas.

KENNY BRAUN / AMERICAN FORESTS

The Rio Grande Valley (RGV) of Texas encompasses Cameron, Hidalgo, Starr and Willacy Counties and has a combination of climate, vegetation and associated wildlife that creates an ecosystem unlike any other in the United States.



42%
of all U.S. butterfly species

45
federal and state threatened or endangered species

The region's historically dominant land cover, the Tamaulipan thornscrub or thornforest ecosystem, is characterized by diverse subtropical vegetation that provides habitat for a stunning array of biodiversity (Beattie 1996, Diamond 1998). This assemblage includes 45 federal and state threatened or endangered species, 519 bird species (58% of all U.S. bird species can be found here), 316 butterfly species (42% of all U.S. butterfly species) and 1,200 plant species (Leslie 2016).

Yet, Tamaulipan thornforest habitats have been extensively cleared in modern times and exist now as scattered patches separated by large expanses of intensive agriculture and urban development. Various studies have identified the region as being a priority for protection given both its rich biodiversity and high degree of human influence (Ricketts and Imhoff 2003, Armsworth et al. 2020).

Despite strong resource planning within local units of the National Wildlife Refuge System (Department of the Interior-U.S. Fish & Wildlife Service), watersheds (e.g., Arroyo Colorado, Laguna Madre) and individual municipalities, no regional stakeholder association has previously existed to guide conservation (e.g., preservation and ecological restoration) of RGV thornforest. Here, the presence of dedicated planning could help to 1) identify landscape-level conservation priorities for the RGV; and 2) guide efforts to ensure that conservation efforts occur in the most strategically important places. In the context of shared stewardship for this ecosystem, matching individual stakeholders' expertise to the mounting number of existential challenges (e.g., intensified development, invasive species) is a key step towards achieving its long-term survival (Baldwin et al. 2018).

About the Thornforest Conservation Partnership

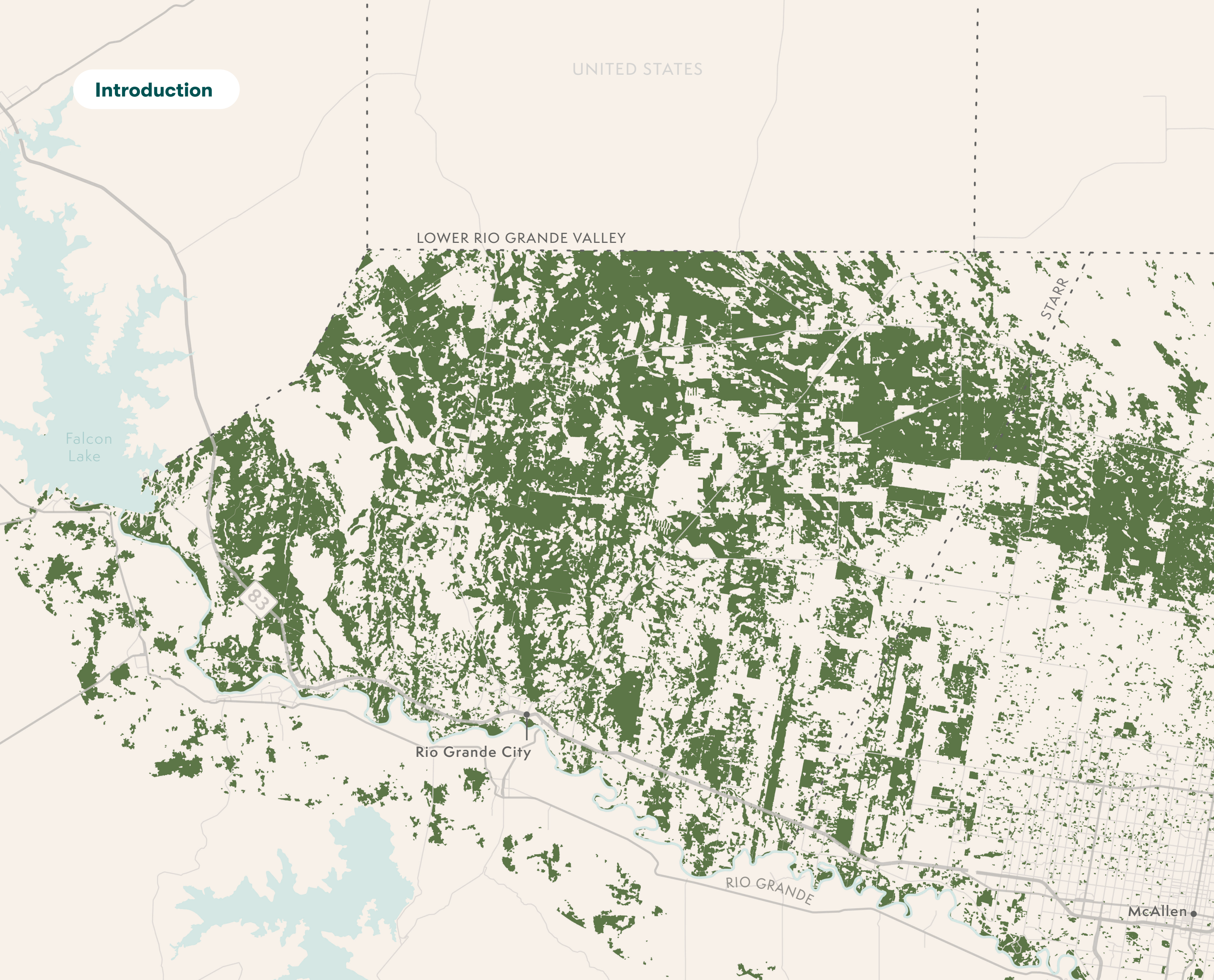
To meet these needs, the Thornforest Conservation Partnership (TCP) was formed in 2018 to jointly develop science-based plans and goals to guide conservation efforts in the RGV, communicate the importance of thornforest habitat and conservation progress to the public, and encourage action for stronger public policies and funding. The TCP is a coalition of state and federal agencies, universities, nonprofit and community organizations working to restore thornforest habitat in south Texas. Its existing mission objective is to facilitate conservation of the RGV's thornforest ecosystem for the benefit of the region's endemic biodiversity.

Partners include: American Forests, U.S. Fish & Wildlife Service, Texas Parks & Wildlife Department, The Conservation Fund, The Nature Conservancy, Rio Grande Joint Venture, Texas A&M University-Kingsville, USDA-Natural Resources Conservation Service, The University of Texas-Rio Grande Valley, Texas A&M Forest Service and others.

ALTAMIRA ORIOLE

58%
of all U.S. bird species

1,200
plant species



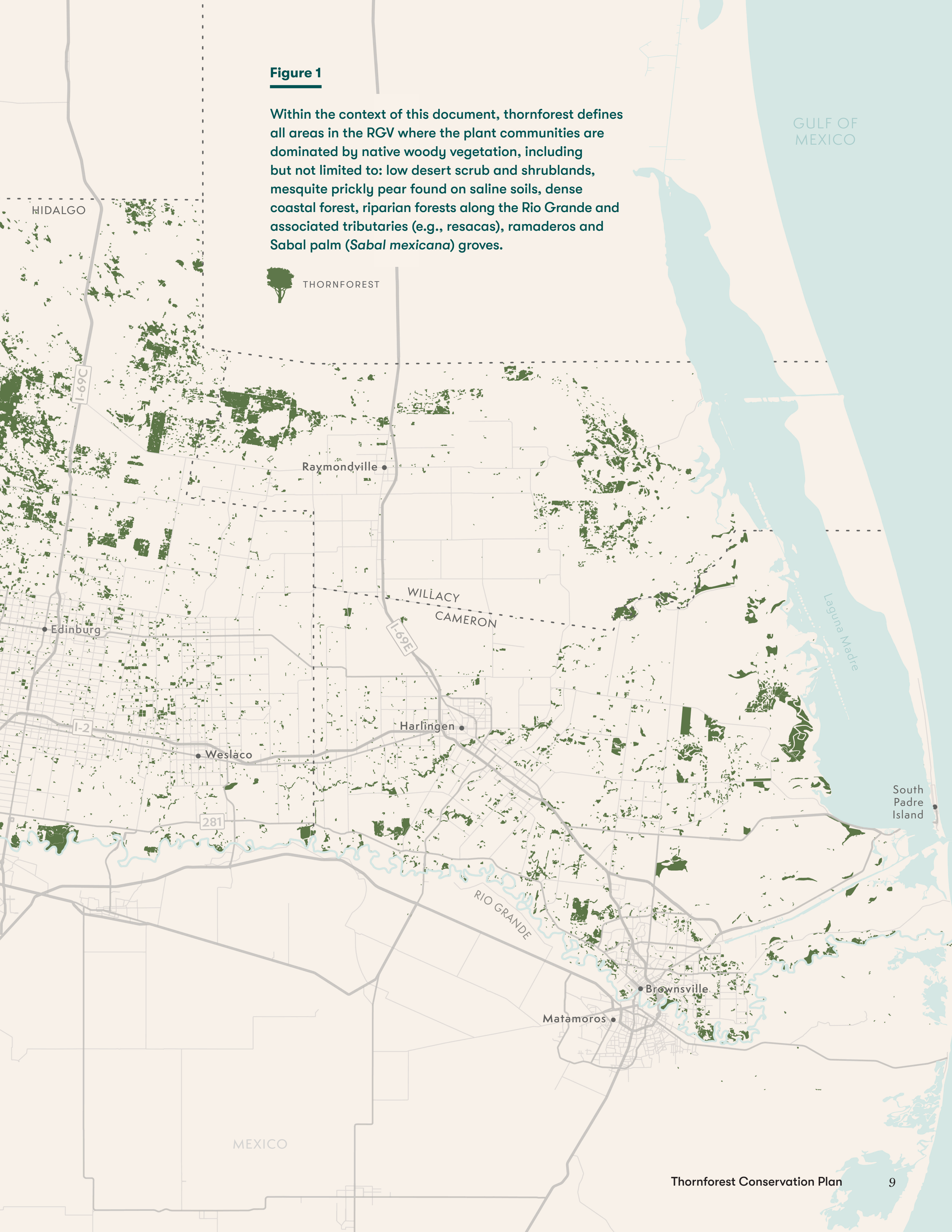
The Importance of Thornforest

Texas' four southernmost counties (**Figure 1**) encompass the delta of the Rio Grande River. The local Tamaulipan thornforest vegetation is generally characterized by dense and diverse brush that provides habitat for many wildlife species. It is often described that, in the absence of trails, a person would have to crawl on their stomach to traverse mature thornforest habitat.

