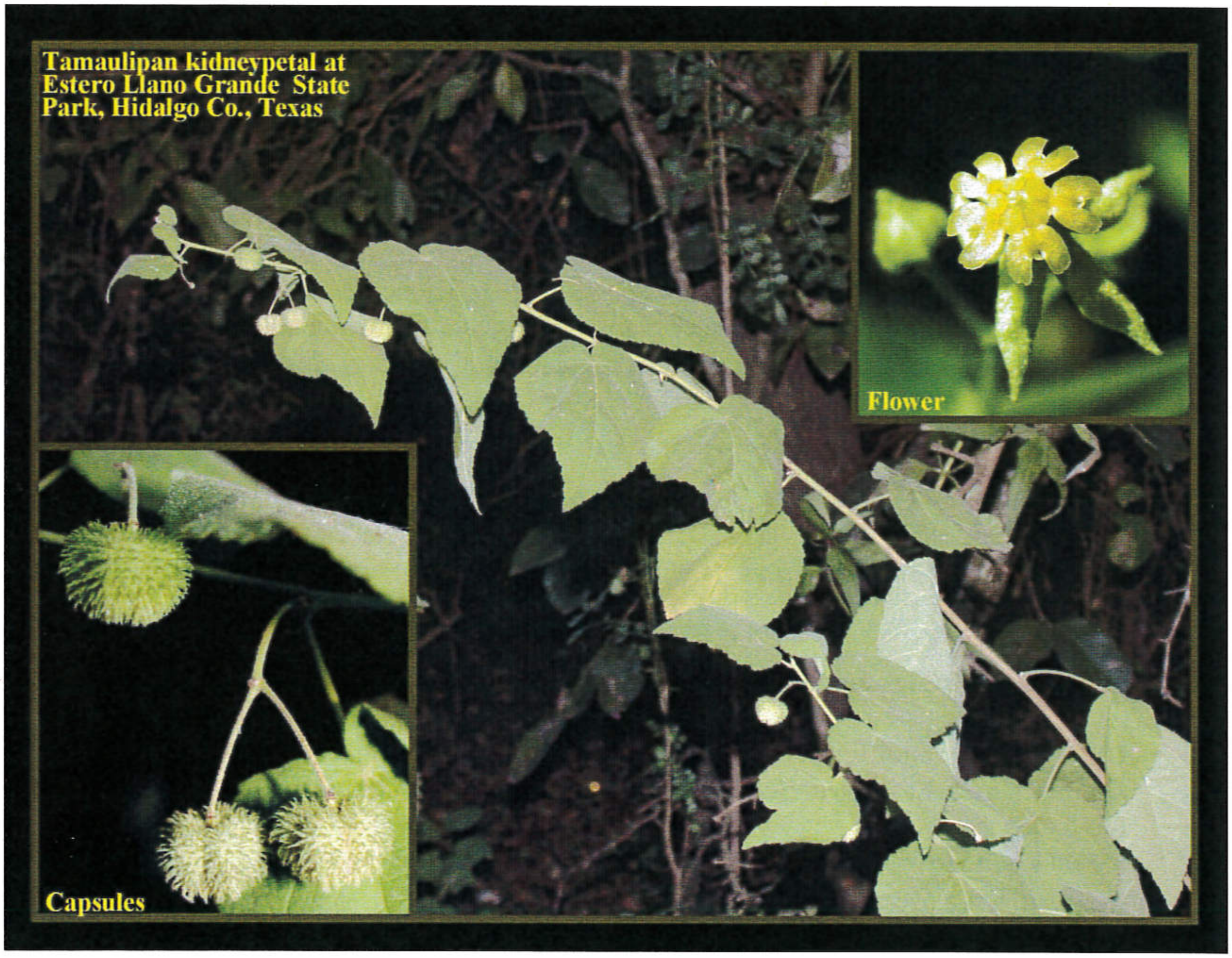
RECOVERY PLAN FOR THE TAMAULIPAN KIDNEYPETAL (TEXAS AYENIA) (*AYENIA LIMITARIS*)



Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, NM

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Date:

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The first use of technical terms and words with arcane meanings in the lexicons of science and government are underlined, and are defined in the glossary on pages 82-87. For convenience, the first uses of scientific units are spelled out, and are also summarized on page 80. Photographic credits are listed on page 80. Acronyms are listed and spelled out on pages 80-81.

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The draft recovery plan was published in the Federal Register for public comment in June 2014. The current plan reflects updated guidance on recovery planning (NMFS and USFWS 2010).

EXECUTIVE SUMMARY

Current Species Status:

Tamaulipan kidneypetal (*Ayenia limitaris*) was federally listed as endangered, with a common name of "Texas Ayenia," on August 24, 1994 (USFWS 1994). The plant was listed throughout its range, including southern Texas and northeastern Mexico. However, Tamaulipan kidneypetal is not protected by the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT; the Mexican government equivalent to the U.S. Fish and Wildlife Service). The federal listing established a Recovery Priority Number (RPN) of 5, and did not designate critical habitat. The State of Texas listed the species as endangered on January 30, 1997. The 5-year review (USFWS 2010b) revised the RPN to 8C and recommended adopting "Tamaulipan kidneypetal" as a more appropriate common name. Five extant populations, ranging from about 100 to 1,000 individuals, have been documented in the three southernmost counties of Texas. Ten extant populations, totaling at least 4,000 individuals, occur in two *municipios* of the Mexican State of Tamaulipas. At least seven populations in Texas have been extirpated. One population reported from Coahuila, Mexico has not been seen since 1936. A specimen was collected in 1985 in Topia, Durango, Mexico, but the species has not subsequently been reported from that area.

Habitat Requirements and Limiting Factors:

Tamaulipan kidneypetal is a spineless sub-shrub of the semi-arid, subtropical Tamaulipan shrublands and thorn forests of south Texas and northeast Mexico. Occupied habitats are isolated fragments of Texas ebony - anacua/brasil woodlands and Texas ebony - snake-eyes shrublands in the deltas of rivers draining into the Gulf of Mexico. Individual plants occur in association with other shrub species and native grasses and forbs in a wide range of alluvial soil types, from fine sandy loam to heavy clay, and appear to require at least some direct sunlight for successful reproduction. The species' range appears to be restricted by increasing aridity further inland and by the prevalence of freezing weather further north and at higher elevations in the mountain ranges of northeast Mexico. However, the vegetation of the Tamaulipan region in Texas and northeast Mexico has been altered by poor rangeland management since the onset of European colonization in 1750. The distribution and abundance of Tamaulipan kidneypetal may have been impacted by increased woody plant cover and lack of wildfire, and its extant relict habitats might not be optimal. Introduced invasive grasses, particularly guineagrass, are abundant and highly competitive in the remaining occupied habitats.

Recovery Strategy:

- Coordination and collaboration with government agencies, academic institutions, and non-governmental (NGO) conservation organizations in both the U.S. and Mexico.
- Outreach, collaboration, and support for conservation-minded private landowners and *ejidos* in the U.S. and in Mexico.
- Protection, conservation, and improved management of extant populations in the U.S. and Mexico.

- Habitat restoration and population augmentation and reintroduction to attain the number and size of populations necessary to assure the continued survival of the species, and to establish ecological corridors necessary for gene flow between and among populations.

Recovery Goals, Objectives, and Criteria:

Goal: Downlisting to Threatened.

1. Threat-based objective: Mitigate habitat loss and degradation, invasive species competition, poor rangeland management, and other threats to the continued survival of Tamaulipan kidneypetal.

Criterion 1: The successful accomplishment of threats reduction and mitigation is demonstrated by a stable or improving status of Tamaulipan kidneypetal, compared to the baseline conditions described in section II.5.1, throughout its known range over a period of at least 10 years.

2. Habitat-based objective: Conserve, restore, and manage appropriately the quantity and quality of habitat needed for the recovery of Tamaulipan kidneypetal.

Criterion 2: At least 10 populations of Tamaulipan kidneypetal, and at least 1 per recovery unit, are documented in optimal habitats for a period of at least 10 years. Habitat is considered optimal when: It is protected for conservation purposes; it is managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal; it has less than 10% cover of introduced invasive plant species; it consists of at least 400 ha (988 ac) of contiguous habitat; and where Tamaulipan kidneypetal populations are observed to be stable or increasing.

3. Population-based objective: Conserve, protect, and restore populations of Tamaulipan kidneypetal needed for its recovery. Populations must be self-sustaining, of sufficient size to endure climatic variation and stochastic events, of sufficient number to endure catastrophic losses, and must represent the full range of the species' geographic and genetic variability.

Criterion 3: Protect at least 20 populations, including no fewer than 5 populations per recovery unit. Quantitative monitoring conducted in at least 5 different years over a period of at least 10 years demonstrates that protected populations have no fewer than 250 mature individuals, and are stable or increasing over this time frame. Furthermore, at least one population per recovery unit must have at least 1,000 mature individuals.

Goal: Delisting.

4. Objective: After accomplishing all objectives for downlisting to threatened, Tamaulipan kidneypetal may be removed from the endangered species list when its overall habitat and population status continues at the same or an improved level for an additional 10 years.

Criterion 4: 20 or more protected populations, including no less than 5 per recovery unit, have maintained stable or increasing populations of at least 250 mature individuals for a total of at least 20 years.

Table 1. Actions needed.

Priority	Action	Description	Objectives Addressed		
			1	2	3
1	1	Protect and conserve the known populations and their habitats in the U.S. and Mexico.	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7	2.2	3.3, 3.4, 3.6
1	2	Monitor known populations and habitats.	1.1	2.4	3.2
1	3	Develop partnerships with Mexican government agencies, academic institutions, and NGOs to promote investigation, conservation, and recovery of the species in Mexico.	1.7		
2	4	Improve management of known populations and habitats, based on the conclusions of scientific investigations (adaptive management).	1.2, 1.3, 1.5, 1.7	2.4	3.1, 3.6
2	5	Conduct public outreach in the U.S. and Mexico to promote the species' conservation and recovery.	1.3, 1.5, 1.7	2.4	3.1, 3.2, 3.6
2	6	Conduct scientific investigations necessary for conservation and recovery.		2.1, 2.4	3.1, 3.2, 3.4, 3.6
2	7	Conduct surveys of publicly-owned land in the U.S. and Mexico.	1.7		3.1
3	8	Restore native vegetation within the Rio Grande delta recovery units to increase the amount of available habitat and to establish functioning ecological corridors that reconnect isolated habitat fragments.	1.1	2.2, 2.3	
3	9	Collect seeds from wild populations, and augment and reintroduce populations in appropriate habitats within known range in U.S. and Mexico.	1.4		3.3, 3.4, 3.5
3	10	Prepare post-delisting monitoring plan.	All	All	All

Table 2. Estimated time and cost of recovery (from the Implementation Schedule).

		Costs ($1,000s) and Time Frames (Years)				
Action	Prior to 2014[1]	2016-2020	2021-2025	2026-2030	2031-2035	Total
1	504.0	755.0	755.0	755.0	755.0	3,524.0
2	3.0	20.0	15.0	15.0	15.0	68.0
3	5.0	5.0	5.0	5.0	5.0	25.0
4	0.5	32.5	35.0	30.0	30.0	128.0
5	0.0	20.0	10.0	0.0	0.0	30.0
6	16.9	380.0	10.0	10.0	10.0	426.9
7	42.2	50.0	30.0	15.0	15.0	152.2
8	2,000.0	610.0	610.0	610.0	610.0	4,440.0
9	2.7	125.0	51.0	2.0	2.0	182.7
10	0.0	0.0	0.0	0.0	20.0	20.0
T O T A L S :	2,574.3	1,997.5	1,521.0	1,442.0	1,462.0	8,996.8

1. This column reports recovery actions and costs that were carried out after Tamaulipan kidneypetal was listed in 1994, and prior to the establishment of the draft recovery plan, published in June 2014.

The figures reported above and in the Implementation Table (section IV) include $3.4 million for ongoing land acquisition, begun in 1980, and $4.44 million for ongoing habitat restoration, begun in 1982, at Lower Rio Grande Valley National Wildlife Refuge (LRGV NWR). Land acquisition and habitat restoration are expected to benefit much of the region's diverse native flora and fauna, including Tamaulipan kidneypetal and other listed species such as the ocelot and jaguarundi. Therefore, $7.94 million (88 percent) of the amounts shown represent previously completed and ongoing expenses of existing government programs. The remaining $1.05 million (12 percent) are additional costs for recovery of Tamaulipan kidneypetal. Of the total $8.99 million projected to achieve full recovery of Tamaulipan kidneypetal, $2.57 million have been spent (primarily on land acquisition and habitat restoration at LRGV NWR) prior to the establishment of this recovery plan.

Time: 20 years from 2014, when the draft recovery plan was published.

Cost: $1.05 million for Tamaulipan kidneypetal alone, + benefits from $7.94 million from completed and ongoing efforts to restore all native species through existing government programs.

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I. BACKGROUND

Section 4(f)1 of the ESA (U.S. Congress 1988) directs the Secretaries of Interior and Commerce to develop and implement recovery plans for the conservation and survival of listed threatened and endangered species. These responsibilities are carried out by USFWS and National Marine Fisheries Service. Recovery plans provide recommended actions for resolving threats to listed species and ensuring the survival of their self-sustaining populations in the wild.