Varying regional climate and underlying soils result in a mix of vegetation types, ranging from desert-like stretches of short stature plants in the west, to tall, forest-like remnants along resacas and other riparian areas, to grassland-dominated habitats in the eastern coastal sections.

Figure 1

Within the context of this document, thornforest defines all areas in the RGV where the plant communities are dominated by native woody vegetation, including but not limited to: low desert scrub and shrublands, mesquite prickly pear found on saline soils, dense coastal forest, riparian forests along the Rio Grande and associated tributaries (e.g., resacas), ramaderos and Sabal palm (*Sabal mexicana*) groves.



This binational ecosystem is truly unique to southern Texas and northeastern Mexico and is home to a diverse group of wildlife and plants, including:

45 **federal and state threatened or endangered species,** including the ocelot, a neotropical forest cat with a U.S. distribution that is now limited to approximately 80 individuals in the RGV.

519 **bird species,** with multiple neotropical species reaching their northern distributional limits in the RGV. The presence of both resident and migratory species makes thornforest a critical habitat for breeding and stopover ecology as well as a much-sought-after destination for ecotourist visitors from around the world.

316 **butterfly species,** a number that encompasses approximately 42% of all butterfly species found in the U.S. The occurrence of many individual species is linked to the distribution of respective thornforest plants that serve as hosts during their larval life stages. This area also includes crucial migratory habitat for dwindling numbers of the monarch butterfly as they embark on their 2,000-mile migrations across North America.

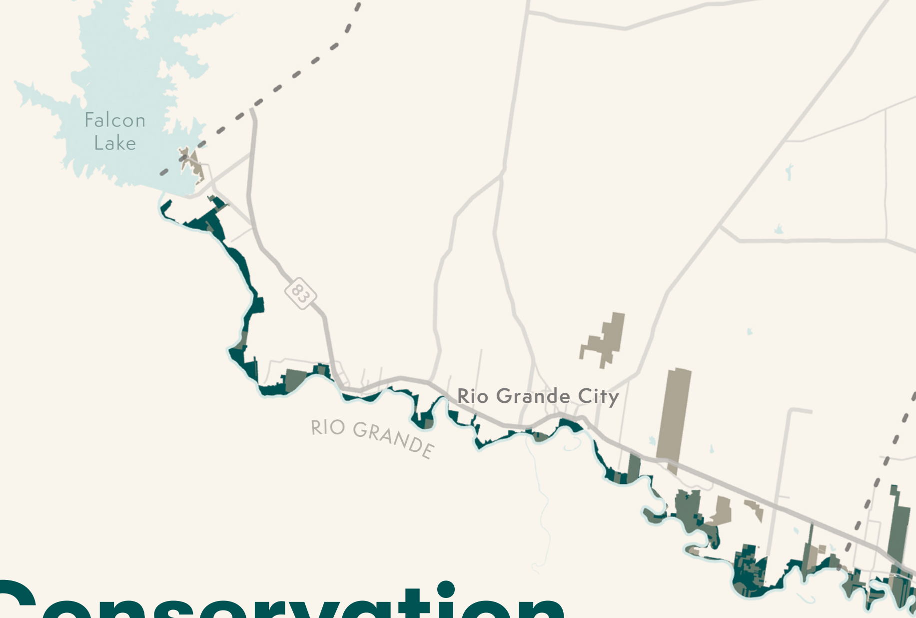
1,200 **plant species,** including six threatened and endangered species. As with birds, a number of neotropical plant genera (e.g., *Esenbeckia*, *Adelia*) reach their northern distributional limit in south Texas, with endemism to the RGV and neighboring regions of northeastern Mexico occurring in several species.

Thornforest was once extensive and covered much of the RGV up through the first decades of the 20^{th} century (Tremblay et al. 2005). Today, less than 10% of this historic acreage remains within the three eastern counties, mostly on private ranches, in scattered protected areas, fence rows, highway rights-of-way and along canals. Since the early 1900s, the conversion of this habitat has had a profound impact on the RGV's biodiversity. As breeding habitat and movement corridors have been lost, wildlife populations have been greatly diminished. For example, there are approximately 80 endangered ocelots remaining in the RGV. In Texas and northeastern Mexico, the ocelot is a thornforest habitat specialist, and its future in the U.S. is now dependent on the success of habitat restoration and other conservation efforts (USFWS 2016).

<10% remains of the extensive thornforest that covered much of the RGV through the first decades of the 20th century.

The loss of intact thorn woodlands has also impacted important ecosystem service functions such as the filtering of water pollutants, recharging of water supplies, carbon sequestration and erosion control. This ongoing degradation carries a real cost for conservation in the RGV and, increasingly, within a social context as well. Conserving and restoring native thornforest is a clear economic development strategy as the region draws in thousands of birdwatchers each year to view migrations and regional specialties like the **green jay** (*Cyanocorax yncas*). More than $340 million has been generated annually in the RGV from ecotourism alone (Woosnam et al. 2011).

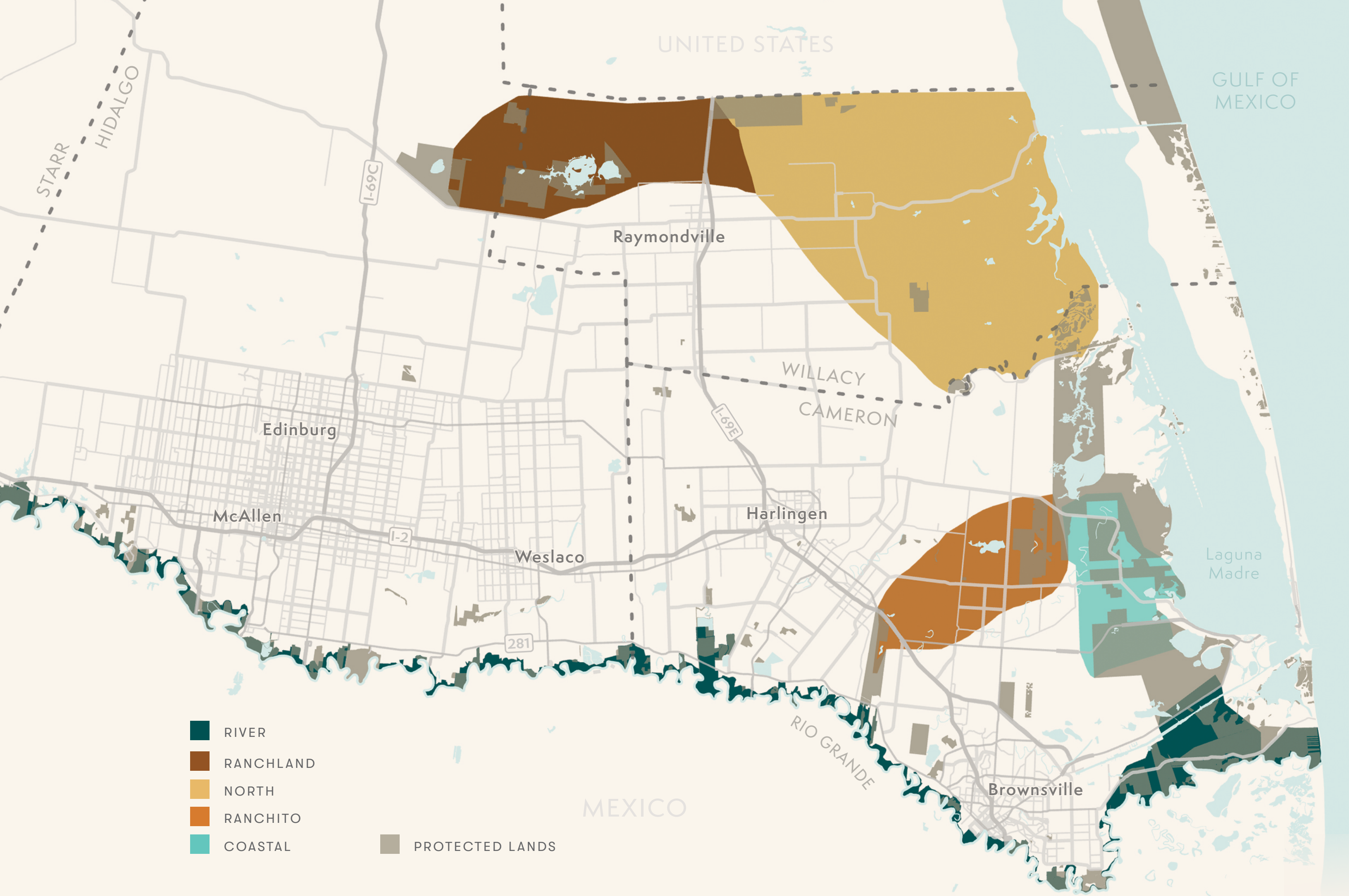
GREEN JAY



Existing Conservation Planning in the Rio Grande Valley

The U.S. Fish & Wildlife Service (USFWS) manages three national wildlife refuges (Laguna Atascosa, Lower Rio Grande Valley and Santa Ana) to collectively steward some of the most ecologically significant remaining forest in the RGV. The USFWS also manages a restoration program that converts cropland and disturbed areas into a diverse mix of thornforest species through reforestation. Since 1982, they have planted over 16,000 acres on protected public lands (USFWS 2021, pers. comm).

Over the past 40 years, this program has pioneered an effort that is unique to both the region and to this agency. The work has evolved to include proven restoration methodologies across many distinctive thornforest types. For example, a reliance on direct seeding in the early days proved insufficient to meet program goals and was replaced by container-grown nursery production in the mid-1990s (Twedt and Best 2004, Albrecht et al. 2021). Similarly, the diversity and density of plantings has changed over time as program managers have become more efficient in seedling production and familiar with variability in planting conditions. High-density plantings (750–1000 seedlings/acre) using 20 or more species are now common on an annual basis within this effort. Planning continues to adapt in response to existing challenges in successful forest establishment (e.g., invasive species) as well as to deeper threats, such as those presented by a changing climate.



The USFWS has developed five conceptual corridor areas to focus their conservation efforts: ranchland, north, coastal, ranchito and river (**Figure 2**). These corridors were identified by the USFWS' Comprehensive Conservation Plans for Laguna Atascosa NWR (USFWS 2010), Lower Rio Grande Valley NWR (USFWS 1997) and Santa Ana NWR (USFWS 1997). The expectation is that many regional wildlife populations will have a greater chance at long-term survival by enhancing landscape-level connectivity through thornforest preservation and restoration within these distinctive areas (Lehnen et al. 2021). These corridors provide an informed vision of where this connectivity could likely be achieved over time but must be viewed in balance with other considerations to ultimately determine their likelihood of success (e.g., adoption of reinforcing land management practices by private landowners).

Increasingly, the USFWS is focusing protection and restoration efforts in areas used by ocelots (e.g., north, ranchland and coastal corridors). There are no known ocelots using the river corridor as it has developed into a mosaic of intensive agriculture, sprawling development, border security areas and protected lands. Restoration along the Rio Grande should not be de-emphasized, however, since it provides benefits to resident and migratory birds, plants and watershed health, as well as economic and health benefits for communities.

In assessing the value of planning efforts contained in this document, restoration will need to be implemented with care so as not to cause unintended consequences for species like the ocelot. For example, thornforest restoration could inadvertently cause ocelots to enter more developed areas where they are at increased risk for car collisions and other threats. Here, the importance of alternatives in corridor routing, projections in development (e.g., dense residential use) as well as a willingness and capacity to implement infrastructural accommodations (e.g., wildlife crossings) cannot be understated with respect to achieving long term goals (USFWS 2016).

Figure 2

Increasingly, the USFWS is focusing protection and restoration efforts in areas used by ocelots (e.g., north, ranchland and coastal corridors). There are no known ocelots using the river corridor as it is still a mosaic of intensive agriculture, sprawling development, border security areas and protected lands.

Plan Overview

To complement these existing approaches, the TCP has developed this document, the Thornforest Conservation Plan (plan), as a starting point for catalyzing a coordinated, regional response to thornforest conservation. The plan was developed by modeling the RGV's existing green infrastructure and then creating a spatial analysis of wildlife movement within it to inform potential restoration opportunities. Much like how roads, utilities and other infrastructure provide the foundation on which communities thrive, green infrastructure units are the foundation for wildlife habitat, clean water, air and other natural benefits in the RGV (Allen 2012, Lennon and Scott 2014, Lanzas et al. 2019). At landscape scales, green infrastructure management is based on principles of conservation biology and landscape ecology. The goal is to reduce habitat fragmentation, maintain viable populations of native species, conserve and increase interior habitat and improve an ecosystem's resiliency to disturbances, including development and climate change.

The building blocks of the RGV's green infrastructure network include core areas of remaining forest and corridors. Core areas contain fully functioning portions of the ecosystem and provide high-quality habitat for native plants and animals. They serve as recruitment sources for colonization of the surrounding landscape, provide ecosystem services like clean water, air and carbon sequestration, and create recreational opportunities for nearby communities. Corridors are generally linear features that link core areas together through an unsuitable landscape pattern or matrix (e.g., row crops or development) and allow animal and plant movement between them by providing connectivity. Connectivity helps to mitigate forest habitat fragmentation within the landscape by enhancing recruitment of new population members into otherwise isolated core area populations (Bennett 1998). The hope is that any localized extinction within a core area will be offset by recolonization and that genetic exchange will maintain fitness, ensuring the long-term survival of animal and plant species in the region.

In the following sections, the plan's findings are presented as the top potential restoration sites identified through this spatial analysis of green infrastructure. These results include county-level acreage breakouts of restoration opportunities that would have meaningful impact on the long-term conservation of signature thornforest species. The plan's implications for restoration on both private and protected lands are also discussed with special attention given to scaling the existing capacities of the USFWS restoration program. Finally, a section on next steps for the incremental expansion of this analysis is included. For the sake of transparency, a series of appendices also relates key terminology and the stepwise development of the analysis used to produce the results, including major sections on identification of core areas, potential corridors and restoration potential. Throughout this document we also present figures and tables to better illustrate the material being described.

Goals of restoration

1. **Protecting and expanding core habitat**
2. **Increasing connectivity**

Findings

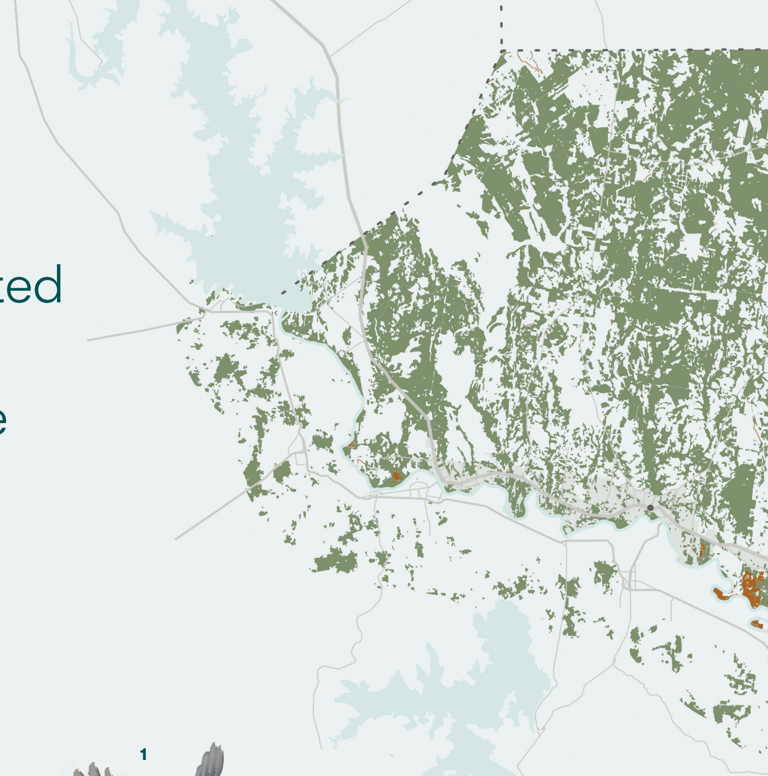
Top Potential Restoration Sites

Lands that corresponded to a higher restoration score in the spatial analysis were defined as top potential restoration sites (TPRS).

Thornforest restoration at these sites would provide lasting benefits to several focal wildlife species (e.g., Altamira oriole, ocelot, Texas tortoise, olive sparrow and plain chachalaca) whose habitat requirements were used in the analysis as proxies for the RGV's extensive forest-dependent biodiversity (see Appendix B). To expand the conservation planning value of this analysis, TPRS were refined to reflect some of the administrative, spatial and biological complexities that landscape restoration efforts of this scale should be cognizant of. This process resulted in the selection of contiguous 5-acre sites as the minimum size threshold for inclusion within the TPRS. Additionally, it was understood that planning at this level should distinguish between restoration opportunities still present within the RGV's frontier of urbanization and those in more rural areas where development pressure is not currently as extensive. Generally speaking, these "urban" opportunities are fewer in number and smaller in size but could still provide substantial value as corridor linkages if not long-term source habitat for these focal species. Reforestation in these more developed spaces also serves as a gateway to public engagement, wherein community members have a chance to become familiar with restoration as a regional strategy for conservation, economic development and community resilience. To this end, an "urbanized areas" layer was designated in the map figures to provide a rough spatial distinction between rural and urban restoration opportunities.

GIORGIO QUATTRONE / FLICKR

Findings



A total of **81,444 acres** distributed throughout Cameron, Hidalgo, Starr and Willacy Counties were considered to be TPRS (**Figure 3**).

Of these, 24,724 acres (30% of total) are protected lands owned by agencies that include USFWS, the Texas Parks & Wildlife Department, National Park Service and others. This figure also includes acreage located adjacent to existing forest that is owned by nonprofit organizations focused on *in-situ* conservation efforts (e.g., The Nature Conservancy's Lennox Foundation Southmost Preserve near Brownsville). Given that these entities are expected to provide long-term ownership and consistency in management, said lands present a unique opportunity for high return on restoration investment in coming years. In some cases, the present use of these parcels features active row-crop production under lease agreements but also includes former production fields in various stages of abandonment. Conditions on these protected lands TPRS also include areas where earlier restoration efforts have not achieved desired levels of forest cover or where disturbances have removed vegetation (e.g., non-permanent easements, burn scars). Supplemental or "augmentation" planting in these areas will function to reset previous restoration efforts by closing existing forest gaps with a contiguous, high-quality habitat over time. **Table 1** presents a breakout of protected lands TPRS by county and restoration opportunity type.

The remaining 56,720 acres of identified TPRS are located on private lands that are equally essential to achieving goals in biodiversity conservation within the RGV's thornforest ecosystem (USFWS 2016). As with public agencies, many ranching and farming operations are guided by strategies that seek to conserve natural resources through sustainable land management practices. Private lands are highly valued for the wildlife conservation benefits they provide, and landowners have adopted business models to showcase these assets where feasible (e.g., hunting, ecotourism, etc.). Reforestation in such areas will supplement these existing economic growth and conservation strategies for some while creating new incentives for others. **Table 1** presents a county-level breakout of private lands TPRS by the number of landowners and urban/rural restoration opportunity type. On the surface, the high number of landowners and the smaller average size of individual landholdings (3–52 acres across category types) is in-line with the region's dense settlement pattern (Lopez et al. 2019). Rural private lands TPRS, however, are concentrated on larger, contiguous ranches as well as irrigated and dryland production fields.