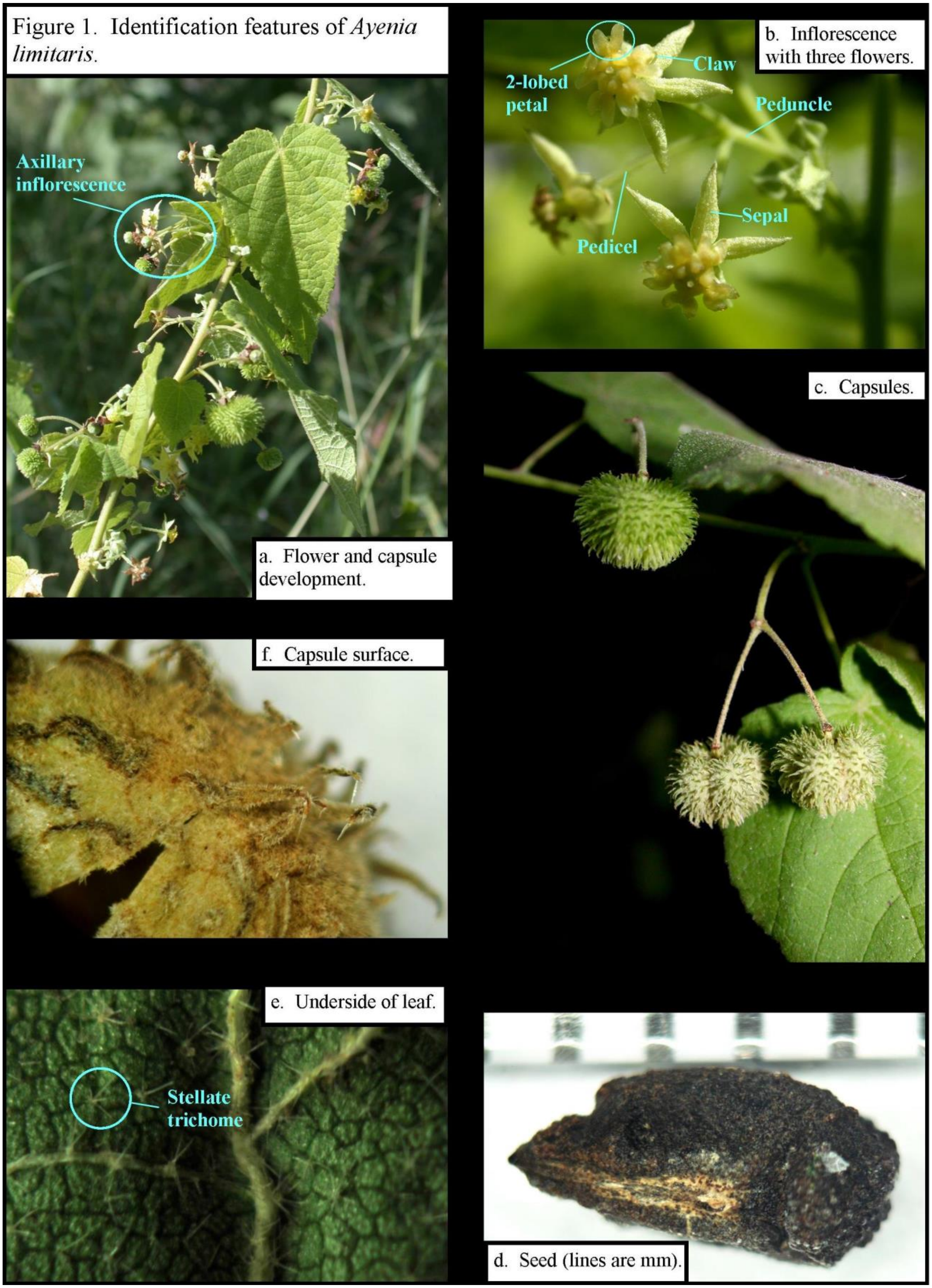
I.1. Brief Overview and Status of Tamaulipan Kidneypetal

Tamaulipan kidneypetal was federally-listed as endangered without critical habitat on August 24, 1994 (USFWS 1994). The State of Texas listed the species as endangered on January 30, 1997. When federally listed, the RPN was 5, meaning that the taxon is a species (rather than an infra-species), the threat level is high, and the recovery potential is low. The 5-year review (USFWS 2010b) revised the RPN to 8C, indicating that the species' threat level is moderate, the recovery potential is high; "C" denotes possible conflicts with economic activity. Several common names have been used for the species, including Tamaulipan kidneypetal (Carr 2005, Poole et. al. 2007), kidneypetal (Center for Plant Conservation 2010), Texas Ayenia (Poole et. a. 2007, Integrated Taxonomic Information Service 2009, Center for Plant Conservation 2010, NatureServe 2009, USFWS 2010a), and Rio Grande Ayenia (Poole et. al. 2007, Integrated Taxonomic Information Service 2009, Natural Resource Conservation Service 2009). Tamaulipan kidneypetal is threatened principally by habitat loss, habitat alteration, and competition with introduced invasive grasses. Many of the documented collection sites in Cameron and Hidalgo Counties, Texas, have been lost to agricultural and urban development. However, since the species was listed, several new populations have been found in south Texas and in the Mexican state of Tamaulipas. Three of the five U.S. populations are now protected at LRGV NWR, Estero Llano Grande State Park in Hidalgo County, and C.B. Wood County Park in Cameron County, Texas. Pilot reintroductions initiated in 1998 indicate that it is feasible to reintroduce self-sustaining populations in appropriate sites.

I.2. Description, Taxonomy, and Genetics

Tamaulipan kidneypetal is a spineless shrub with a canopy reaching up to 2.0 meters (m) (6.6 feet [ft]) in height and 2.8 m (9.2 ft) in breadth (Figure 1). However, mature, reproductive plants may be as little as 0.3 m (1.0 ft) tall and broad. The alternate, soft, heart-shaped leaves have minute hairs and toothed margins; microscopically, the hairs on the lower surfaces of the leaves are stellate. The older, woody stems are reddish-brown, up to 2 centimeters (cm) (0.8 inches [in]) thick, and dotted with cream-colored lenticels. Inflorescences arise from the leaf axils, from 1 to 4 per node; the peduncles are about 1 cm (0.4 in) long, usually bearing 3 flowers on pedicels up to 1 cm (0.4 in) long. The flowers are about 6 millimeters (mm) (0.24 in) wide, with five greenish, 3 mm- (0.12 in-) long sepals and 5 yellow- to cream-colored, kidney-shaped petals (having two prominent, ovate lobes) bearing filamentous claws. The fruit, a five-chambered capsule up to 1 cm (0.4 in) in diameter before drying, is covered with curved, velcro-like appendages that may adhere to the hair of animals. Capsules produce up to 5 dark brown to black, tuberculate seeds 4 to 5 mm (0.16 to 0.20 in) in length. The maturing capsules turn from

Figure 1. Identification features of *Ayenia limitaris*.



green to straw-colored; eventually the 5 chambers split apart, ejecting the seeds up to about 3 m (10 ft) from the parent plant.

Tamaulipan kidneypetal was first collected by C.G. Pringle (Pringle no. 2272) in 1888 in the vicinity of Hidalgo, Texas. This collection was initially identified as *Ayenia berlandieri* S. Watson; the genus *Ayenia* was classified at that time in the Sterculiaceae (cacao family). Robinson and Greenman (1896) based their description of a new species, *Nephropetalum pringlei* B.L. Rob. & Greenm., on Pringle's specimen. Tamaulipan kidneypetal was collected several times in Cameron County, Texas, between 1924 and 1955 (see Table 3), and identified as *A. berlandieri*. Cristóbal (1960) first described the species *limitaris*, based on Shiller's 1955 specimen from Brownsville, in her monograph on the genus *Ayenia*, which she also placed in the Sterculiaceae; this continues to be the authoritative treatment of the genus (Tropicos 2009). Both *A. limitaris* and *N. pringlei* were recognized as valid species until Dorr and Barnett (1986) established their synonymy. The name *A. limitaris* was retained, since Cristóbal had already described another species as *A. pringlei* Cristóbal.

Cristóbal placed *A. limitaris* within the section *Cybiostigma* of the genus (this was reported incorrectly in the 5-year review (USFWS 2010b)). It is distinguished from other species by the ovate-rounded, somewhat convergent petal lobes, and by the crenate or dentate-crenate leaf margins. Toward the south of its geographic range, *A. limitaris* might be confused with *A. berlandieri* S. Watson (section Cybiostigma), which is distinguished by 6- to 7-mm long, purplish sepals, clearly terminal inflorescence, and dense, long pubescence on leaves; this species is reported from the Mexican states of Guerrero, Jalisco, México, Michoacán, Morelos, San Luis Potosí, and Tamaulipas (Tropicos 2013a). The diminutive *A. pilosa* Cristóbal is present throughout much or all of the range of *A. limitaris*, but is readily distinguished by its small size and decumbent habit. In Cristóbal's monograph, *A. limitaris* appears most closely related to *A. mexicana* Turcz. and *A. jaliscana* S. Watson. *Ayenia mexicana* ranges from the Mexican states of Durango and Aguascalientes south and east to the Departamento de Huehuetenango, Guatemala (Tropicos 2013b). *Ayenia jaliscana* is reported from the Mexican states of Sonora and Chihuahua southward to Chiapas (Tropicos 2013c). When not in flower or fruit, *A. limitaris* may be difficult to distinguish from co-occurring understory shrub species of the Malvaceae (mallow family), such as *Bastardia viscosa* and several species of *Abutilon*. Consequently, field surveys should be conducted when seasonal rainfall has stimulated flowering and fruiting.

The traditionally circumscribed Sterculiaceae is now believed to be polyphyletic (Alverson et. al. 1999). Whitlock, et al. (2001) analyzed chloroplast ndhF gene sequences to determine the phylogeny of a group of plants within the Sterculiaceae. They identified a monophyletic clade, which they named Byttnerioideae, that includes the genus *Ayenia*. Stevens (2012) placed the genus *Ayenia* within the tribe Byttnerioideae of the family Malvaceae. Whitlock and Hale (2011) examined three chloroplast regions of 9 species of *Ayenia* (not including *A. limitaris*), 27 species of *Byttneria*, and *Rayleya bahiensis*; they concluded that the genus *Ayenia* is nested within the genus *Byttneria*. Despite this currently active topic of phylogenetic research at the family and genus level, no taxonomic revisions within the genus *Ayenia* have been published since the status report (Damude and Poole 1990) and the federal listing (USFWS 1994) were published, and the species *limitaris* continues to be recognized.

Genetic variation within Tamaulipan kidneypetal or among its close relatives has not been investigated. Cristóbal (1960) reported diploid chromosome numbers for 11 *Ayenia* species (not including *limitaris*). For eight species the diploid number was 20, while the remainder, with 2n = 40, were determined to be tetraploid.

I.3. Abundance, Distribution, and Population Trends

Table 4 summarizes the known populations reported in the Texas Natural Diversity Database (TXNDD) (2009) or obtained from other sources. Figure 2 shows the global range of these populations.

<u>Historical populations</u>

Texas:

Damude and Poole's status report (1990) lists nine historical records for Tamaulipan kidneypetal in Texas. These records appear to correspond to seven naturally-occurring element occurrences (EOs), as defined in NatureServe (2002), and one site where propagated individuals had been planted (see Table 4). Cyrus Pringle first collected the species (originally identified as *Ayenia berlandieri*, and described as *Nephropetalum pringlei* by Robinson and Greenman (1896)) in 1888 in woodlands of Hidalgo, Hidalgo County, Texas (Dorr and Barnett 1986). Former Brownsville mayor Robert Runyon collected the species between 1924 and 1963 near the Cameron County communities of Olmito, Barreda Station, Los Fresnos, and San Benito, and also propagated and planted it at his house at 812 St. Charles St. in Brownsville. V.L. Cory collected specimens from the site of Runyon's former house. Ivan Shiller, entomologist with the USDA Cotton Insects Research Lab in Brownsville, collected the species in 1941 and 1955 from unspecified locations in Brownsville. Damude and Poole conducted thorough surveys of all historical sites in Texas, but found only six individuals of the species at a single site, then known as the Methodist Camp Thicket, near Weslaco in Hidalgo County. This site was first reported by Dr. James Everitt, U.S. Department of Agriculture (USDA), around 1980 (Everitt 2010). Therefore, seven wild populations (not including Runyon's residence) in Texas have either been extirpated or cannot be re-located.

Mexico:

Múzquiz, Coahuila. Ernest G. Marsh, Jr. collected Tamaulipan kidneypetal at Yuda (or Yudo) Spring, Múzquiz, Coahuila on September 18, 1936. Contreras-Arquieta (2005), who conducted surveys of *A. limitaris* in northeast Mexico from 2003 to 2005, was unable to find a spring by this name in the vicinity of Múzquiz. Residents who had lived their entire lives in Múzquiz told him that this spring probably disappeared more than 20 years prior to his study; most had never heard of Yuda or Yudo Spring. Six springs remain in the area, but the stream-side vegetation is heavily impacted by grazing animals and farming operations. Consequently, this population is probably extirpated.

Topia, Durango. The UT-Austin herbarium contains a specimen of Tamaulipan kidneypetal that was not reported in previous status updates. This was collected by P. Tenorio L. et al. on

September 19, 1985, in the vicinity of Topia, Durango (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad 2009); the specimen was annotated by Paul Fryxell, who identified it as *A. limitaris*. The precise collection site is unknown, and the population has not been observed since that time.

Extant populations.