Habitat requirements for five native species were used in the TPRS analysis as proxies for the RGV's extensive forest-dependent biodiversity (see Appendix B).

1. **Altamira oriole**
2. **ocelot**
3. **Texas tortoise**
4. **olive sparrow**
5. **plain chachalaca**

If we translate restoration opportunities into tree planting potential, there are additional figures to consider. **Table 2** (see page 23) illustrates one way to consider this by using planting density scenarios similar to those currently being employed by the USFWS restoration program. While these are rough projections, the reader can see that following the low end of planting density could result in a demand for over 12 million trees on suitable protected lands within the RGV.

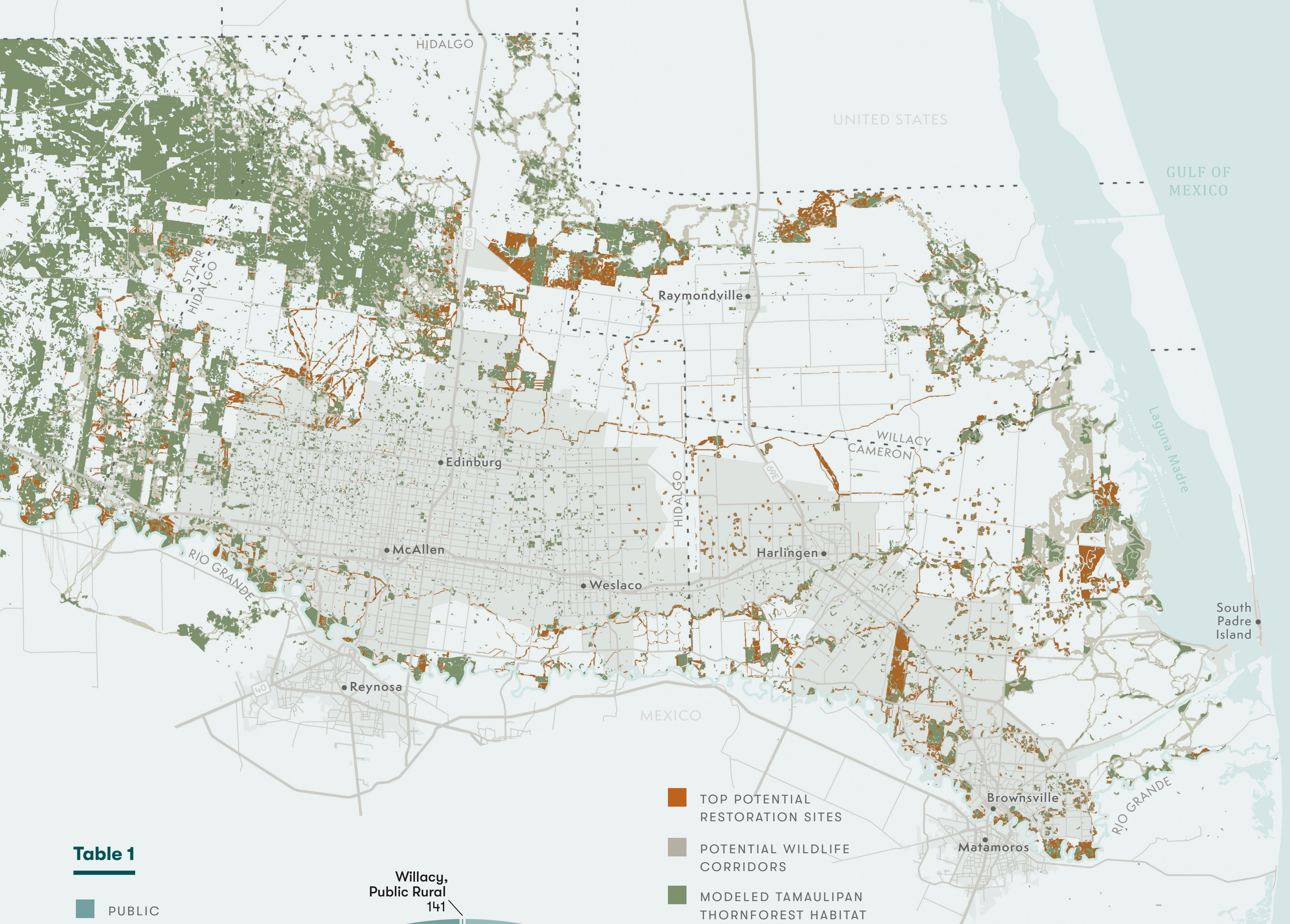


Table 1

PUBLIC

PRIVATE

(in acres)

OF LANDOWNERS

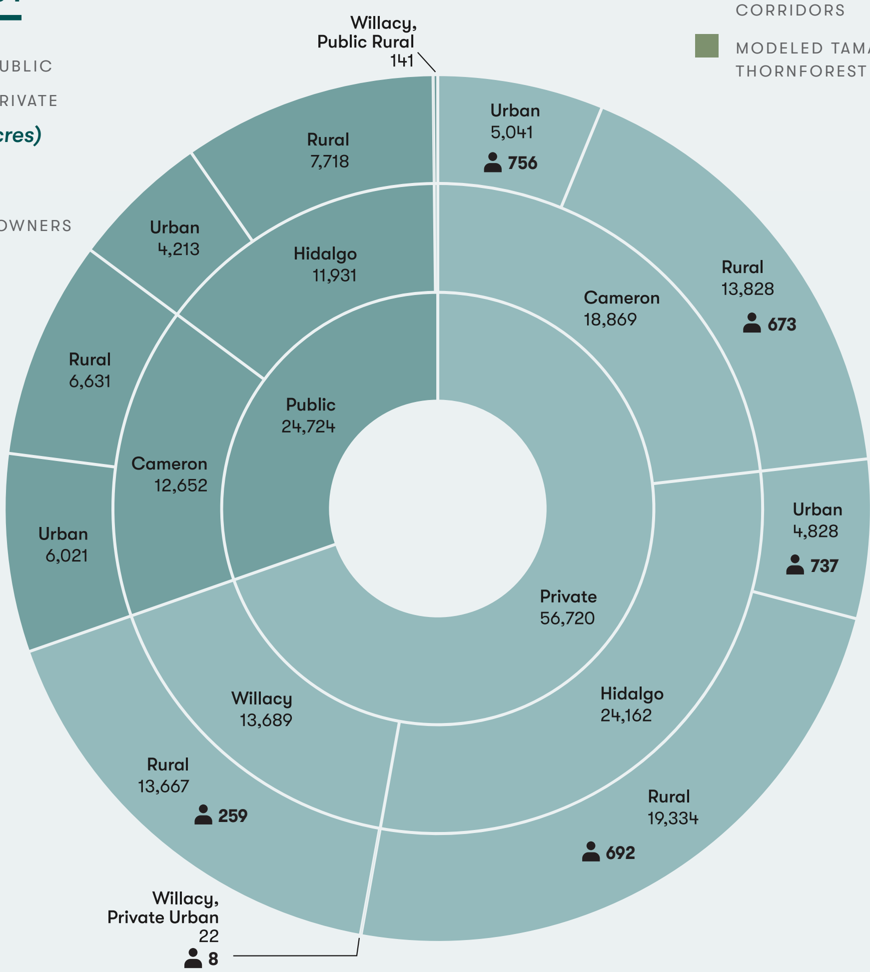


Figure 3

"Urbanized areas," shaded grey on map figures, provide a rough spatial distinction between rural and urban restoration opportunities. Planning at this level should distinguish between restoration opportunities still present within the RGV's frontier of urbanization and those in more rural areas where development pressure is not currently as extensive. Generally speaking, these "urban" opportunities are fewer in number and smaller in size but could still provide substantial value as corridor linkages if not long-term source habitat for these focal species.

Implications for Thornforest Restoration

State of Protected Lands

Through public trust, protected lands in the U.S. are expected to model our best efforts at attaining goals in ecosystem management.

For any responsible agency, however, maintaining the integrity of these efforts and scaling their reach can be difficult in the face of socio-ecological complexities, changing conditions on the ground and budget constraints. In the RGV, exceptional foresight by the USFWS more than 40 years ago pioneered forest restoration as a strategy for mitigating ecosystem degradation. In contrast to other federal land-management agencies, the Service has gradually refined this tool into a program with no expectation for revenue generation or cost-recovery. Yet, they are tasked with intensifying all aspects of their work to deliver long-term conservation of focal species like the ocelot under appropriations that are highly variable. Moreover, the parallel trajectories of binational economic dependence, population growth, habitat loss and resource scarcity inherent to the U.S.-Mexico border now magnify the importance of this protected lands base for the region's future. If the established restoration program is to facilitate an expected model of ecosystem conservation over the long run, significant assistance will be needed to fill gaps in reforestation capacity.

Restoration success is dependent on multiple factors but two stand out in particular:

1. Nursery Production
2. Applied Research

At the current rate of annual seedling production, it would take nearly

150 years

to reforest the TPRS identified in this plan's analysis.

1

Nursery production addresses the supply of thornforest seed and seedlings needed to reforest priority areas.

A recently completed case study conducted by American Forests highlights concerns over capacity gaps in this regional production by providing insight into the current status of native plant nurseries. For example, at the current rate of annual seedling production, it would take nearly 150 years to reforest the TPRS identified in this plan's analysis (American Forests 2021a). Additionally, the existing production pipeline is dependent on seed collection activities that require extensive commitments in manpower and time throughout a calendar year that is saturated with overlapping priorities in plant care, maintenance and planting site preparation. These and other report findings broadly underscore the need for solutions that can address expanded nursery infrastructure and staffing levels for these activities.

Table 2

We can translate restoration opportunities into tree planting potential by using planting density scenarios similar to those currently being employed by the USFWS restoration program. Even rough projections indicate that the low end of planting density could result in a demand for over 12 million trees on suitable protected lands within the RGV.

2

Concurrently, applications of both lab- and field-based research are essential to restoration success and have facilitated these actions in south Texas since first originating more than 60 years ago (Riskind et al. 1987).

More recently, studies into the survivorship of restored stands over time, recruitment, planting densities and responses to manipulation are beginning to provide a clearer picture of which restoration methods hold the greatest promise for long-term gains in quality habitat for imperiled species like the ocelot (Mohsin et al. 2021). This small but growing body of study also includes a new initiative to determine what implications our changing climate may have on thornforest survival and, by extension, efforts to restore it. To date, the products of this initiative include a strategy document which relates the USFWS restoration program's existing efforts to an overarching goal of climate resilience and a pilot project that was the first planting to fully incorporate this strategy document's approach to reforestation (American Forests 2021). These local assets are now supporting recent directives to begin implementing decision-making frameworks around ecosystem change on protected lands in the U.S. (e.g., Resist-Accept-Direct (RAD)) and will facilitate additional research lines into climate change impacts in the RGV. Clearly, more work remains for agencies, institutions and conservation groups to ensure that restoration practices result in mature, functioning habitat down the line.

Scaling Up

Expanded nursery infrastructure, increased staffing and advanced research are essential groundwork for realizing the most pressing need in the RGV's thornforest ecosystem: scaling up reforestation on protected lands.

With the greatest share of protected lands TPRS identified in this analysis and additional land acquisitions with restoration potential likely in the future, the USFWS is key to realizing this growth. However, with the restoration program's acreage targets remaining static (e.g., 100–200 acres/year), the likelihood of creating a substantial base of additional habitat for focal species remains remote. At issue here is that every acre of reforested land requires significant front-end investment from the Service to avoid poor stand establishment. Beyond seedling production, costs associated with site preparation, tree shelters, planting labor and post-plant treatments (to mitigate invasive species) are considered essential to success. To catalyze this scale up and promote long-term conservation gains at the landscape level, it will be necessary for regional stakeholders and other partners to share these costs moving forward.

Informed estimates of these costs and detailed rationale for the previously mentioned restoration capacity needs are explored in a companion document also designed by TCP membership: the Thornforest Business Plan. Among other deliverables, the plan identifies focal species goals and metrics (e.g., increasing population sizes), establishes an implementation strategy for re-forestation in support of these goals and provides a due-diligence risk assessment of proposed activities. The culmination of this work is a projected budget inclusive of habitat restoration objectives on both protected and private lands over the next 10 years. Ultimately, the reader will come to view this companion document as an investment roadmap for partners who share the TCP's vision of thornforest ecosystem conservation in the RGV.

GISEL GARZA / AMERICAN FORESTS

Wider Implications

While an established effort exists for forest restoration on protected lands in the region, much work is needed to mainstream this practice in private lands stewardship.

This is a profound reality in Texas as approximately 97% of the state's area is privately held (Haines et al. 2006a). Where incentives still existed to clear large core areas of mature thornforest only a few decades ago, there is now an even stronger need to both conserve and restore this vegetation in strategically important ways within the Rio Grande delta. The region's extensive rate of residential and commercial development over the past 25 years has driven these realities home for all TCP stakeholders as well as for large segments of the RGV's public. Although this ongoing transition can support economic gains and quality of life improvements for residents, growth must be balanced to support the region's natural capital as well. Our analysis places a significant premium on private lands restoration and will inform future pathways for incentivizing this trajectory in land management.

The Thornforest Conservation Plan will also have value for federal and state agencies tasked with mitigating the effects of hardened road and border security infrastructure in the RGV. For example, outputs from the analysis, including potential corridors and TPRS, are derived in part from existing or planned wildlife crossing locations **(Figure 4)**. Along these same lines, future reforestation directed at TPRS will help to catalyze more intensive planning of a feedback nature by the Texas Department of Transportation (TXDOT) and others to address renovation, increased coverage and/or frequency in wildlife crossing structures. Similarly, border barrier and modified protective levee infrastructure commissioned by U.S. Customs and Border Protection and managed jointly with the International Boundary and Water Commission (IBWC) figured into our analysis. We are cognizant of the need for additional, detailed study into how portions of the barrier may be influencing connectivity between wildlife populations along the entire river corridor. Further analysis and ground-truthing will also be needed to assess the efficacy of restoration along proposed corridors in these same areas **(Figure 5)**.

Figure 4

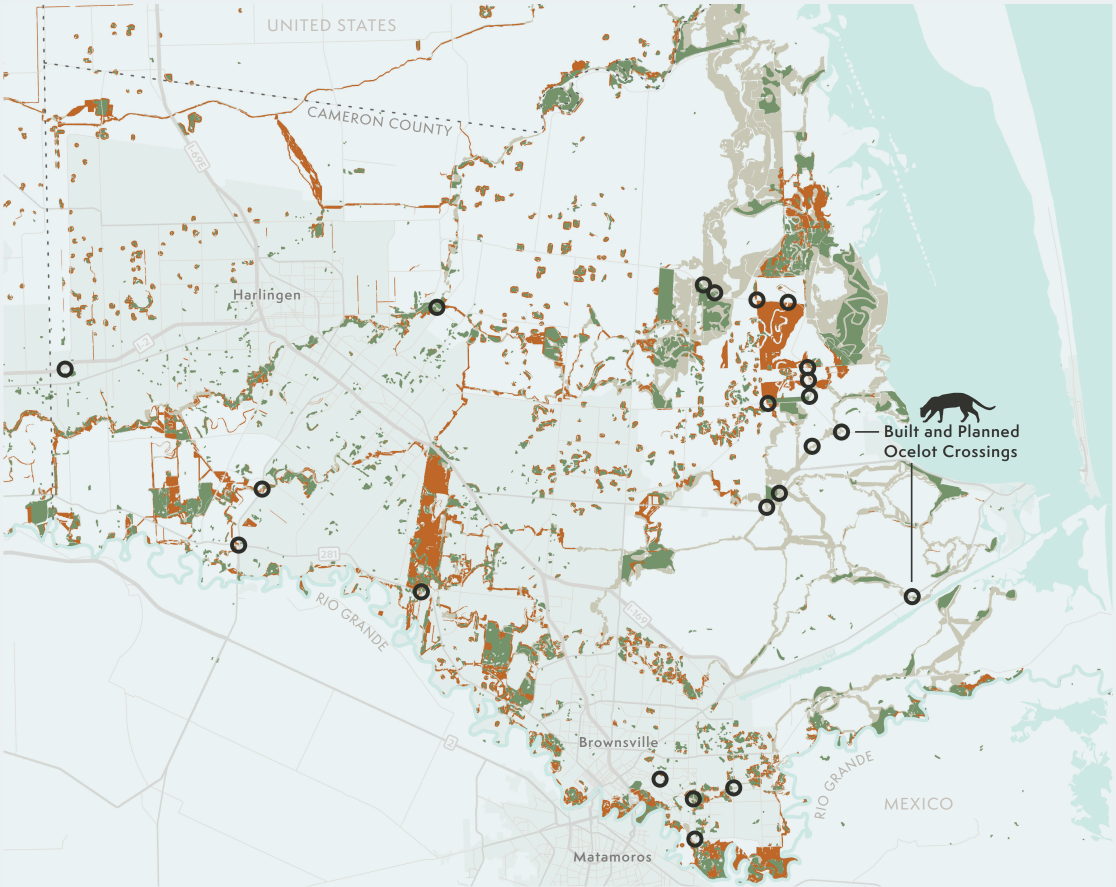
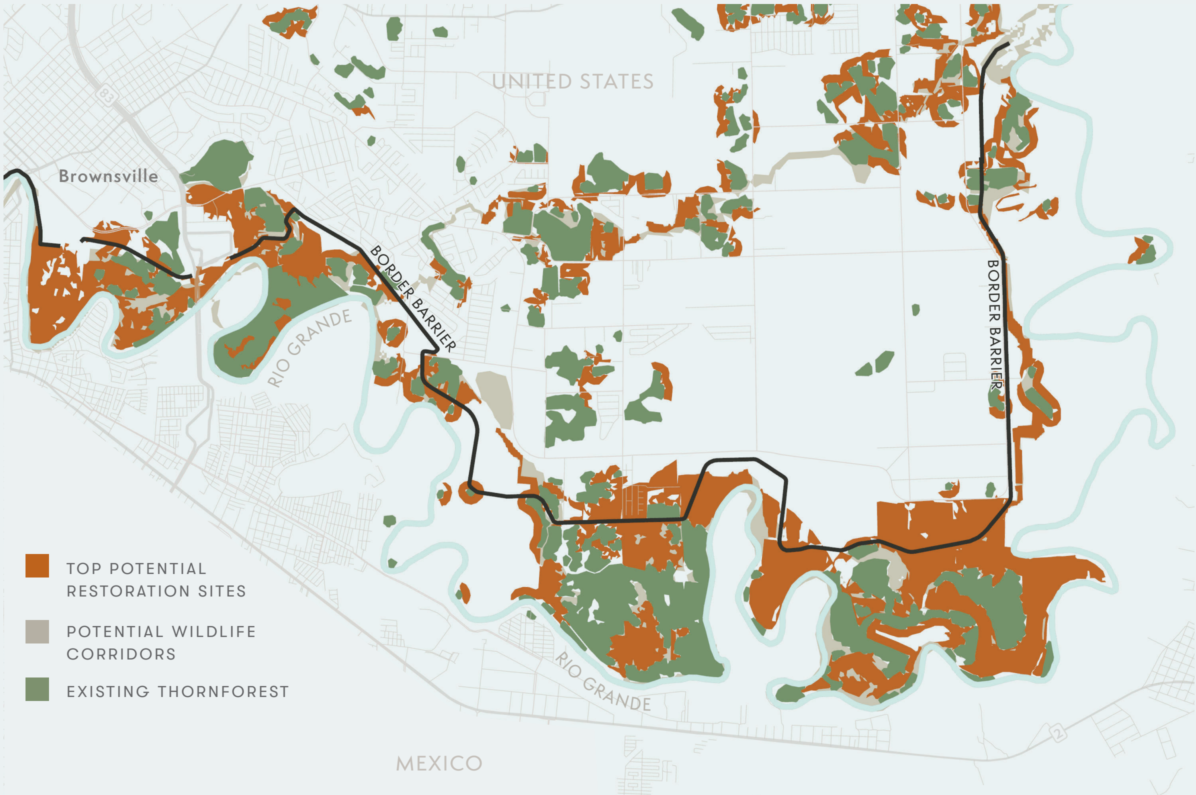


Figure 5



Next Steps

The Thornforest Conservation Plan is a living document that will be subject to adaptation at subsequent intervals in time when additional research, developments and/or circumstances arise to better inform this approach to conserving and restoring thornforest habitat.