Texas:

Methodist Camp Thicket. The population of Tamaulipan kidneypetal at the Methodist Camp Thicket in Hidalgo County, Texas, has increased from 28 individuals in 1994 (Ideker 1994) to 147 on October 30, 2007 (Best 2007), including a previously unknown cluster of plants that extends into adjacent property of Estero Llano Grande State Park. These plants ranged in height from 10 to 150 cm (3.9 to 59 in) (average = 49 cm (19 in), standard deviation = 31 cm (12 in)) and had from 1 to 10 stems (average = 2.4); forty-two individuals (29%) had developing or mature seed capsules, but none were flowering. On December 8, 2009, USFWS personnel observed 49 Tamaulipan kidneypetal plants with mature seed capsules at this site, but did not determine the number of non-reproductive plants (USFWS 2010b). The entire Methodist Camp Thicket site was acquired by Texas Parks and Wildlife Department (TPWD) in 2010 and added to Estero Llano Grande State Park. Protection and management of Tamaulipan kidneypetal is a high priority at this park, and TPWD is conducting invasive grass suppression and population augmentation with support from a USFWS Coastal Program cooperative agreement (2013-2018).

Four new Texas populations have been confirmed since Tamaulipan kidneypetal was listed as endangered in 1994:

Rudman Tract, Lower Rio Grande Valley National Wildlife Refuge. On November 18, 1999, USFWS personnel discovered a small population on the Rudman tract of LRGV NWR, in Willacy County (Evans, 1999). On December 9, 2009, 118 live Tamaulipan kidneypetal plants were observed at this site as well as at least 100 dead but identifiable Tamaulipan kidneypetal plants (Wahl 2010).

C.B. Wood Municipal Park. In about 2001, Mike Heep, a biology instructor from University of Texas-Pan American (UTPA), discovered a population of at least 100 Tamaulipan kidneypetal plants at C.B. Wood Municipal Park, in Harlingen (Carr 2002, Williams 2006). Amateur botanist Christina Mild of Harlingen and USFWS personnel visited the C.B. Wood site on December 8, 2009, where they observed mature seed capsules on 31 Tamaulipan kidneypetal plants. This park is managed primarily for recreation, and the Tamaulipan kidneypetal habitat is impacted by invasive guineagrass (*Megathrysus maximus*) and mother of thousands (*Kalanchoe* sp.; Kim Wahl, pers. comm., October 19, 2015).

Private Property North Rio Hondo. In 2003, a private landowner asked Christina Mild to conduct a plant survey of his property in Cameron County, near the Arroyo Colorado north of Rio Hondo (Carr 2003a). She discovered a population of about 100 Tamaulipan kidneypetal plants there. The landowner enthusiastically participated in the conservation and monitoring of this population and its habitat (Williams 2006); although this property was recently sold, the new owner has also expressed a desire to conserve the population. Mild and USFWS personnel visited the Rio Hondo site on December 8, 2009, where they observed mature seed capsules on 36 Tamaulipan kidneypetal plants.

Private Property in Northwest Willacy County. Bill Carr of The Nature Conservancy obtained permission from private landowners to conduct a plant survey on their property in northwest Willacy County. He discovered a population consisting of at least 1,000 individual Tamaulipan kidneypetal plants at the site, which is about 6.5 km (4.0 mi) northeast of the Rudman tract population (Carr 2003b, Williams 2006). This is the largest documented population in the U.S. Carr and USFWS personnel visited this site in June and November, 2010. At that time the population remained in a healthy, actively reproductive state. Most of the Tamaulipan kidneypetal plants occurred where the vegetative cover consisted of about 50 percent shrubs, ranging from 1.5 to 4 m (4.9 to 13.1 ft) in height, and 50 percent native grasses and forbs. Charred wood was evident there, and the landowner stated that a wildfire had burned there about 10 years before. These observations support the premise that Tamaulipan kidneypetal is best adapted to savanna rather than dense woodland, and that its populations tolerate and perhaps are benefited by periodic wildfire.

In addition to these documented populations, we have occasionally received credible, confidential reports that other small populations of Tamaulipan kidneypetal occur at undisclosed locations near Brownsville and Olmito, and along the Arroyo Colorado, in Cameron and Willacy Counties. These reports were made by private individuals who were familiar with the species and were qualified to identify it, and who had the permission of landowners to access the sites but not to reveal the locations of listed plant and animal species to USFWS. Although undocumented, these sites nevertheless contribute to the species' actual status. Landowners who voluntarily choose to conserve the populations may also contribute to the species' recovery.

Mexico:

Tepehuajes. Tamaulipas. On September 16, 1981, P.A. Fryxell collected Tamaulipan kidneypetal in the Municipio of Soto la Marina, Tamaulipas, along the road to Tepehuajes, 1.5 km east of its junction with Highway 180. On November 12, 1994, Mexican botanist Francisco González Medrano and Chris Best, USFWS, documented 48 Tamaulipan kidneypetal plants 0.5 km (0.3 mi) west of the site reported by Fryxell (Best 1994). Since we do not know the geographic precision of Fryxell's reported position, this may be the same location.

San José de las Rusias, Tamaulipas. Contreras-Arquieta (2005) conducted a three-year survey of U.S.-listed endangered plant species in northeast Mexico. This project was supported through federal Section 6 funds allocated to TPWD. He documented up to 4,000 individual Tamaulipan kidneypetal plants at 13 new sites in Tamaulipas (in addition to the site or sites reported by Fryxell and Best), which he meticulously surveyed and mapped with GPS. Since several of these sites are separated from each other by 1 km (0.6 mi) or less, Contreras-Arquieta's observations probably are equivalent to nine element occurrences, as defined in NatureServe (2002). These sites are situated on *ejidos* and privately-owned ranches distributed over an area of 10 km by 40 km (6.1 mi x 24.8 mi) centered near San José de las Rusias, in the *municipio* of

Soto la Marina, Tamaulipas. Although he observed few individuals at some sites, he estimated that other sites had a density of as many as 2,000 individuals per ha (809 per ac).

González, Tamaulipas. Martínez-Avalos (2012), a professor of botany at Universidad Autónoma de Tamaulipas, reported Tamaulipan kidneypetal in the *municipio* of González, within the proposed Sierra de Tamaulipas Protected Natural Area (see discussion in Section I.g.). However, since specimens from this site have not yet been positively identified, González should be considered a potential rather than confirmed population site.

The few reported extant and historic populations of Tamaulipan kidneypetal are widely distributed over a geographic range of about 250,000 km^2 (96,525 mi^2) (see global range inset in Figure 2). The known range in Texas is about 1,760 km^2 (680 mi^2), or about 0.7 percent of the total geographic range. The Topia, Durango site is more than 850 km (528 mi) west of the populations in Texas and Tamaulipas. The Múzquiz site is 400 km (248 mi) northwest of the Texas populations, and 580 km (360 mi) northeast of the Topia site. The Texas populations are 250 km (155 mi) north of the Tamaulipas populations.

It is difficult to determine the significance of the two isolated herbarium specimens from Coahuila and Durango. The collectors did not record the precise geographic locations, so these plants could have come from anywhere within the *municipios* of Múzquiz and Topia, respectively. We know nothing about the associated vegetation of the Múzquiz site. The Topia site is an oak woodland with yellow clay soil, and the elevation at the municipal seat is 1,800 m (5,900 ft) above sea level. These habitat characteristics are clearly distinct from the low-elevation populations near the Gulf of Mexico in Texas and Tamaulipas. Why has the species not been reported from the vast region that lies between such widely disjunct populations? One or more of the following hypotheses might explain this apparent anomaly:

> Hypothesis 1. Additional, undiscovered populations of Tamaulipan kidneypetal may exist within the known geographic range. The species is easily overlooked, as it resembles many common mallows (Malvaceae *sensu lato*). Botanists have intensively searched for Tamaulipan kidneypetal in the Rio Grande delta for more than 20 years, yet 4 of the 5 known Texas sites were not discovered until 1999 - 2003. More than 99 percent of the species' geographic range lies in Mexico, where botanists have yet to survey vast, remote regions. *Ayenia limitaris* might also have been misidentified as the more common *A. berlandieri* or another similar species.
>
> Hypothesis 2. Tamaulipan kidneypetal may have been far more abundant in the past; subsequently, a change in climate, fire frequency, land use, etc. could have led to a drastic decline, until only a few relict populations remained.
>
> Hypothesis 3. The disjunct populations in Coahuila and Durango could represent different, perhaps un-described species of *Ayenia* that are similar in appearance to A. *limitaris*. This hypothesis could be tested through genetic analyses.

Summary of abundance, distribution, and population trends

- Seven sites were reported in Cameron and Hidalgo Counties, Texas, between 1888 and 1963 that have not been observed for more than 40 years. These sites are presumed extirpated.
- In Mexico, one site was reported in Múzquiz, Coahuila, Mexico, in 1936. A recent attempt to re-locate this site indicates that it was probably developed and the population extirpated. Another site was reported in Topia, Durango, in 1985, but has not been observed since then; its status is unknown.
- Five extant populations in Cameron, Hidalgo, and Willacy Counties, Texas, have been monitored since 2009. Two of these sites are located on well-managed private land, one site is on a National Wildlife Refuge, one site is in a city park, and one site is on a State Park managed by TPWD. Four of these populations range from 100 to 200 individuals, and the fifth site has at least 1,000 individuals.
- Thirteen sites (constituting nine element occurrences) were documented and mapped in 2005 in the *municipio* of Soto la Marina, Tamaulipas. The total population was estimated to be at least 4,000. An additional population of unknown size has been reported from the *municipio* of González, Tamaulipas.
- Three pilot reintroductions were successfully established at LRGV NWR in 1999. The population at one reintroduction site increased 3.5-fold (from 84 to 295 individuals) by October, 2008 (see discussion on propagation and reintroduction in Section I.g).

Table 3. Global populations of Tamaulipan kidneypetal.

Site Name	**County / *Municipio***	**State, Country**	**Last Observed**	**Estimated Population**	**TXNDD E.O. No.**	**Pronatura Sitio**	**Citation/Specimen**
Hidalgo	Hidalgo	Texas, USA	6?-Aug-1888*	Unk	n/a	n/a	Pringle 2272, VT (Lectotype); Dorr & Barnett 1986; Davis 1936
Barreda Road, near Los Fresnos	Cameron	Texas, USA	28-Oct-1924*	Unk	3	n/a	R. Runyon 689, TEX 337412
Yuda Spring	Múzquiz	Coahuila, Mexico	18-Sep-1936*	Unk	n/a	n/a	Marsh 949, TEX-LL
San Benito - Barreda Station	Cameron	Texas, USA	5-Jun-1939*	Unk	4	n/a	R. Runyon 2093, TEX 337410; R. Runyon 4910, TEX 281712; R. Runyon 4911, TEX 337411
812 St. Charles St, Brownsville	Cameron	Texas, USA	12-Jun-1941*	Unk; Cultivated	2	n/a	V.L. Cory 51373, SM s/n.; R. Runyon 2744, TEX 337414
Brownsville	Cameron	Texas, USA	1-Aug-1941*	Unk	n/a	n/a	I. Shiller 103, 765, US 590031, US 590029
Near Olmito	Cameron	Texas, USA	16-Jun-1943*	Unk	1	n/a	R. Runyon 3107, TEX 337413

Site Name	County / *Municipio*	State, Country	Last Observed	Estimated Population	TXNDD E.O. No.	Pronatura Sitio	Citation/Specimen
Brownsville	Cameron	Texas, USA	October 1955	Unk	n/a	n/a	I. Shiller s.n. LIL-454806 (Holotype)
Olmito	Cameron	Texas, USA	20-Oct-1963*	Unk	n/a	n/a	R. Runyon 5769, TEX 442953, 337409
Topia	Topia	Durango, Mexico	19-Sep-1985	Unk	n/a	n/a	P. Tenorio L., C. Romero de T., J. Ignacio S., P. Dávila A. TEX 212022
Carretera a Tepehuajes km 0.45 - 1.5	Soto la Marina	Tamaulipas, Mexico	1-Apr-2005	48	n/a	287, 288, 289, 304, 306, 307	Fryxell TEX 212025; Best 1994; Contreras 2005
Camino a Tres de Abril, km 0.5	Soto la Marina	Tamaulipas, Mexico	2-Apr-2005	Unk	n/a	311	Contreras 2005
Camino a Tres de Abril, km 3.5 - 4.1	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	314, 359	Contreras 2005
Camino a San Felipe km 1.3	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	364	Contreras 2005
Carretera 180, km 110.8	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	365	Contreras 2005
Carretera 180, km 130.4	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	358	Contreras 2005
Carretera 180, km 135	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	357	Contreras 2005
Ej. Diez de Abril	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	362	Contreras 2005
Rancho Santo Domingo	Soto la Marina	Tamaulipas, Mexico	5-Aug-2005	Unk	n/a	363	Contreras 2005
Resaca de los Fresnos tract, LRGV NWR	Cameron	Texas, USA	9-Oct-2008	≥ 80 (pilot reintro.)	n/a	n/a	Best 2009; this report
Villa Nueva tract, LRGV NWR	Cameron	Texas, USA	9-Oct-2008	≥ 11 (pilot reintro.)	n/a	n/a	Best 2009; this report
Phillips Banco	Cameron	Texas, USA	29-Oct-2009	295 (pilot reintro.)	n/a	n/a	Best 2009; this report
Methodist Camp Thicket	Hidalgo	Texas, USA	8-Dec-2009	147	6	n/a	Damude & Poole 1990, Ideker 1994, Best 2007.
C.B. Wood Park, Harlingen	Cameron	Texas, USA	8-Dec-2009	100 - 200	8	n/a	Carr 2002; this report
Rudman Tract, LRGV NWR	Hidalgo	Texas, USA	9-Dec-2009	118	7	n/a	Evans 1999; Wahl 2009

Site Name	County / *Municipio*	State, Country	Last Observed	Estimated Population	TXNDD E.O. No.	Pronatura Sitio	Citation/Specimen
Private Property, N of Rio Hondo	Cameron	Texas, USA	9-Dec-2009	± 100	n/a	n/a	Carr, 2003; this report
Private Property	Willacy	Texas, USA	Nov-2010	> 1,000	n/a	n/a	Carr 2003b
?	González	Tamaulipas, México	2012	?	n/a	n/a	Martínez-Avalos 2012

* Indicates probable extirpation.