Specifically, refinements of the modeling analysis are to be expected as conditions change within the RGV's dynamic landscape. These refinements will provide more detail regarding connectivity at the parcel level, which may include prioritization of alternate sites that are currently ranked in the low range of potential restoration. Further, it is stressed that private landowners who are intent on utilizing restorative practices remain so inclined regardless of their location in the RGV because these are some of the scenarios that will compel adaptation of the plan going forward. Along these same lines, there are plans to conduct additional study into Starr County's existing core areas and the potentially outsized role that they may play in the regional population dynamics of one or more of the identified focal species.

The plan is the first phase in an ongoing strategic effort that will eventually lead to project-based work in reforestation, additional research lines and technical guidance services (e.g., restoration technique best management practices) sponsored by TCP membership. Components missing from this plan but that will be addressed in subsequent partnership developments include integration of other ecosystems native to the RGV (e.g., grasslands, wetlands, etc.) and designation of an urban restoration trajectory within parts of the region. The former component will provide opportunities to conserve species that may benefit from reduced woody species cover. Similarly, urban restoration will address reforestation as a means for providing dual impact on community resilience (e.g., ecosystem services, environmental literacy, economic incentives, etc.) and our existing mission objectives in conservation.

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Appendix

A Keyword Definitions

The following definitions are provided to enhance the reader's understanding of this document:

Core areas
intact natural habitats that, if protected and/or expanded via restoration, will support a diversity of native wildlife and plants, and the ecosystem processes they depend upon.

Direct seeding
the planting of seeds directly into an area (e.g., for forest restoration) as opposed to first growing seedlings that are then transplanted into an area.

Focal species
also known as surrogate, indicator or umbrella species, are a conservation tool wherein a species' occurrence can be used to identify different levels of habitat quality.

Green infrastructure
an inter-connected network of green spaces that provide a range of biodiversity conservation and ecosystem services.

Interior habitat
sections of a forest core area found away from the edges and containing comparatively undisturbed habitat.

Neotropical
regions primarily comprising Mexico, Central and South America including the northernmost extensions of tropical forest into North America (e.g., El Cielo Biosphere Reserve ~300 km (200 miles) south of the Rio Grande Valley). Temperature and precipitation create conditions for rapid plant growth and long growing seasons in these areas.

Ramaderos
native south Texas woodlands found along drainages and that are infrequently and briefly flooded during local rain events.

Resacas
shallow oxbow lakes that were former channels of the Rio Grande River in south Texas.

Thornforest
also known as Tamaulipan thornscrub, these woodlands are a dominant vegetation throughout much of south Texas and northeastern Mexico. Blair (1950) developed a separate Texas subclassification for the Rio Grande Valley's 4 counties (e.g., "Matamoran district") based on some of the unique attributes of this geography vs. the larger Tamaulipan ecoregion north to San Antonio (e.g., presence of many species with distributions centered further south in Mexico and that rarely range north of the 4-county area).

B Analysis Fundamentals

Analysis Flowchart

Map thornforest habitat based on proxy information

1 Identify focal species and associated habitat requirements

2 Identify suitable vegetation types and soils

Identify core thornforest habitat sufficient to encompass territory sizes for focal species

3 Core areas (Forest/ shrubland patches > 30 ha)

Model connectivity between the identified core thornforest

4 Potential wildlife corridors

Select potential restoration sites, ranked by priority level

5 Based on a suitability index

1. Identify focal species and associated habitat requirements

As a first step in developing the spatial analysis that would enable our plan's findings, we selected a set of focal wildlife species to help define core area conditions across the range of thornforest vegetation types in the RGV. Focal species, also known as surrogate, indicator or umbrella species, are a conservation tool wherein a species' occurrence data (e.g., sight records) can be used as a proxy for identifying different levels of habitat quality (Chase and Geupel 2005). For example, a species whose documented occurrences only correspond to more structurally complex and diverse vegetation may also serve as an indicator for locations of greater wildlife diversity within a landscape. This form of rapid assessment can provide value to planning exercises seeking to maximum ecosystem conservation, especially in regions like the RGV where a high human-impact factor exists (Hayes et al. 2008). This part of the analysis is most interested in correlating focal species occurrence data with a basic set of habitat requirements, including thornforest presence and territory size.

As a federally endangered species and an iconic part of the RGV's natural heritage, occurrences of the ocelot (*Leopardus pardalis albescens*) were initially chosen to define core area conditions in this analysis. This species utilizes diverse thornforest, has a relatively large home range [averaging 2.5–18 km^2 (618–4,450 acres) for males, 2.0–11 km^2 (494–2,718 acres) for females] and will require substantial connectivity for interbreeding if the species is to persist in the U.S. (Navarro-Lopez 1985, Tewes 1986, Laack 1991, Haines et al. 2006).

However, since the bulk of ocelot occurrences are associated with a breeding population that is confined to Cameron and Willacy Counties, a suite of additional species was also selected to assist in identifying core area conditions throughout the entire RGV (Cameron, Hidalgo, Starr and Willacy Counties). The full suite includes:

- **ocelot** *(Leopardus pardalis albescens)*
- **Altamira oriole** *(Icterus gularis)*
- **plain chachalaca** *(Ortalis vetula)*
- **olive sparrow** *(Arremonops rufivirgatus)*
- **Texas tortoise** *(Gopherus berlandieri)*

Regional occurrence of these additional species is associated almost exclusively with thornforest habitat, and these observations were the basis for their selection. Collectively, they have much smaller territories than ocelot, generally ranging from <1–11.3 ha (<2.5–28 acres), according to NatureServe. The significance of this range in territory size is key to considerations over whether a given core area can theoretically provide enough breeding habitat to support a population of one or more of these focal species. Beyond the scope of this plan, more detailed assessments of habitat quality within specific core areas can eventually be achieved through ground-truthing exercises. These efforts could also lead to multi-year population studies where some baseline demographic data has already been gathered (Wright 1996, Werner 2007).

2. Identify suitable vegetation types and soils

After identifying the habitat requirements of the focal species, their occurrence data was associated with existing ecological land-cover mapping. Here, forest and shrubland classifications were selected from the 2016 Texas Ecological Systems Classification (TEMS) developed by the Texas Parks & Wildlife Department. Expert feedback on which classes corresponded to thornforest and which classes provided habitat for the five focal species was also solicited (see Appendix C).

The next step was to compare the TEMS vegetation classes with existing focal species occurrence data from the Global Biodiversity Information Facility database (GBIF). While a portion of this data was derived from research methodologies designed expressly for rigor (e.g., transects, standardized point counts, etc.), the majority can be characterized as originating from citizen science formats (e.g., ebird) and are, therefore, open to selection bias. Despite these limitations, this comparison was utilized to gauge a focal species' preference for specific vegetation classes by noting where their occurrence was more frequent but unequal to the actual percent of area covered by the class.

To further refine thornforest core area identification, regional soils that sustained a combination of both TEMS vegetation classes and occurrence records from our focal species were selected. These soils include the general associations listed below:

Riparian and floodplain vegetation

Soils fertile and highly suitable for thornforest.

Ramaderos

Deep-soiled drainage ways with higher moisture; able to support denser and taller vegetation than surrounding uplands.

3. Core areas

Next, existing forest or shrubland found within the suitable TEMS vegetation classes and soils were selected. As could be expected with the degree of development and subsequent fragmentation present throughout the region, this resulted in the identification of thousands of discrete forest "patches" that exist along a wide spectrum in size [e.g., <0.1–>800ha (<0.25–>1,977 acres)]. From these areas, only patches containing at least a minimum amount of interior habitat [e.g., >0.1 ha (>0.25 acres)] and that were a minimum of ≥30 ha (74 acres) in area were selected to represent the remaining core areas of RGV thornforest for this analysis (**Figure 6**).

TCP stakeholders decided that this minimum area was sufficient to encompass one or more territory sizes for the majority of focal species. Hidalgo, Willacy and Cameron Counties were much more fragmented, with fewer and smaller core areas present on average, than in Starr County. However, TCP stakeholders recognized that the structure of vegetation communities in the latter are also quite different in stature. Further, traditional land-uses in Starr (e.g., ranching) allow for more thornforest to exist intact across the landscape despite some negative impacts to the function of ecological systems.

For the three counties most impacted by this woodland fragmentation, **Table 3** provides additional detail on identified core areas by illustrating a county-level breakdown of the number and type (protected/private) of ownership. Here, "protected" status indicates lands that are primarily under the public ownership of several state and federal agencies with existing mission objectives devoted to natural resource protection. From this breakout the reader can interpret that, for instance, approximately 85% of Cameron County's existing core areas are in public ownership, almost all thornforest within Willacy is privately held and that with slightly over 100,000 acres, Hidalgo currently retains roughly three times as much core area as the other counties combined.

Table 3

County	Type	# of landowners	Acreage	County total
Cameron	Protected	-	16868	19972
	Private	110	3104	
Hidalgo	Protected	-	17066	102905
	Private	651	85839	
Willacy	Protected	-	255	14716
	Private	49	14461	
TOTAL		**810**	**137593**	**137593**

To underscore the relationship between habitat loss and biodiversity values in the RGV, the spatial relationship between the remaining core areas and the vertebrate species currently listed under the Endangered Species Act can be observed by comparing **Figures 6 and 7**. Here, the reader can gain a basic sense of where imperiled species, like the ocelot, exist in relation to thornforest scattered throughout Cameron, Hidalgo and Willacy Counties (NatureServe Network 2021). While some of these listed species are dependent on additional habitats for survival (e.g., grasslands for Aplomado falcon (*Falco femoralis*)), the proportion of core areas that overlap with higher zones of species richness (darker colors in the figure) supports the logic for sustained conservation efforts in this highly diverse region.

Figure 6

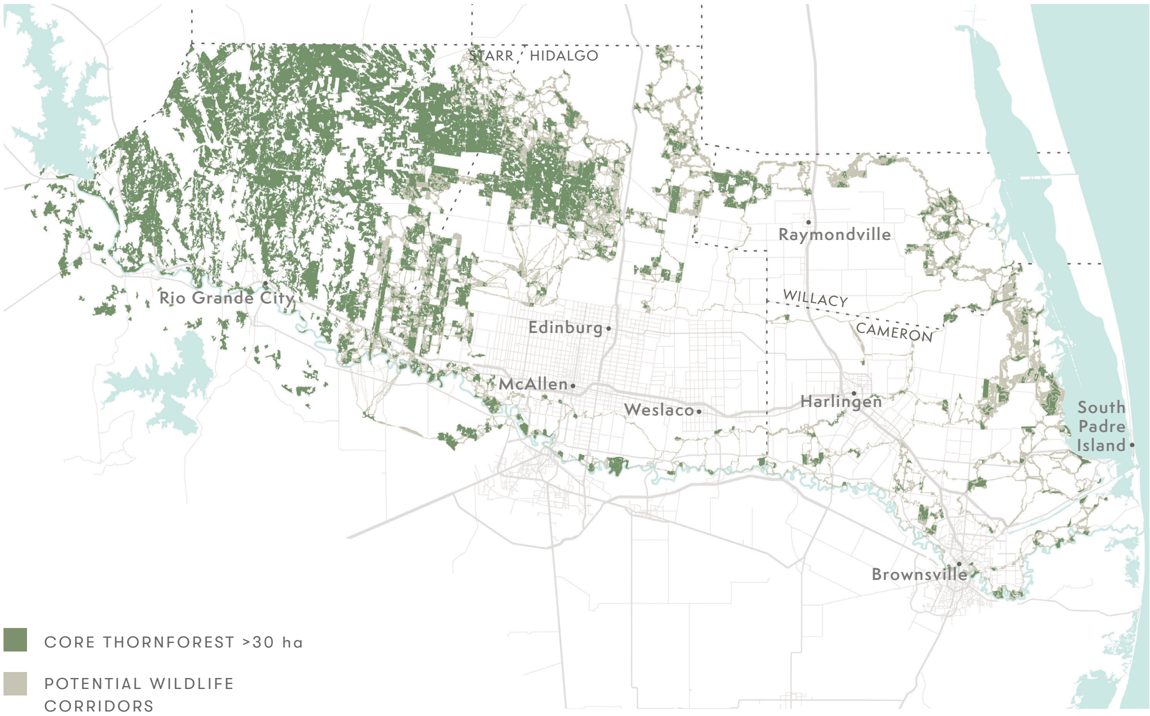
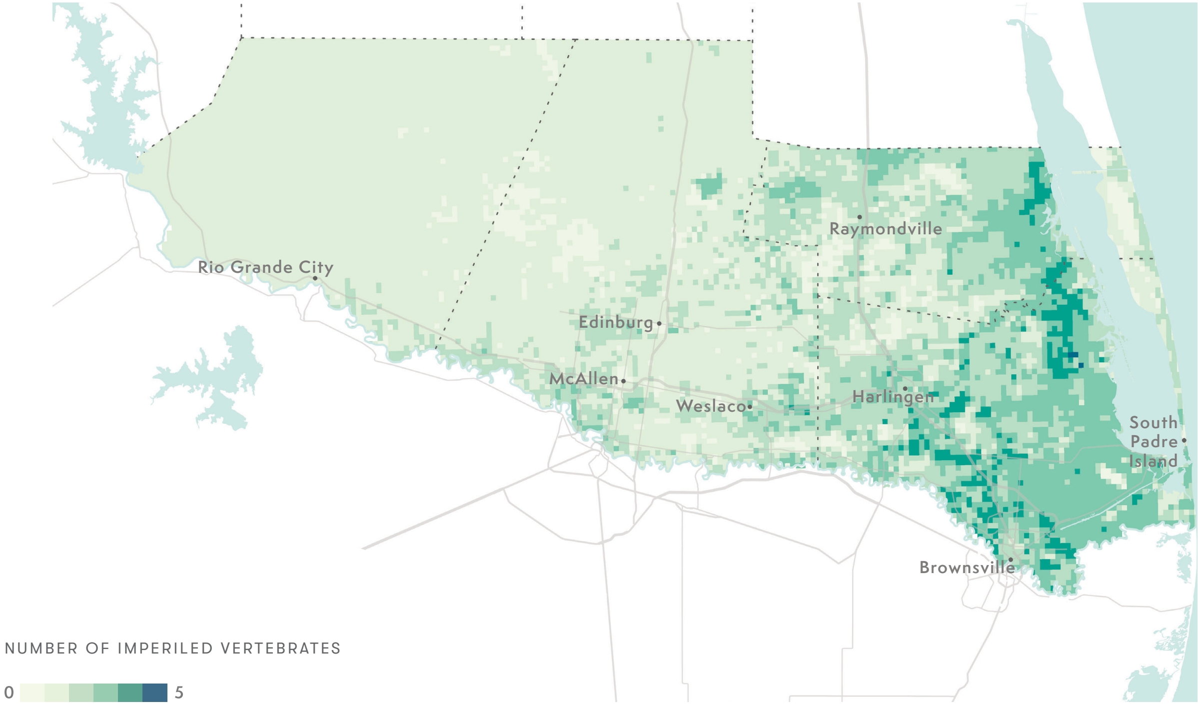


Figure 7



4. Potential corridors

The existence of linkages between core areas, or corridors, is critical to the survival of focal species populations and the health of the thornforest ecosystem. For example, remaining woodland core areas are mostly isolated, exacerbating conditions of inbreeding and other random fluctuations (e.g., severe weather, prey shortages) that influence the ocelot population. Additionally, collisions with motor vehicles are the leading cause of known ocelot mortality (Haines et al. 2005, USFWS 2016). If habitat is not restored, conserved and connected, ocelots have a 33% chance of going extinct in the U.S. by 2050. Improving connectivity and creating more useable habitat around core areas are tools to help solve this problem (Haines et al. 2006, Janečka et al. 2007).

After discussion and examination of different thresholds, this plan set out to model connectivity between the identified core areas. Based on the cover classifications found in both TEMS and the North American Land Change Monitoring System (NALCMS) database, forest and shrubland were considered the most suitable cover types for inter-core movement, especially away from edges, along waterways or on protected land (parks, refuges, preserves, conservation easements, etc.). Bridges and existing or planned wildlife crossings were considered as the best places to cross roads (e.g., **Figure 8**). These factors were quantified and combined to derive a layer of overall suitability for focal species movement.

To identify the spatial distribution of these potential corridors, the Terrestrial Movement Analysis (TMA) tool was employed in line with methodology used in previous connectivity modeling studies (Weber and Norman 2015). This software program treats the landscape as a circulatory system, identifying those pathways most likely to be followed by wildlife. The TMA generates random sets of starting locations (with each location corresponding to an individual wildlife species) and then calculates optimal or "least-cost" paths to all other habitat within the landscape. The cell values along the pathway are the summed area (the number of patch cells) that a pathway is connected to at that point. This process is run repeatedly over a fixed period of time with each iteration having a different set of random start locations and corresponding least-cost paths. The tool identifies corridors by adding suitable land along this pathway. Finally, it calculates overall movement potential by considering both the amount of core area habitat connected by a pathway, and how good that pathway is (e.g., is it mostly covered by natural vegetation or are portions converted to other land uses). Connectivity potential exists both within and outside core areas, but for this analysis potential corridors were defined as pathways existing only outside, or between, core areas.

Figure 6 illustrates the relationship between thornforest core areas and the respective potential corridors modeled by the TMA analysis. With the exception of a buffer zone along the Hidalgo County line, connectivity in Starr County was not modeled as most core areas there were already connected to a high degree.

Figure 8 | Wildlife crossing structures

USFWS

5. Restoration potential

After identifying core areas and potential corridors, TCP stakeholders examined the four counties for restoration potential. Here, the goal was to reinforce the essential role that expanded thornforest restoration is believed to play in connecting the RGV's green infrastructure at the landscape level. For existing core areas, restoration potential serves to identify adjacent lands that could be forested to increase the core's overall size and, by extension, source populations of focal species over time. Restoration potential is also key to the benefits that corridors are expected to provide since wildlife typically require dense cover along these pathways for avoiding predators, food sources, etc. while in transit.

Meanwhile, parts of the RGV's landscape are not as conducive to restoration for landscape-level forest conservation objectives for any number of reasons. More obvious barriers here include dense urban settings, non-target soils that support dissimilar climax vegetation (e.g., wetlands, grasslands) and locations where long-term management priorities will preclude significant reforestation (e.g., portions of flood control infrastructure). To emphasize this part of the assessment, a suitability index was developed to measure restoration potential across the region and where a "restoration score" (low, high or highest) was ultimately assigned to much of the RGV. However, several data inputs were necessary before reaching this stage.