I.4. Habitat, Phenology, Reproduction, and Ecology

Habitat

Runyon's herbarium labels (University of Texas 2010) describe the habitat of Tamaulipan kidneypetal as open ground, the edges of thickets, or within thickets, on dry, alluvial clay soils. Ideker (1994) described the Methodist Camp Thicket habitat as a dense shrub and herbaceous understory under a somewhat open canopy, similar to the *Pithecellobium ebano - Ehretia anacua* (Texas ebony – anacua) climax series of Diamond et al. (1987). Tamaulipan kidneypetal and associated shrubs appeared to favor partially shaded niches, rather than under either dense or open canopy cover. Guineagrass (*Megathyrsus maximus*), an introduced, invasive grass, occupied much of the understory and was a serious threat to the Tamaulipan kidneypetal population. Ideker observed 22 arthropod species on Tamaulipan kidneypetal plants, but only the mealy flata (*Ormenis pruinosa* Say, a lantern-fly of the Order Homoptera), appeared to feed on it. Green lacewings may benefit Tamaulipan kidneypetal by feeding on aphid parasites.

The entire population at the Methodist Camp Thicket occurs on Hidalgo sandy clay loam, 0 to 1 percent slope (U.S. Department of Agriculture 1981). Damude and Poole (1990) describe the occupied habitat there as a formerly active flood plain formed of Holocene alluvial deposits, and suggest that the species may have been dependent on periodic flooding. However, this site is just north of the Mission Ridge, a slight rise in elevation that marks the northern edge of the Holocene flood plain of the Rio Grande (Clover 1937). The site, which has an elevation of 23 m (75 ft) above sea level, forms the high bank of the Arroyo Colorado (Llano Grande Lake) distributary channel; the Arroyo has an elevation of 16 m (53 ft), and the flood plain to the south is 20 m (65 ft) above sea level. Like other known stands of Texas ebony-anacua/brasil forest, the site would remain above flood waters during the Holocene in all but the most catastrophic floods.

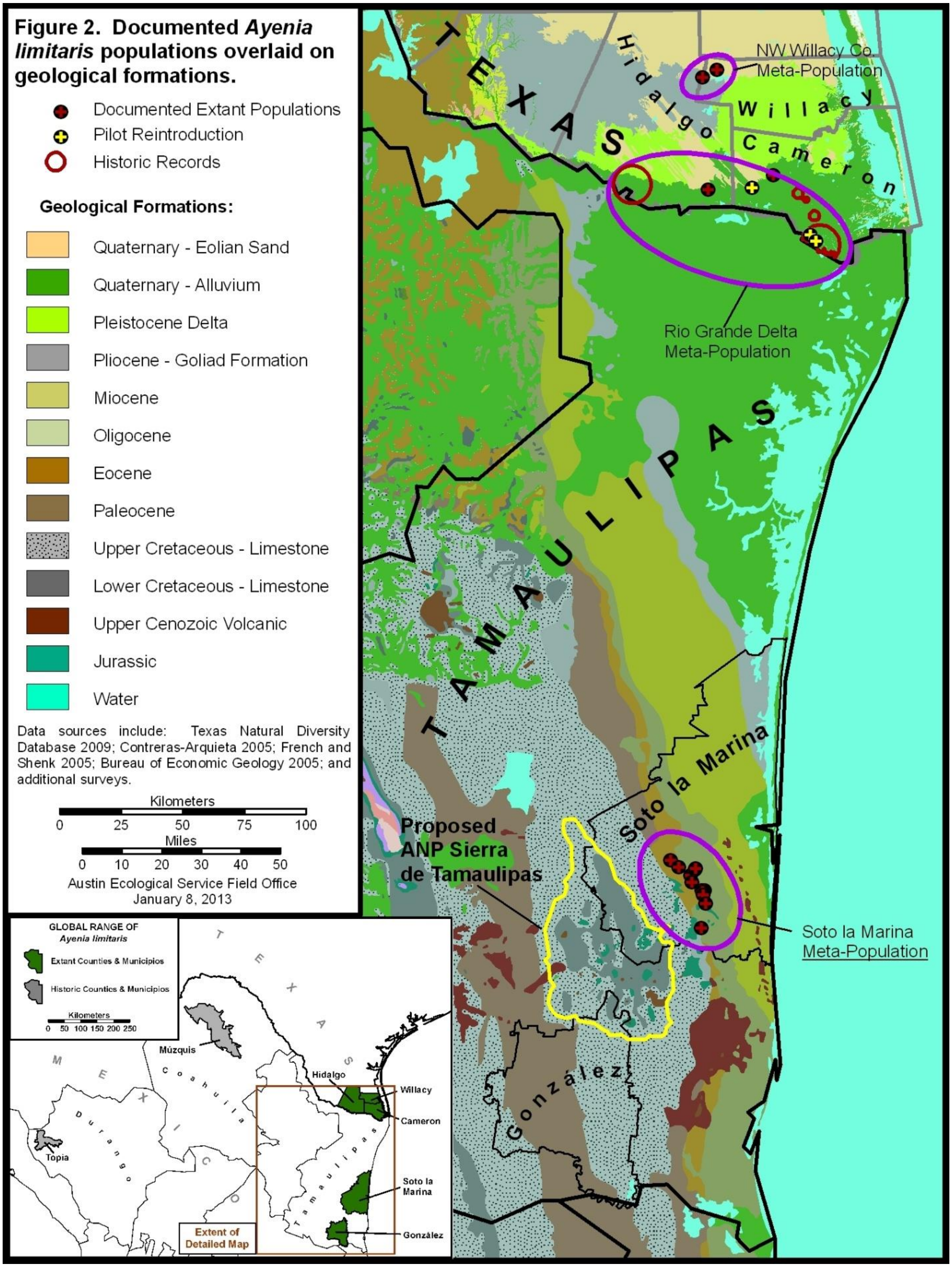


Figure 2. Documented Ayenia limitaris populations overlaid on geological formations.
Documented Extant Populations
Pilot Reintroduction
Historic Records
Geological Formations:
Quaternary - Eolian Sand
Quaternary - Alluvium
Pleistocene Delta
Pliocene - Goliad Formation
Miocene
Oligocene
Eocene
Paleocene
Upper Cretaceous - Limestone
Lower Cretaceous - Limestone
Upper Cenozoic Volcanic
Jurassic
Water
Data sources include: Texas Natural Diversity Database 2009; Contreras-Arquieta 2005; French and Shenk 2005; Bureau of Economic Geology 2005; and additional surveys.
Kilometers
0 25 50 75 100
Miles
0 10 20 30 40 50
Austin Ecological Service Field Office
January 8, 2013
TEXAS
Hidalgo
Willacy
Cameron
NW Willacy Co. Meta-Population
Rio Grande Delta Meta-Population
TAMAULIPAS
Soto la Marina
Proposed ANP Sierra de Tamaulipas
Soto la Marina Meta-Population
González
GLOBAL RANGE OF Ayenia limitaris
Extant Counties & Municipios
Historic Counties & Municipios
Kilometers
0 50 100 150 200 250
TEXAS
MEXICO
Coahuila
Durango
Tamaulipas
Múzquis
Hidalgo
Willacy
Cameron
Topia
Soto la Marina
González
Extent of Detailed Map

More recently, two Tamaulipan kidneypetal populations have been reported from clay bluffs along the Arroyo Colorado in Cameron County, in Mercedes clay and Raymondville clay loam soils. Two additional populations have been discovered in spiny shrubland on Willacy fine sandy loam soils (U.S. Department of Agriculture 1982) in western Willacy County.

Contreras-Arquieta (2005) described 15 occupied sites (including 13 new sites) in the *municipio* of Soto la Marina, Tamaulipas. The vegetation at these sites ranged from low deciduous tropical forest to tall spiny shrublands. Tamaulipan kidneypetal plants occurred in the open or in shade, in fine sandy loam soils. Contreras-Arquieta noted that Tamaulipan kidneypetal plants favor partially shaded sites where they receive at least some direct sunlight (Contreras-Arquieta, pers. comm. 2005).

The single herbarium specimen from Topia, Durango, Mexico, described the habitat as disturbed, grazed, oak woodland with yellow clay soil. The specimen collected in Múzquis, Coahuila, does not include information on soils, habitat, or associated vegetation. The great distance between these two disjunct historic populations and the extant populations near the Gulf of Mexico, and the dissimilarity in their habitats, appear anomalous and require further investigation.

Table 4 summarizes the plant species associated with Tamaulipan kidneypetal at 17 sites reported by Damude and Poole (1990), Ideker (1994), Carr (2002, 2003a and 2003b), and Contreras (2005). Although these investigators did not record associated species in the same way, it is interesting to compare the frequency of species occurrence at these sites. Eleven plant species that were reported from more than 50 percent of the sites, and their frequencies of occurrence, are tenaza (*Havardia pallens* 0.82), colima (*Zanthoxylum fagara* 0.76), *Abutilon* spp. (0.76), crucillo (*Randia rhagocarpa* 0.71), granjeno (*Celtis ehrenbergiana* 0.71), Texas ebony (*Ebanoposis ebano* 0.65), heart-leaf hibiscus (*Hibiscus martianus* 0.59), anacahuita (*Cordia boissieri* 0.59), Trecule yucca (*Yucca treculeana* 0.53), tropical sage (*Salvia coccinea* 0.53), and coyotillo (*Karwinskia humboldtiana* 0.53). Although the *Abutilon* may represent one or more species, amantillo (*A. trisulcatum*) is very common in this type of vegetation.

Table 4. Plant species[1] associated with Tamaulipan kidneypetal.

Family	Genus	Species	Origin[2]	Damude & Poole 1990	Ideker 1994	Carr 2002	Carr 2003a	Carr 2003b	Contreras 2005[3]	Frequency[4]
Acanthaceae	*Carlowrightia*	*parviflora*	N			+				0.06
Acanthaceae	*Justicia*	*pilosella*	N		+		+			0.12
Acanthaceae	*Ruellia*	*nudiflora*	N						3	0.18
Acanthaceae	*Ruellia*	*sp.*	N			+				0.06
Achatocarpaceae	*Phaulothamnus*	*spinescens*	N	+	+	+	+	+	3	0.41
Agavaceae	*Manfreda*	*variegata*	N		+		+?			0.12
Agavaceae	*Yucca*	*treculeana*	N			+[5]	+[5]		7	0.53
Amaranthaceae	*Celosia*	*nitida*	N		+					0.06
Arecaceae	*Sabal*	*mexicana*	N						8	0.47
Asclepiadaceae	*Cynanchum*	*barbigerum*	N				+?		5	0.35
Asclepiadaceae	*Matelea*	*reticulata*	N		+					0.06
Asclepiadaceae	*Matelea*	*sp.*	N						1	0.06
Asclepiadaceae	*Unidentified*[6]	*sp.*	UNK				+			0.06
Asteraceae	*Acourtia*	*runcinata*	N		+					0.06
Asteraceae	*Baccharis*	*salicifolia*	N						2	0.12