With the analysis' guidance on the relationship between core areas, potential corridors and existing land use conditions in hand, several vegetation classes were selected from TEMS (barren land, disturbed grassland, saltcedar shrubland, orchards, row crops and grass farms) as general areas suitable for restoration. Of these classes, disturbed grassland and row crops were by far the most common, with the former representing fallow/abandoned row crop production in many instances. In partnership with USFWS staff, soils were also categorized for restoration potential by identifying those most suitable for diverse thornforest development. In effect, much of the area that includes these primarily agricultural TEMS classes was historically thornforest. Although the surface layers and native seed bank have been impacted through successive decades of crop production, the soil's profile remains largely intact in many of these locations. Therefore, selecting for these soil types is a key consideration for reforestation efforts, including those employed within the existing USFWS restoration program.

Other restoration suitability factors that affected the index ranking of lands within these vegetation classes included:

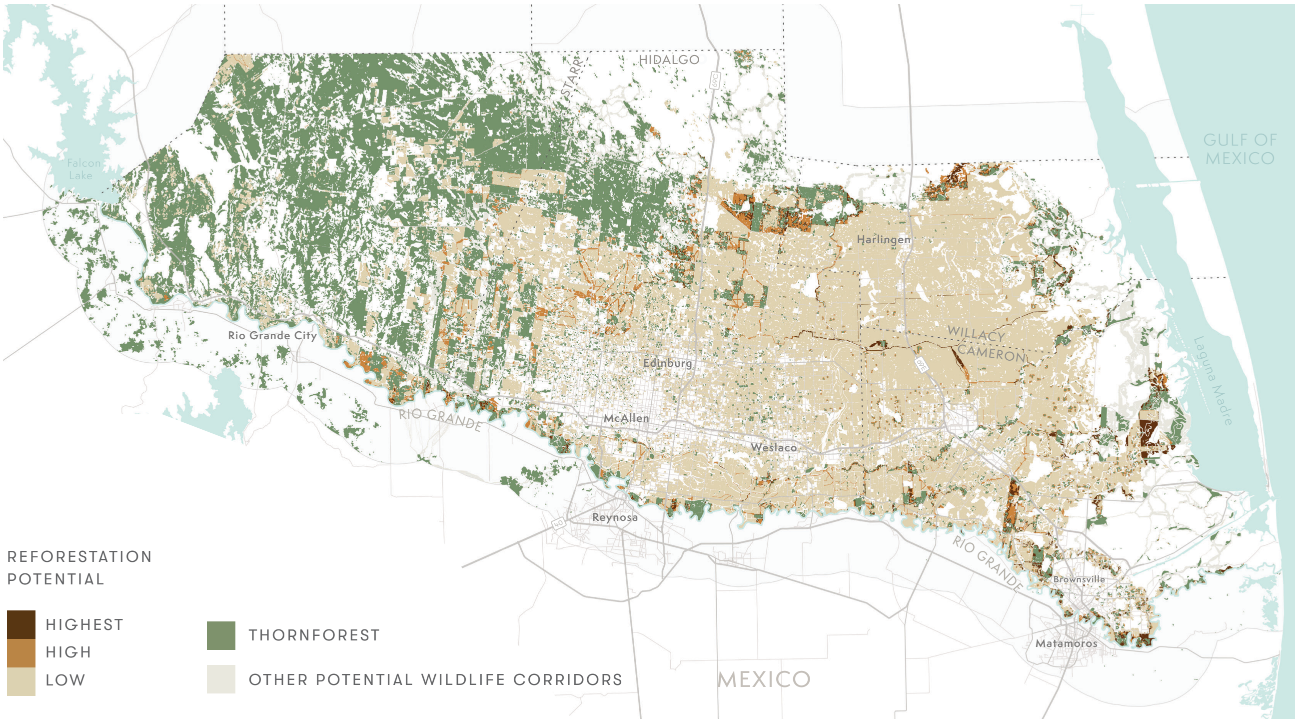
- proximity to **open water**
- proximity to **ocelot occurrences**
- proximity to **existing core areas**
- being along a **modeled corridor**
- being on **protected land**
- being on **USFWS focal properties** or along an **identified connection**

After examining the output from two different weighting schemes, these factors were weighted as follows:

Factor	Weight	Value range
Proximity to open water	4	4-8
Proximity to ocelot occurrences	1	1-4
Proximity to existing core areas	1	1-4
Along a modeled corridor	4	4-8
Protected land/ USFWS focal properties	4	4-8

Per the analysis of these weights, **Figure 9** displays the RGV's thornforest restoration potential from low to highest ranking. The high and highest scores in this ranking are considered to be TPRS [see section on Findings: Top Potential Restoration Sites].

Figure 9


HIDALGO
STARR
Falcon Lake
GULF OF MEXICO
Harlingen
Rio Grande City
WILLACY
CAMERON
Edinburg
Laguna Madre
RIO GRANDE
McAllen
Weslaco
Reynosa
RIO GRANDE
Brownsville
Matamoros
MEXICO
REFORESTATION POTENTIAL
HIGHEST
HIGH
LOW
THORNFOREST
OTHER POTENTIAL WILDLIFE CORRIDORS

C Thornforest Vegetation Classes

The following breakdown lists the TEMS vegetation classes that were most likely to provide habitat for each respective focal species according to the analysis.

Altamira oriole

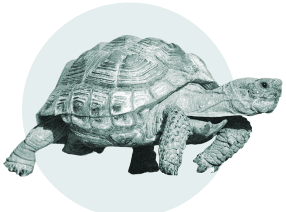
- Urban low intensity
- **Rio Grande Delta:** Evergreen thorn woodland and shrubland
- **South Texas:** Floodplain evergreen forest and woodland
- **South Texas:** Floodplain mixed deciduous — evergreen forest and woodland
- **South Texas:** Floodplain hardwood forest and woodland
- **South Texas:** Clayey blackbrush mixed shrubland
- **South Texas:** Floodplain deciduous shrubland

Plain chachalaca

- Urban low intensity
- **South Texas:** Saline lake grassland
- **South Texas:** Floodplain evergreen forest and woodland
- **South Texas:** Clayey blackbrush mixed shrubland
- **South Texas:** Floodplain mixed deciduous — evergreen forest and woodland

Olive sparrow

- Urban low intensity
- **Rio Grande Delta:** Evergreen thorn woodland and shrubland
- **South Texas:** Clayey blackbrush mixed shrubland
- **South Texas:** Floodplain evergreen forest and woodland
- **South Texas:** Floodplain mixed deciduous — evergreen forest and woodland
- **South Texas:** Floodplain hardwood forest and woodland
- **South Texas:** Floodplain deciduous shrubland
- **Coastal:** Sea ox-eye daisy flats



Texas tortoise

- Row crops
- **Coastal:** Sea ox-eye daisy flats
- **South Texas:** Sandy mesquite dense shrubland

Some of the classes with GBIF observations (e.g., urban low intensity, saline lake grassland and row crops) are not useful for identifying core habitat areas that can serve as source breeding areas, etc., so expert opinions were used to refine the final, comprehensive selections as listed below.

Note that not all of the wooded areas were thornforest per se, but they do provide similar cover.

- **Coastal and sandsheet:** Deep sand shrubland
- **Coastal and sandsheet:** Deep sand live oak forest and woodland
- **Coastal and sandsheet:** Deep sand live oak — mesquite woodland
- **Coastal and sandsheet:** Deep sand live oak shrubland
- **South Texas:** Salty thornforest
- **South Texas:** Clayey mesquite mixed shrubland
- **South Texas:** Clayey blackbrush mixed shrubland
- **South Texas:** Sandy mesquite — evergreen woodland
- **South Texas:** Sandy mesquite woodland and shrubland
- **South Texas:** Sandy mesquite dense shrubland
- **South Texas:** Shallow shrubland
- **South Texas:** Shallow dense shrubland
- **South Texas:** Shallow sparse shrubland
- **South Texas:** Loma evergreen shrubland
- **South Texas:** Loma deciduous shrubland
- **South Texas:** Floodplain evergreen forest and woodland
- **South Texas:** Floodplain mixed deciduous — evergreen forest and woodland
- **South Texas:** Floodplain hardwood forest and woodland
- **South Texas:** Floodplain evergreen shrubland
- **South Texas:** Floodplain deciduous shrubland
- **South Texas:** Palm grove
- **South Texas:** Ramadero evergreen woodland
- **South Texas:** Ramadero woodland
- **South Texas:** Ramadero dense shrubland
- **South Texas:** Ramadero shrubland
- **Rio Grande Delta:** Evergreen thorn woodland and shrubland
- **Rio Grande Delta:** Deciduous Thorn woodland and shrubland
- **Rio Grande Delta:** Dense shrubland
- **Native invasive:** Deciduous woodland
- **Native invasive:** Mesquite shrubland
- **Native invasive:** Huisache woodland or shrubland
- **South Texas:** Pond and laguna woodland
- **South Texas:** Pond and laguna shrubland

In Mexico, the 2010 NALCMS was used, selecting the following classes:

- Tropical or sub-tropical broadleaf evergreen forest
- Tropical or sub-tropical broadleaf deciduous forest
- Mixed forest
- Tropical or sub-tropical shrubland
- Temperate or sub-polar shrubland

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About the Thornforest Conservation Partnership

The Thornforest Conservation Partnership (TCP) was formed in 2018 to jointly develop science-based plans and goals to guide conservation efforts in the RGV, communicate the importance of thornforest habitat and conservation progress to the public, and encourage action for stronger public policies and funding. The TCP is a coalition of state and federal agencies, universities, nonprofit and community organizations working to restore thornforest habitat in south Texas. Its existing mission objective is to facilitate conservation of the RGV's thornforest ecosystem for the benefit of the region's endemic biodiversity.

Partners include: American Forests, U.S. Fish & Wildlife Service, Texas Parks & Wildlife Department, The Conservation Fund, The Nature Conservancy, Rio Grande Joint Venture, Texas A&M University-Kingsville, USDA-Natural Resources Conservation Service, The University of Texas-Rio Grande Valley, Texas A&M Forest Service and others.

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