Family	Genus	Species	Origin[2]	Damude & Poole 1990	Ideker 1994	Carr 2002	Carr 2003a	Carr 2003b	Contreras 2005[3]	Frequency[4]
Asteraceae	*Borrichia*	*frutescens*	N			+				0.06
Asteraceae	*Chromolaena*	*odorata*	N		+		+			0.12
Asteraceae	*Fleischmannia*	*incarnata*	N				+			0.06
Asteraceae	*Gamochaeta*	*sp.*	N				+			0.06
Asteraceae	*Gymnosperma*	*glutinosum*	N					+		0.06
Asteraceae	*Helianthus*	*annuus*	N				+			0.06
Asteraceae	*Helianthus*	*ciliaris*	N			+				0.06
Asteraceae	*Palafoxia*	*texana*	N				+			0.06
Asteraceae	*Parthenium*	*hysterophorus*	N				+		7	0.47
Asteraceae	*Parthenium*	*sp.*	N			+				0.06
Asteraceae	*Perityle*	*microglossa*	N				+			0.06
Asteraceae	*Sanvitalia*	*ocymoides*	N						2	0.12
Asteraceae	*Senecio*	*ampullaceus*	N				+		2	0.18
Asteraceae	*Sonchus*	*sp.*	N				+			0.06
Asteraceae	*Tamaulipa*	*azurea*	N	+	+					0.06
Asteraceae	*Thymophylla*	*pentachaeta*	N			+			1	0.12
Asteraceae	*Thymophylla*	*tenuiloba*	N						1	0.06
Asteraceae	*Trixis*	*inula*	N	+	+	+	+			0.18
Asteraceae	*Verbesina*	*microptera*	N		+		+			0.12
Asteraceae	*Viguiera*	*stenoloba*	N			+				0.06
Asteraceae	*Xylothamnia*	*palmeri*	N			+				0.06
Basellaceae	*Anredera*	*sp.*	N		+					0.06
Bixaceae	*Amoreuxia*	*wrightii*	N						3	0.18
Boraginaceae	*Cordia*	*boissieri*	N	+	+	+	+		7	0.59
Boraginaceae	*Ehretia*	*anacua*	N	+	+		+			0.12
Boraginaceae	*Heliotropium*	*angiospermum*	N						8	0.47
Boraginaceae	*Heliotropium*	*curassavicum*	N				+			0.06
Boraginaceae	*Tournefortia*	*volubilis*	N		+		+			0.12
Brassicaceae	*Lepidium*	*sp.*	UNK				+			0.06
Brassicaceae	*Lesquerella*	*lasiocarpa*	N				+			0.06
Brassicaceae	*Physaria*	*sp.*	N						1	0.06
Brassicaceae	*Sibara*	*viereckii*	N				+			0.06
Brassicaceae	*Sisymbrium*	*irio*	N				+			0.06
Bromeliaceae	*Tillandsia*	*baileyi*	N			+	+			0.12
Bromeliaceae	*Tillandsia*	*recurvata*	N			+	+			0.12
Cactaceae	*Acanthocereus*	*tetragonus*	N			+	+		5	0.41
Cactaceae	*Cylindropuntia*	*leptocaulis*	N			+	+		6	0.47
Cactaceae	*Echinocereus*	*sp.*	N			+				0.06
Cactaceae	*Ferocactus*	*hamatacathus var. sinuatus*	N			+	+			0.12
Cactaceae	*Mammillaria*	*heyderi*	N				+			0.06
Cactaceae	*Mammillaria*	*spp.*	N			+				0.06
Cactaceae	*Opuntia*	*engelmannii*	N			+			5	0.35
Cactaceae	*Opuntia*	*sp.*	UNK				+			0.06
Capparaceae	*Koeberlina*	*spinosa*	N			+				0.06
Chenopodiaceae	*Chenopodium*	*ambrosioides*	N				+			0.06
Chenopodiaceae	*Chenopodium*	*murale*	N				+			0.06
Commelinaceae	*Tradescantia*	*sp.*	UNK						2	0.12
Convolvulaceae	*Dichondra*	*micrantha*	I				+			0.06
Convolvulaceae	*Ipomea*	*sp.*	UNK						3	0.18
Crassulaceae	*Kalanchöe*	*sp.*	I			+				0.06
Cucurbitaceae	*Ibervillea*	*lindheimeri*	N						3	0.18
Ebenaceae	*Diospyros*	*texana*	N	+	+	+	+	+	3	0.41
Euphorbiaceae	*Adelia*	*vaseyi*	N		+	+	+			0.18

Family	Genus	Species	Origin[2]	Damude & Poole 1990	Ideker 1994	Carr 2002	Carr 2003a	Carr 2003b	Contreras 2005[3]	Frequency[4]
Euphorbiaceae	*Bernardia*	*myricifolia*	N	+	+	+	+	+		0.24
Euphorbiaceae	*Chamaesyce*	*sp.*	UNK				+		7	0.47
Euphorbiaceae	*Croton*	*cortesianus*	N				+	+		0.12
Euphorbiaceae	*Croton*	*humilis*	N		+					0.06
Euphorbiaceae	*Croton*	*incanus*	N						2	0.12
Euphorbiaceae	*Croton*	*sp.*	UNK	+					5	0.29
Euphorbiaceae	*Jatropha*	*dioica*	N						3	0.18
Euphorbiaceae	*Ricinus*	*communis*	I				+			0.06
Fabaceae	*Acacia*	*berlandieri*	N						1	0.06
Fabaceae	*Acacia*	*farnesiana*	N						4	0.24
Fabaceae	*Acacia*	*roemeriana*	N						1	0.06
Fabaceae	*Acacia*	*sp.*	N				+			0.06
Fabaceae	*Caesalpinia*	*mexicana*	N						4	0.24
Fabaceae	*Chamaecrista*	*sp.*	N						1	0.06
Fabaceae	*Dalea*	*scandens*	N			+				0.06
Fabaceae	*Desmanthus*	*virgatus*	N						6	0.35
Fabaceae	*Ebenopsis*	*ebano*	N	+	+	+	+	+	7	0.65
Fabaceae	*Havardia*	*pallens*	N	+	+	+	+	+	10	0.82
Fabaceae	*Leucaena*	*pulverulenta*	N						3	0.18
Fabaceae	*Mimosa*	*malacophylla*	N						1	0.06
Fabaceae	*Parkinsonia*	*aculeata*	N				+		6	0.41
Fabaceae	*Parkinsonia*	*texana var. macra*	N				+[7]		1	0.12
Fabaceae	*Prosopis*	*glandulosa*	N	+	+	+	+	+	4	0.47
Fabaceae	*Rhynchosia*	*minima*	N						5	0.29
Hydrophyllaceae	*Nama*	*jamaicense*	N				+			0.06
Lamiaceae	*Hedeoma*	*sp.*	UNK						2	0.12
Lamiaceae	*Salvia*	*ballotiflora*	N		+			+		0.12
Lamiaceae	*Salvia*	*coccinea*	N		+	+	+		6	0.53
Lamiaceae	*Scutellaria*	*drummondii*	N				+			0.06
Lamiaceae	*Scutellaria*	*sp.*	N			+				0.06
Lamiaceae	*Stachys*	*drummondii*	N				+			0.06
Lamiaceae	*Teucrium*	*cubense*	N				+		2	0.18
Liliaceae	*Cooperia*	*sp.*	N			+				0.06
Lythraceae	*Heimia*	*salicifolia*	N		+					0.06
Malpighiaceae	*Malpighia*	*glabra*	N		+		+			0.12
Malpighiaceae	*Malpighia*	*sp.*	UNK						2	0.12
Malvaceae	*Abutilon*	*sp.*	N		+		+		11	0.76
Malvaceae	*Allowissadula*	*lozanii*	N				+			0.06
Malvaceae	*Billieturnera*	*helleri*	N			+				0.06
Malvaceae	*Hibiscus*	*martianus*	N			+	+	+	6	0.59
Malvaceae	*Malvastrum*	*americanum*	N				+			0.06
Malvaceae	*Pavonia*	*lasiopetala*	N						1	0.06
Malvaceae	*Sida*	*sp.*	N						1	0.06
Malvaceae	*Wissadula*	*amplissima*	N		+					0.06
Menispermaceae	*Cocculus*	*diversifolius*	N		+	+	+			0.18
Nyctaginaceae	*Acleisanthes*	*obtusa*	N				+		2	0.18
Nyctaginaceae	*Acleisanthes*	*sp.*	N						1	0.06
Oleaceae	*Forestiera*	*angustifolia*	N	+	+		+	+		0.18
Oxalidaceae	*Oxalis*	*dichondrifolia*	N						1	0.06
Oxalidaceae	*Oxalis*	*drummondii*	N						1	0.06
Papaveraceae	*Argemone*	*sp.*	N				+			0.06
Passifloraceae	*Passiflora*	*foetida*	N						3	0.18
Passifloraceae	*Passiflora*	*sp.*	N		+		+			0.12

Family	Genus	Species	Origin[2]	Damude & Poole 1990	Ideker 1994	Carr 2002	Carr 2003a	Carr 2003b	Contreras 2005[3]	Frequency[4]
Phytolaccaceae	*Rivina*	*humilis*	N	+	+		+			0.12
Poaceae	*Bouteloua*	*trifida*	N			+				0.06
Poaceae	*Chloris*	*cucullata*	N			+				0.06
Poaceae	*Chloris*	*sp.*	UNK						1	0.06
Poaceae	*Megathyrsus*	*maximus*	I	+	+	+	+			0.18
Poaceae	*Melinis*	*repens*	I						1	0.06
Poaceae	*Panicum*	*hallii*	N			+	+			0.12
Poaceae	*Pennisetum*	*ciliare*	I			+				0.06
Poaceae	*Setaria*	*sp.*	UNK				+			0.06
Poaceae	*Tridens*	*eragrostoides*	N				+			0.06
Polemoniaceae	*Giliastrum*	*incisum*	N				+			0.06
Polygonaceae	*Antigonon*	*leptopus*	I		+	+				0.12
Pteridaceae	*Cheilanthes*	*alabamensis*	N				+			0.06
Ranunculaceae	*Clematis*	*drummondii*	N						8	0.47
Rhamnaceae	*Colubrina*	*texensis*	N			+	+			0.12
Rhamnaceae	*Condalia*	*hookeri*	N	+	+		+		1	0.18
Rhamnaceae	*Karwinskia*	*humboldtiana*	N		+		+	+	6	0.53
Rhamnaceae	*Ziziphus*	*obtusifolia*	N	+	+		+		2	0.24
Rubiaceae	*Chiococca*	*alba*	N			+	+			0.12
Rubiaceae	*Randia*	*rhagocarpa*	N	+	+	+	+		9	0.71
Rutaceae	*Amyris*	*madrensis*	N	+	+	+	+			0.18
Rutaceae	*Amyris*	*texana*	N	+	+	+	+			0.18
Rutaceae	*Zanthoxylum*	*fagara*	N	+	+	+	+	+	9	0.76
Salicaceae	*Salix*	*nigra*	N						1	0.06
Sapindaceae	*Cardiospermum*	*corindum*	N				+			0.06
Sapindaceae	*Serjania*	*brachycarpa*	N		+	+	+			0.18
Sapindaceae	*Urvillea*	*ulmacea*	N		+					0.06
Sapotaceae	*Sideroxylon*	*celastrinum*	N	+	+	+	+		1	0.24
Scrophulariaceae	*Leucophyllum*	*frutescens*	N			+	+	+	3	0.35
Simaroubaceae	*Castela*	*erecta var. texana*	N			+	+		2	0.24
Solanaceae	*Capsicum*	*annuum*	N		+		+			0.12
Solanaceae	*Lycium*	*berlandieri*	N			+	+		2	0.24
Solanaceae	*Nicotiana*	*repanda*	N		+					0.06
Solanaceae	*Physalis*	*sp.*	N				+			0.06
Solanaceae	*Solanum*	*sp.*	N			+	+			0.12
Solanaceae	*Solanum*	*triquetrum*	N			+			2	0.18
Solanum	*Solanum*	*lycopersicum var. cerasiforme*	UNK				+			0.06
Sterculiaceae	*Ayenia*	*limitaris*	N	+	+	+	+	+	13	1.00
Ulmaceae	*Celtis*	*ehrenbergiana*	N	+	+	+	+	+	8	0.71
Ulmaceae	*Celtis*	*laevigata*	N	+						0.06
Urticaceae	*Parietaria*	*pensylvanica*	N				+			0.06
Urticaceae	*Urtica*	*chamaedryoides*	N		+		+			0.12
Urticaceae	*Urtica*	*sp.*	UNK						1	0.06
Verbenaceae	*Aloysia*	*gratissima*	N				+	+		0.18
Verbenaceae	*Citharexylum*	*berlandieri*	N				+		2	0.18
Verbenaceae	*Glandularia*	*bipinnatifida*	N				+			0.06
Verbenaceae	*Glandularia*	*quadrangulata*	N				+			0.06
Verbenaceae	*Lantana*	*achyranthifolia*	N				+			0.06
Verbenaceae	*Lantana*	*canescens*	N				+			0.06
Verbenaceae	*Lantana*	*sp.*	UNK			+				0.06
Verbenaceae	*Lantana*	*urticoides*	N				+	+	4	0.35

Family	Genus	Species	Origin[2]	Damude & Poole 1990	Ideker 1994	Carr 2002	Carr 2003a	Carr 2003b	Contreras 2005[3]	Frequency[4]
Verbenaceae	*Lippia*	*alba*	N						5	0.29
Verbenaceae	*Priva*	*lappulacea*	N				+			0.06
Verbenaceae	*Verbena*	*sp.*	UNK						1	0.06
Viscaceae	*Phoradendron*	*tomentosum*	N			+				0.06
Vitaceae	*Cissus*	*incisa*	N		+	+	+		3	0.35
Zygophyllaceae	*Guaiacum*	*angustifolium*	N		+	+	+	+		0.24

SPECIES TOTAL: 178

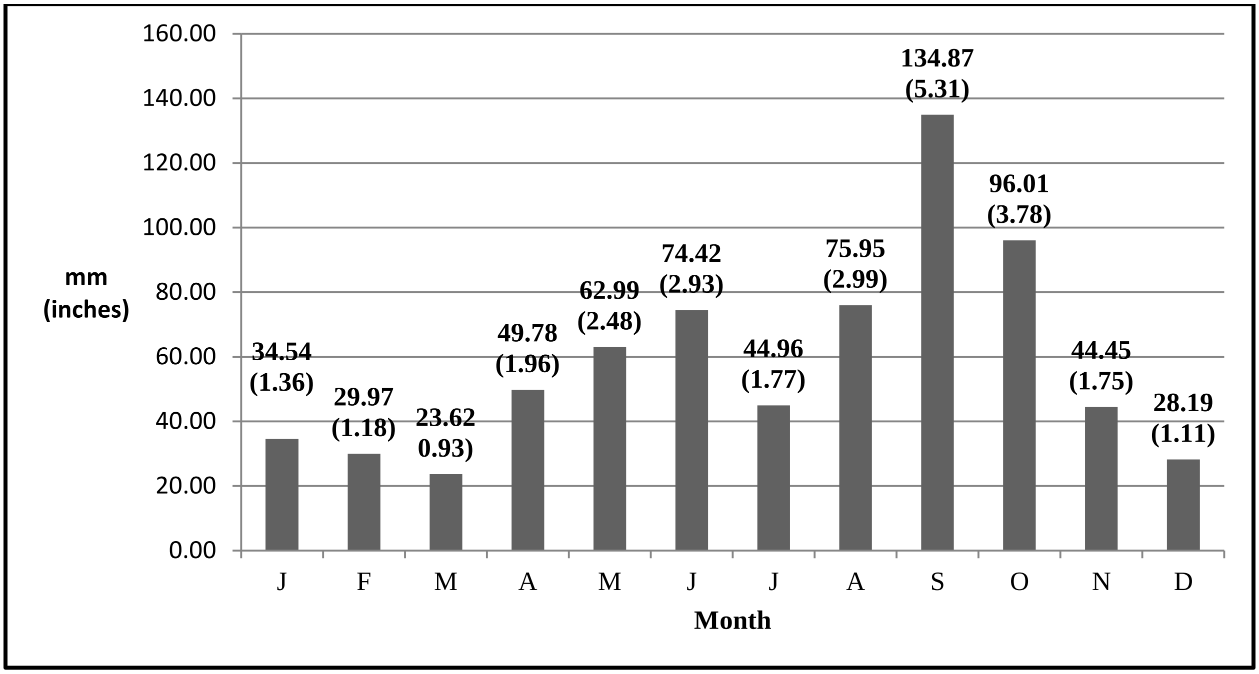
1. Taxonomic classifications have been standardized to conform to Natural Resources Conservation Service (2010).
2. N = Native; I = Introduced; UNK = Unknown Origin.
3. Numbers indicate the number of sites where a species was found, from a total of 13 Tamaulipan kidneypetal sites.
4. Total of 17 sites (Damude and Poole 1990 and Ideker 1994 describe the same site, so these results are combined).
5. Or *Y. torreyana.*
6. *Sarcostemma* or *Cynanchum* sp.
7. Listed as *P. texana*, presumed to be var. *macra*.

Phenology

Herbarium specimens and observations of Tamaulipan kidneypetal in Texas indicate that wild plants flower most often in June, July, September, October, and November. Contreras-Arquieta (2005) documented flowering of Tamaulipan kidneypetal in Tamaulipas during the months of March, April, May, and August, but did not observe the plants in other months. Tamaulipan kidneypetal plants in seed-increase plots and landscapes at Santa Ana NWR that received no supplemental water exhibited a bimodal phenology. The more consistent and prolific flowering and fruiting lasts from September through November; flowers and capsules may also be observed from May to June following significant rainfall. This pattern coincides with the prevailing bimodal rainfall pattern in the Rio Grande delta (see Table 5), in which the highest amounts of rainfall occur from late August to early November, with a secondary maximum in May and June. During seasons when there has been little or no precipitation, Tamaulipan kidneypetal plants do not flower. Therefore, reproduction appears to be stimulated primarily by rainfall.

Positive identification of Tamaulipan kidneypetal plants requires observation of the flowers or capsules. For this reason, the recommended season to conduct field surveys for Tamaulipan kidneypetal populations is from mid-September through November or December. In any given year, surveys may begin about two to four weeks after the onset of significant precipitation. The survey season ends when there has been a hard freeze, an extended drought, or when capsules have completely shattered and fallen from the plants. It may also be possible to survey from late April to early July if rainfall has been sufficient to stimulate growth and flowering. Appropriate survey times may best be judged by observing plants from known populations that have experienced the same weather patterns.

Table 5. Brownsville normal precipitation 1971 – 2000 (National Climate Data Center 2010b).



Reproduction

The reproduction biology of Tamaulipan kidneypetal has yet to be investigated. With the exception of a few cleistogamous species, most members of the genus *Ayenia*, including *A. limitaris*, are obligately allogamous; their floral morphology renders self-fertilization mechanically impossible (Cristóbal 1960). Cristóbal also observed that many small, unidentified insects visited the flowers of *Ayenia* species, perhaps attracted by the faint fetid odor produced by some. Based on these observations and the floral morphology, she concluded that insects are the probable pollinators. Propagated plants at the restoration nursery and landscapes at Santa Ana NWR and the pilot reintroduction sites at LRGV NWR have consistently produced large quantities of viable seed. Intensive searches have not detected any wild Tamaulipan kidneypetal populations sufficiently close to these propagation sites to have served as sources of unique pollinators or seed vectors. Therefore, we deduce that Tamaulipan kidneypetal is effectively pollinated by a locally abundant insect of the Rio Grande delta. The capsules dehisce upon drying, scattering the seeds up to a few meters away from the parent plant. Spontaneous progeny of propagated plants have been observed up to 21.4 m (70 ft) distant from the nearest planted seedling in pilot reintroduction sites. The recurved appendages of the fruit capsule may also serve to disperse entire capsules by adhering to animal hair or feathers. Additional seed dispersal may be caused by insects, water flow, or other factors. Seed scarification apparently happens naturally in the field. The longevity of individual Tamaulipan kidneypetal plants is unknown. However, propagated plants in experimental plots and reintroduction sites have lived at least 10 years without any apparent decline in vigor. These plants began flowering and producing viable seed at about 1 to 2 years of age.

Ecology

The known Texas populations of Tamaulipan kidneypetal occur in the *Ebenopsis ebano – Ehretia anacua*/*Condalia hookeri* (Texas ebony – anacua/brasil) forest association (Figure 3), which has a conservation status rank of G1, and the *Ebenopsis ebano – Phaulothamnus spinescens* (Texas ebony – snake-eyes) shrubland association, ranked G2, as defined by NatureServe (2013a; 2013b). G1 indicates that the association is critically imperiled, often with five or fewer global occurrences. G2 stands for globally imperiled, often with 20 or fewer occurrences. The known Tamaulipan populations occur in essentially the same types of vegetation. It is difficult to define what constitutes a single occurrence of a vegetation association, particularly where single large stands have been fragmented into many smaller ones. These vegetation types occur only on alluvial soils of the Tamaulipan biotic province (Blair 1950), within the flood plains and deltas of the Rio Grande, Río San Fernando, Río Soto la Marina, and a few minor watersheds and estuaries along the Laguna Madre de Tamaulipas. Where they can be irrigated, these alluvial soils are suitable for cotton, sugar cane, citrus, grain sorghum, and a wide variety of winter vegetables. Consequently, most of the region's floodplain vegetation has been cleared for irrigated cropland. Estimates of the amount of native vegetation remaining on the Texas side of the Rio Grande delta range from 1 to 5 percent (Jarsdoerfer and Leslie, Jr. 1988). The Tamaulipan side of the delta has been cleared to about the same extent. Remaining stands of old-growth vegetation are greatly fragmented, and the isolation of these habitat fragments may impede gene flow among the remnant populations of flora and fauna. Recent satellite images indicate that a somewhat greater proportion of intact habitat remains, including a few very large tracts, south of San Fernando, Tamaulipas.

In December 2009, USFWS personnel observed that nearly half of the Tamaulipan kidneypetal plants at Rudman tract, in northwestern Willacy County, had died during the previous year. A likely cause of this episode of mortality was the exceptional drought during the previous summer. A cold front on the night of December 4-5, 2009, briefly dropped the temperature to -1° C (30° F). This freeze killed the younger, un-lignified stems and leaves of the remaining live Tamaulipan kidneypetal plants. These observations suggest that the species' geographic range is restricted to regions of relatively higher or more consistent rainfall and less frequent, less intense freezes.

Within the Tamaulipan ecological region in south Texas and northeast Mexico, stands of native vegetation on un-cleared land are generally considered to be "intact habitat." Nevertheless, the composition and structure of the vegetation may in fact have changed dramatically as a result of human impacts. In addition to land clearing, increasing shrub density has altered much of the native grassland and savanna habitats of south Texas and northeast Mexico since the beginning of Spanish colonization in the mid-eighteenth century (Berlandier 1850, 1980; Mier y Terán 2000; McClintock 1930; Clover 1937; Inglis 1961; Best 2004). This conversion to dense shrubland may have been influenced by periods of intense sheep grazing in the eighteenth and nineteenth centuries (Lehman 1969), fencing of rangeland (Bogusch 1952), and cessation of wildfire (Johnston 1963). Archer et al. (1988) documented the conversion of south Texas grassland to shrubland during several decades of grazing, which they attributed largely to the scarification and dissemination of honey mesquite seeds by cattle. The few remaining subtropical shrub savannas in the Tamaulipan ecological region have greater native plant species richness and diversity than dense shrublands that have encroached on comparable sites; numerous rare, endemic, and federally-listed plant species occur in savanna sites (Best 2004, 2005).

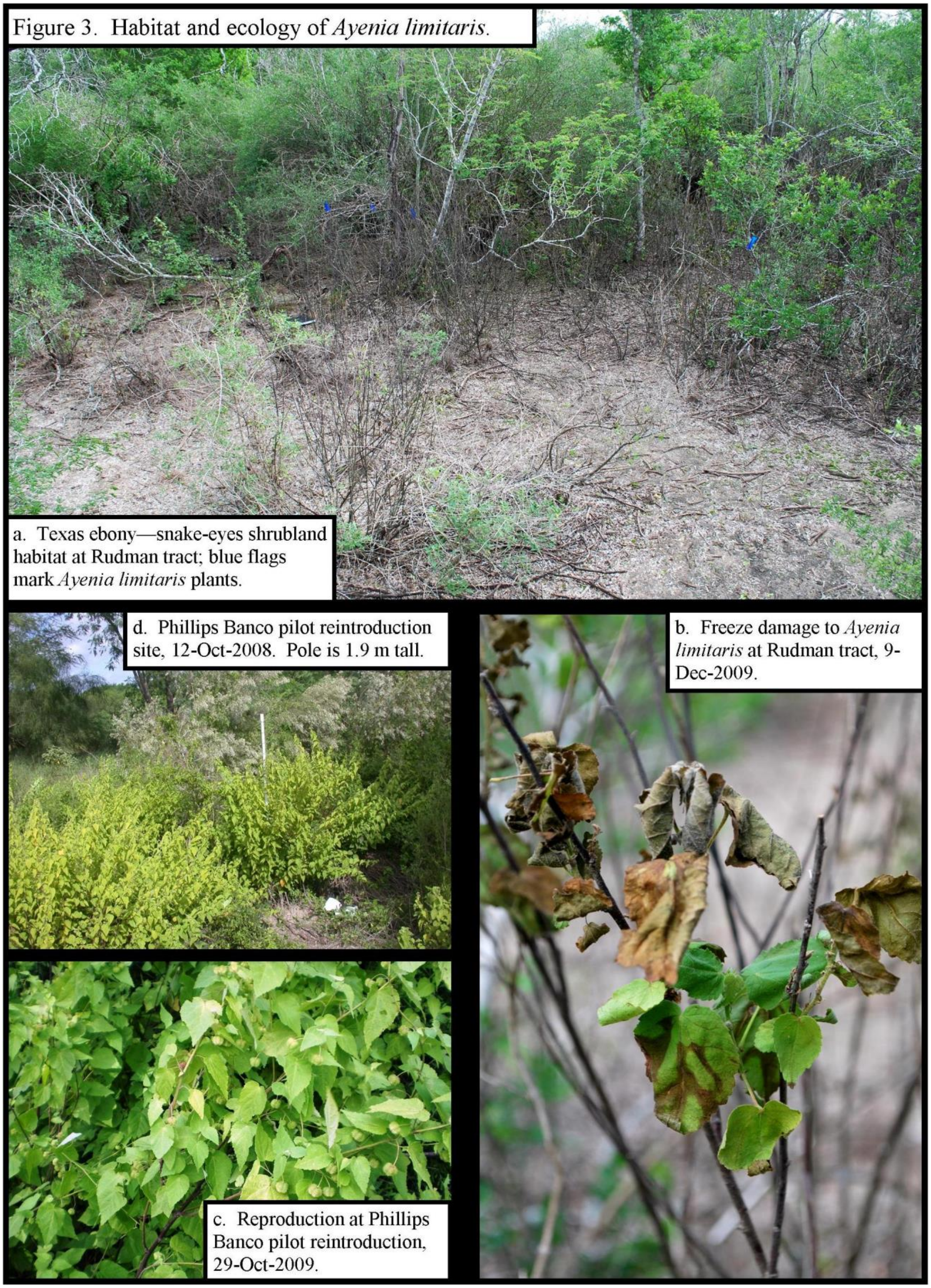
Prescribed burning has been promoted to limit shrub increase and improve forage production of south Texas rangelands (Texas Agricultural Extension Service 1980; Scifres and Hamilton 1993). The response of Tamaulipan kidneypetal to wildfire has not been investigated. However, propagated plants have established well and reproduced rapidly in disturbed soils (see discussion under I.g. Propagation and pilot reintroduction). Furthermore, wild populations frequently occur in partial shade, or at the edge of shrub canopies, rather than under dense shrub or forest canopies. Considering that the largest U.S. population occurs in open shrubland that had recently burned, it is possible that Tamaulipan kidneypetal is best adapted to dynamic, fire-influenced shrub savannas, and that their conversion to dense shrubland and forest has been a factor in the species' decline.

Many species of Old World grasses have been introduced in the Tamaulipan region of south Texas and northeast Mexico for cattle forage and erosion control, including several that are now highly invasive (Best 2009). Guineagrass, Kleberg bluestem (*Dichanthium annulatum*), and buffelgrass (*Pennisetum ciliare*) are frequently present in occupied and potential Tamaulipan kidneypetal habitat. Most guineagrass varieties are erect, shade-intolerant bunch-grasses of the humid tropics. The predominant variety in the subtropical, semi-arid Rio Grande delta is a sprawling, shade-tolerant, rhizomatous grass that displaces most native plants, including Tamaulipan kidneypetal, in partially-shaded niches (Best 2009).

Summary of Habitat, Phenology, Reproduction, and Ecology

Wild populations of Tamaulipan kidneypetal have now been documented in a wide range of alluvial soil types, from fine sandy loam to heavy clay. In Tamaulipas as well as in Texas, flowering follows a bimodal pattern (spring to early summer and fall) which coincides with regional rainfall patterns. Wild plants occur under varying amounts of shade, in association with other shrub species, but are most vigorous and reproduce more successfully in sites that receive at least several hours of direct sunlight daily. Although the reproduction biology is unknown, Tamaulipan kidneypetal is apparently allogamous and insect-pollinated. Propagated plants that are isolated from natural populations reproduce successfully, indicating that pollination vectors are present. The species' range appears to be restricted by aridity further inland and by the prevalence of freezing weather further north or at higher elevations. Occupied habitats are isolated fragments of Texas ebony – anacua/brasil woodlands and Texas ebony - snake-eyes shrublands in the deltas of large rivers draining into the Gulf of Mexico. However, the vegetation of the Tamaulipan region in Texas and northeast Mexico has been altered since the onset of European colonization in 1750 by poor rangeland management. The distribution and abundance of Tamaulipan kidneypetal may have been impacted by increased woody plant cover and lack of wildfire, and its relict habitats might not be optimal. Introduced invasive grasses, particularly guineagrass, are abundant and highly competitive in the remaining occupied habitats.

Figure 3. Habitat and ecology of *Ayenia limitaris*.



a. Texas ebony—snake-eyes shrubland habitat at Rudman tract; blue flags mark *Ayenia limitaris* plants.

d. Phillips Banco pilot reintroduction site, 12-Oct-2008. Pole is 1.9 m tall.

b. Freeze damage to *Ayenia limitaris* at Rudman tract, 9-Dec-2009.

c. Reproduction at Phillips Banco pilot reintroduction, 29-Oct-2009.

I.5. Critical Habitat

The USFWS did not designate critical habitat when *Tamaulipan kidneypetal* was listed, as it was determined that the designation would not be prudent (USFWS 1994).

I.6. Reasons for Listing / Threats Assessment

The following assessment considers the threats identified in the original listing (USFWS 1994) as well as threats documented more recently, such as in the 5-year review (USFWS 2010b) and South Texas Plant Recovery Team Meeting, January 18, 2011.

A. <u>The present or threatened destruction, modification, or curtailment of its habitat or range</u>.

Habitat destruction in Texas and in Mexico.

The single greatest threat to Tamaulipan kidneypetal is the loss of habitat to agricultural and urban development. In the Rio Grande delta of Texas and Tamaulipas, as little as 1 percent of the original habitat remains intact (USFWS 2010b; Jarsdoerfer and Leslie, Jr. 1988). Two of the five known Texas populations of Tamaulipan kidneypetal occur on private land. Currently, an un-quantified but apparently greater proportion of occupied and potential habitat remains southward of the city of San Fernando, Tamaulipas, at least as far as the *municipio* of Soto la Marina. The remaining habitat in Texas and Tamaulipas, however, remains subject to destruction driven by similar economic incentives. Therefore, we consider habitat destruction to be a high magnitude, imminent threat to the species' survival.

Habitat fragmentation and isolation.

Fragmentation and isolation may prevent gene flow among populations and lead to a depletion of genetic diversity. Cristóbal (1960) stated that *Ayenia* species are allogamous and insect-pollinated. Therefore, viable populations of Tamaulipan kidneypetal must be large enough to contain sufficient genetic diversity for out-crossing to occur, and habitats must be sufficiently large and diverse to sustain populations of the insect pollinators. The remaining habitats throughout the species' known range are greatly fragmented, and remaining populations are isolated from each other. Since the genetic diversity within and among populations has not been investigated, we do not know to what extent genetic depletion may have occurred or how soon it could occur. Currently, the known populations continue to reproduce successfully. In synthesis, we consider that habitat fragmentation and isolation and the resulting depletion of genetic diversity are real threats of unknown magnitude and immediacy. However, if not addressed, these are likely to become high magnitude, imminent threats. Furthermore, once genetic diversity has been lost it cannot be recovered. Therefore, the recovery actions that mitigate these threats should not be delayed.

Pesticide drift and runoff.

This potential threat has not been observed. However, due to the fragmentation and small size of occupied habitats and their proximity to agricultural fields and highway rights-of-way, herbicide and insecticide drift and chemical spills could harm some populations or the pollinators they depend on. Nevertheless, it is unlikely that accidental herbicide contamination will impact significant numbers of Tamaulipan kidneypetal plants. This low-magnitude, non-imminent threat can be further reduced through outreach to owners and managers of Tamaulipan kidneypetal habitats.

Competition from introduced invasive grasses.

Several introduced grass species of African and Asian origin are invasive throughout the Tamaulipan region of Texas and northeast Mexico, and have replaced much of the herbaceous plant diversity. In particular, guineagrass has been recorded at most Tamaulipan kidneypetal sites in Texas, and is probably present at all sites in Texas and Tamaulipas. Guineagrass competes directly with Tamaulipan kidneypetal for the same partially-shaded niches. Buffelgrass, King Ranch bluestem (*Bothriochloa ischaemum*), and Angleton bluestem (*Dichanthium aristatum*) were also listed as threats in the listing (USFWS 1994). Buffelgrass is extremely abundant throughout the region, and is a major threat to many rare plant species. Although buffelgrass is not shade-tolerant, it might exclude Tamaulipan kidneypetal from the more open portions of the habitat. Tamaulipan kidneypetal is probably threatened more by Kleberg bluestem and Angleton bluestem than by King Ranch bluestem. The former two grass species are abundant in alluvial, fine-textured soils in the deltas and flood plains of south Texas and northeast Mexico. The latter species prevails in well-drained, rocky uplands, such as the Edwards Plateau of central Texas. These three closely-related taxa pertain to a species complex often generically referred to as Old World bluestems; they are difficult to distinguish in the field and are often confused. Other invasive plants, such as introduced *Kalanchöe* species, may also threaten Tamaulipan kidneypetal in some sites. In summary, competition from introduced invasive grasses is a high-magnitude, imminent threat to all known populations of Tamaulipan kidneypetal.

Trampling.

Foot traffic can damage individual plants that occur along trails in parks and natural areas, or where people illicitly traverse habitats off-trail. Ordinarily, people avoid walking through dense thickets of spiny shrubs. However, undocumented aliens entering the U.S. from Mexico often pass through stands of native vegetation to avoid detection, and have damaged vegetation in natural areas along the border. Nevertheless, little if any actual damage to Tamaulipan kidneypetal plants has been observed from trampling. Consequently, we do not consider trampling to be a threat to the species.

Oil and gas development.

In Texas, mineral rights owners take precedence over surface owners and may clear land for drilling operations without landowner consent. Many surface landowners in south Texas, including most federal and state conservation agencies and non-governmental conservation organizations, do not own mineral rights. Similarly, mineral rights in Mexico are owned by the Mexican federal government rather than the surface owner. Oil and gas exploration and extraction continues at a rapid pace throughout much of south Texas and northeast Mexico, and an ever-increasing proportion of the land has or will be cleared for drilling platforms, pipelines, access roads, and related infrastructure. In addition to the direct loss of populations and habitat through land clearing, these operations will increase the fragmentation of habitat and will create new colonization pathways for invasive grasses. Tamaulipan kidneypetal populations on private lands are particularly vulnerable, since the U.S. ESA does not protect endangered plants on private lands unless there is another form of prevailing federal nexus, such as a federally-funded program or regulated action. Therefore, oil and gas development is an imminent threat; the magnitude is medium to high, depending on the duration and intensity of hydrocarbon exploration that in turn is dependent on economic factors and the intricacies of energy markets.

Altered vegetation structure and composition.

Many ecologists believe that grasslands and savannas were more abundant in south Texas and northeast Mexico prior to European settlement, and that these vegetation types were converted to dense shrubland and forest as a consequence of poor rangeland management and changes in the natural fire cycle (see discussion in section I.d.-Ecology). This dramatic shift in vegetation composition and structure and fire dynamics may also have contributed to the decline of Tamaulipan kidneypetal.

Loss of pollinators.

Currently, flowers of Tamaulipan kidneypetal plants are effectively fertilized by unknown insect pollinators even when isolated from wild populations. This indicates that suitable pollinators are widespread and abundant in the region. Nevertheless, insect pollinators could be depleted, and pollinator access could be disrupted, by the loss and fragmentation of habitats, pesticide drift, or depletion of the native plant diversity. Pollinator loss is currently not a known, imminent threat, but could become a threat in the future. Several recovery actions included in this plan will help prevent the loss of Tamaulipan kidneypetal pollinators.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes.</u>

Tamaulipan kidneypetal has no known commercial, recreational, scientific, or educational uses.

Vandalism or illicit collection.

This potential threat has not been observed, and is unlikely to occur; consequently, we do not consider that vandalism or illicit collection threaten the species.

Unintended impacts of propagation and reintroduction.

The recovery actions proposed under this plan include propagation and reintroduction of Tamaulipan kidneypetal into suitable habitats. These actions could cause unintended harm to the species, such as depletion of the seed banks of wild populations, genetic swamping due to excessive propagation from a genetically limited source population, inbreeding depression, outbreeding depression, and the spread of pathogens or parasites into healthy populations. Pilot reintroduction efforts conducted at LRGV NWR in the 1990s preceded the adoption, in 2000, of the USFWS policy on controlled propagation of endangered species (USFWS and NMFS 2000). This policy now requires that the potential risks of propagation be assessed and addressed prior to initiating propagation by USFWS or through USFWS support. Section E.13 of the policy requires preparation of a controlled propagation and reintroduction plan prior to the reintroduction of federally-listed threatened or endangered species. The plan should be based on strategies identified in an approved recovery plan, and should include protocols for health management, disease screening and disease-free certification, monitoring and evaluation of genetic, demographic, life-history, phenotypic, and behavioral characteristics, data collection, recordkeeping, and reporting, as appropriate. We conclude that, through compliance with USFWS policy on propagation and reintroduction, these actions will not threaten the species.

C. Disease or predation.

Insect herbivory.

Ideker (1994) documented a small planthopper insect called the mealy flata (likely *Anormensis septentrionales*, but also known as *Ormensis septentrionales*, Flatidae: Homoptera or Hemiptera) feeding on Tamaulipan kidneypetal leaves. Damage incurred by this insect appears to be insignificant, and has not been reported subsequently. We have received no additional reports of insect herbivory to Tamaulipan kidneypetal. Therefore, insect herbivory is not a known threat to the species.

Ungulate browsing.

Contreras-Arquieta (2005) observed several Tamaulipan kidneypetal sites in the *municipio* of Soto la Marina, Tamaulipas, that were used as goat pasture. He included goat browsing as a potential threat to the species. Although we have no information on the palatability of Tamaulipan kidneypetal to livestock, or the impacts of grazing on its populations and habitat, it is important to note that the largest U.S. population, and most if not all Mexican populations, occur on land that has been grazed by cattle. We conclude that cattle grazing is not a threat to the species and that goat browsing is an imminent but low-magnitude threat. Browsing by white-tailed deer (*Odocoileus virginiana*) may also constitute a threat where deer populations are high.

D. The inadequacy of existing regulatory mechanisms.

United States.

Tamaulipan kidneypetal is not protected by other U.S. federal or state laws. Federally-listed plants occurring on private lands have limited protection under the ESA, unless also protected by state laws; the State of Texas provides very little protection to listed plant species on private lands. Approximately 95 percent of Texas land area is privately owned. It is reasonable to assume that the vast majority of existing Tamaulipan kidneypetal habitat, including sites that have not been documented, occurs on private land. Therefore, most of the species' populations and habitats are not subject to federal or state protection unless there is a federal nexus, such as provisions of the Clean Water Act or a federally-funded project.

State of Texas. Chapter 88 of the Texas Parks and Wildlife Code lists plant species as state-threatened or endangered once they are federally-listed with these statuses. Tamaulipan kidneypetal was listed as endangered by the State of Texas on January 30, 1997. The State prohibits taking and/or possession for commercial sale of all or any part of a state-listed endangered, threatened, or protected plant from public land. TPWD requires permits for the commercial use of listed plants collected from private land. Scientific permits are required for collection of endangered plants or plant parts from public lands for scientific or educational purposes. In addition to State endangered species regulations, other State laws may apply. For example, Texas State law prohibits the destruction or removal of any plant species from State lands without a TPWD permit. Three Tamaulipan kidneypetal populations are known from public lands in the U.S.; one is a municipal park, one occurs in a State park, and the third is a National Wildlife Refuge.

Federal Lands. The ESA does provide some protection for listed plants on land under federal jurisdiction, such as the National Wildlife Refuges. Currently, one population has been documented on federal land at LRGV NWR. However, the Department of Homeland Security's (DHS) Secure Border Initiative includes the construction of 225 miles (362 km) of pedestrian barriers along the Texas – Mexico border, in addition to surveillance towers and other infrastructure (U. S. Department of Homeland Security et al. 2008). Some of these proposed projects could affect populations and habitat of Tamaulipan kidneypetal and other endangered plants and animals, both on and off the refuge. DHS, under authority of the Real ID Act of 2005 (Section 102 of H.R. 1268), waived consultation with USFWS, which would otherwise be required under section 7 of the ESA. Nevertheless, DHS and USFWS jointly prepared a Biological Resource Plan as part of the DHS Environmental Stewardship Plan (U. S. Department of Homeland Security et al. 2008). The Best Management Practices specific to Tamaulipan kidneypetal are:

> Avoidance of Impacts – Avoid disturbance, including land clearing, introduction and spread of invasive plants, herbivory, altered light levels, trampling, and exposure to toxic substances, to Tamaulipan kidneypetal populations and occupied habitat. Surveys should be conducted on all intact Tamaulipan kidneypetal habitat in Cameron, Hidalgo, and Willacy Counties prior to initiation of activities that may affect individual plants or habitat.
>
> Minimize Impacts – In cases where project activities cannot completely avoid Tamaulipan kidneypetal populations and occupied habitat, the impacts to the populations and habitat should be minimized as much as possible. Minimization may be accomplished by, but is not limited to, the following methods:
>
> - Prevent or control guineagrass and other invasive plants from colonizing sites following disturbance.
> - Avoid permanent impacts to individual populations and habitats.
> - Reduce the duration of impacts to populations and habitats.
> - Where it is necessary to temporarily remove vegetation, cut plants above ground level rather than clear with bulldozers, root plows or other implements that cut into the soil.

Compensation – The project proponent shall fund and/or pursue appropriate conservation measures or recovery objectives in compensation for unavoidable impacts to Tamaulipan kidneypetal populations and habitat. Compensation may be accomplished by, but is not limited to, the following methods:

- Tamaulipan kidneypetal habitat that has been destroyed shall be replaced through acquisition and donation of similar quantity and quality of habitat to an approved conservation organization.
- Tamaulipan kidneypetal habitat that is degraded through vegetation impacts, invasive plant colonization or other deleterious changes, shall be restored to a condition that is consistent with long-term survival and growth of the Tamaulipan kidneypetal population.
- Individual Tamaulipan kidneypetal plants that have been destroyed may be replaced through propagation and reintroduction of Tamaulipan kidneypetal plants in suitable habitat managed by an approved conservation organization. If possible, seeds for propagation should be obtained from populations prior to impact. If this is not possible, propagation may be accomplished using seeds of this species that are available through several conservation seed banks. Successful propagation methods have been developed at LRGV NWR. Compensation for destroyed individuals of Tamaulipan kidneypetal shall consist of five or more propagated, reintroduced plants for each individual destroyed.

Mexico.

About 99 percent of the potential range of Tamaulipan kidneypetal occurs in Mexico. However, this species is not listed under Mexican protected species regulations (Secretaría de Medio Ambiente y Recursos Naturales 2010). See section 1.c.

E. <u>Other natural or manmade factors affecting its continued existence.</u>

Catastrophic events.

Since there are few populations, most populations have few individuals, and populations are confined to limited geographic areas, individual populations are vulnerable to chance catastrophic events, such as hurricanes or the introduction of an invasive pathogen or parasite. However, due to the geographic range of known populations, it is unlikely that a single event could impact all populations. We conclude that catastrophic events represent a low-magnitude, non-imminent threat.

Flooding.

While several populations have been documented near the Arroyo Colorado in Hidalgo and Cameron Counties, due to their elevation above the flood plain, none of these sites would have been flooded during the Holocene (recent) geological era. We conclude that flooding does not constitute a threat to the species.

Drought.

USFWS personnel observed that about 50 percent of the Rudman population had died by December 2009, which they attributed to the exceptional drought of that year. Furthermore, the known populations occur near the Gulf of Mexico, where rainfall is relatively higher than further inland, indicating that the species' range is restricted to regions of higher rainfall. The region also suffered exceptional drought in 2011 and 2012, although the impacts of these more recent droughts on Tamaulipan kidneypetal populations are not yet known. We conclude that prolonged drought is a low-magnitude, non-imminent threat to Tamaulipan kidneypetal.

Sub-zero temperature.

The freeze of December 4-5, 2009 damaged many plants at the Rudman population, indicating that the species' range is limited to regions of infrequent, light freezes. However, there is no evidence that the intensity or frequency of cold weather is increasing within the species' range; conversely, recent meteorological data as well as climate models (discussed below) indicate a warming trend. Therefore, we conclude that sub-zero temperature does not constitute a threat to Tamaulipan kidneypetal.

Climate change.

The Intergovernmental Panel on Climate Change (IPCC) defines "climate" as the mean and variability of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). IPCC defines "climate change" as a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Climate changes can have direct or indirect effects that may be positive, neutral, or negative to a particular species. These effects may change over time, depending on the species and other relevant factors such as the interactions of climate with habitat fragmentation or other variables (IPCC 2007, pp. 8–14, 18–19).

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013, p. 23) projects the following changes by the end of the 21st century, relative to the 1986 to 2005 averages: It is virtually certain that most land areas will experience warmer and/or fewer cold days and nights; it is virtually certain that most land areas will experience warmer and/or more frequent hot days and nights; it is very likely that the frequency and/or duration of warm spells and heat waves will increase in most land areas; it is very likely that the frequency, intensity, and/or amount of heavy precipitation will increase in mid-latitude land masses; it is likely that the intensity and/or duration of droughts will increase on a regional to global scale. The magnitude of projected changes varies widely, depending on which scenario of future greenhouse gas emissions is used. These scenarios are called Representative Concentration Pathways (RCPs). Under the best-case scenario of RCP2.6, the combined emissions of carbon dioxide, methane, and nitrous oxide, represented as the carbon dioxide equivalent, will stabilize at 475 parts per million (ppm) by the year 2100. This figure rises to 630, 800, and 1,313 ppm under the RCP4.5, RCP6.0, and RCP8.5 scenarios, respectively (IPCC 2013, p. 22).

To evaluate how climate changes may affect Tamaulipan kidneypetal, we used the National Climate Change Viewer (U.S. Geological Survey 2016) to compare past and projected future climate conditions for Hidalgo County, Texas. The baseline for comparison was the observed mean values from 1950 through 2005, and 30 climate models were used to project future conditions for 2050 through 2074. We selected the climate parameters of August maximum temperature, January minimum temperature, annual mean precipitation, and annual mean evaporative deficit, and used both the RCP4.5 and RCP8.5 scenarios to provide a range of projected values. The results are summarized in figures 4, 5, 6, and 7. To interpret these results, it is important to consider the means as well as the dispersion of the 30 climate models. For example, using the RCP4.5 scenario, the mean value of 30 models for projected change in August maximum temperature is an increase of 2.0° C (3.6°F), and the models range from – 0.1° C (-0.2° F) to 3.8° C (6.8° F); the mean projected change in January minimum temperature is an increase of 1.6° C (2.9° F), and the range is from 0.3° C (0.5° F) to 2.9° C (5.2° F). The historic baseline average annual precipitation is 1.5 mm/day, or 548 mm/year (21.6 in/year). The mean change in annual precipitation is a decrease of 0.1 mm/day (1.4 in/year), ranging from -0.3 mm/day to +0.3 mm/day. Although the model mean projects only a 7 percent decrease in rainfall, the change in evaporative deficit is greater due to increasing temperatures: 15.8 mm/month (7.5 in/year), ranging from 4.6 to 26.6 mm/month. Evaporative deficit may be a better indicator of plant stress than precipitation alone, since it takes temperature into account. Under the RCP8.5 scenario, the projected changes in temperatures and evaporative deficit are greater, as one would expect. Interestingly, the projected change in annual precipitation differs little from the RCP4.5 scenario.

We do not know how past climate changes have affected Tamaulipan kidneypetal populations and distribution, nor can we predict how future climate changes, forecast by the range of models and emissions scenarios, will affect the synecology of the species and its habitat. For example, a reduced amount or frequency of rainfall could reduce the species' range, while a decreased incidence of freezing could expand its range northward or into higher elevations in Mexican mountains. Furthermore, if the optimal geographic range of Tamaulipan kidneypetal shifts, the species may not be able to migrate fast enough to keep up with the rapid pace of climate changes. Conditions favorable to Tamaulipan kidneypetal might also increase competition from invasive plants, such as guineagrass, or allow new parasites and pathogens to spread into its range, affecting both Tamaulipan kidneypetal and guineagrass in an infinitely complex aggregation of interacting effects. Consequently, we currently have no evidence that the combined effects of climate changes threaten Tamaulipan kidneypetal. However, it is possible that threats induced by climate changes, based on predicted slight increases in temperature and evaporative deficit, may arise in the future.

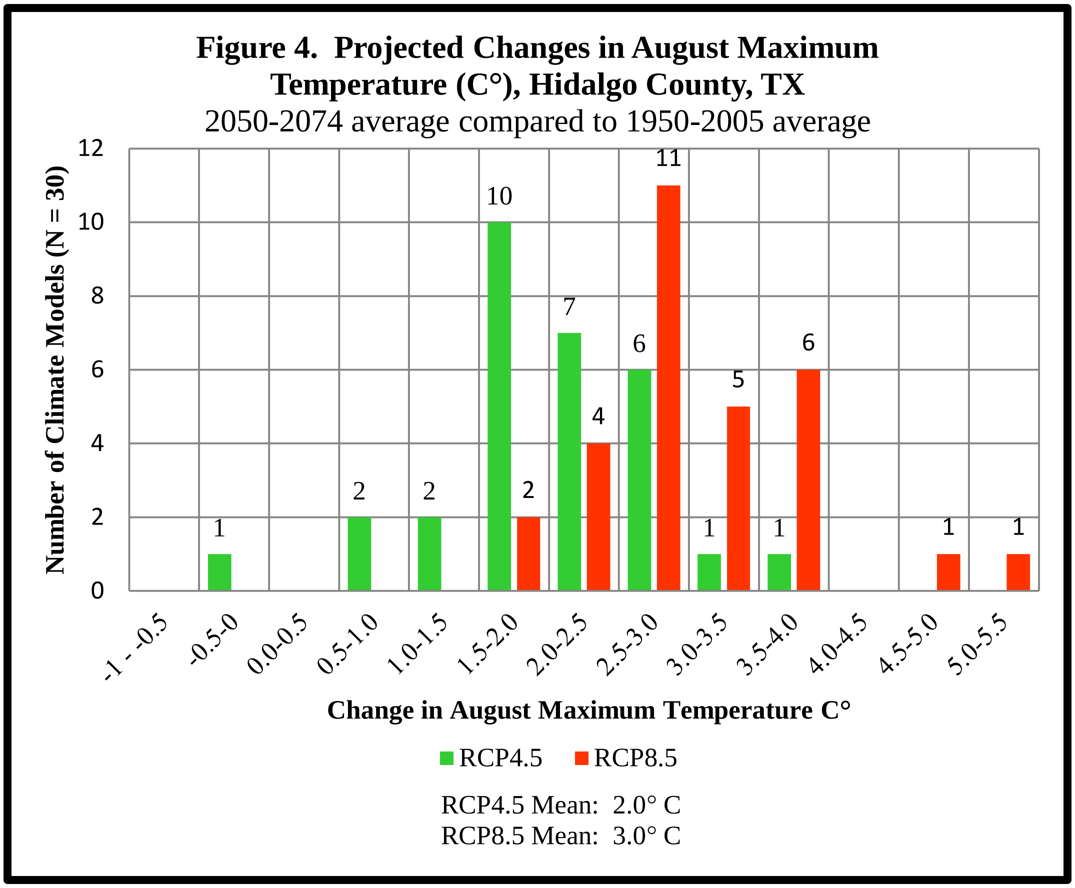
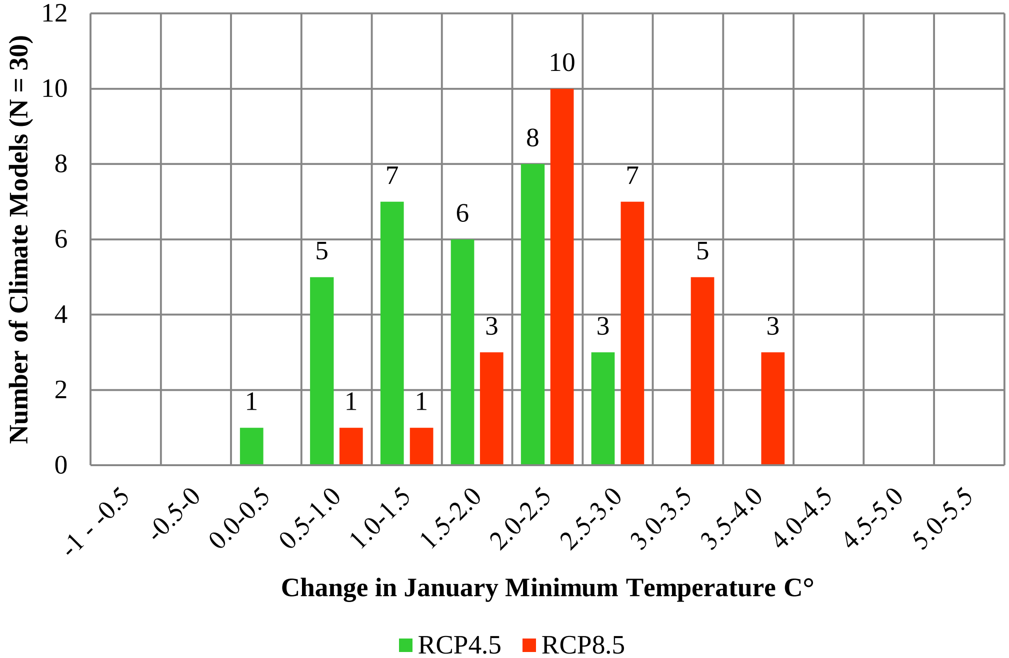


Figure 4. Projected Changes in August Maximum Temperature (C°), Hidalgo County, TX
2050-2074 average compared to 1950-2005 average
Number of Climate Models (N = 30)
0
2
4
6
8
10
12
1
2
2
10
2
7
4
6
11
1
5
1
6
1
1
-1 - -0.5
-0.5-0
0.0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
5.0-5.5
Change in August Maximum Temperature C°
RCP4.5
RCP8.5
RCP4.5 Mean: 2.0° C
RCP8.5 Mean: 3.0° C

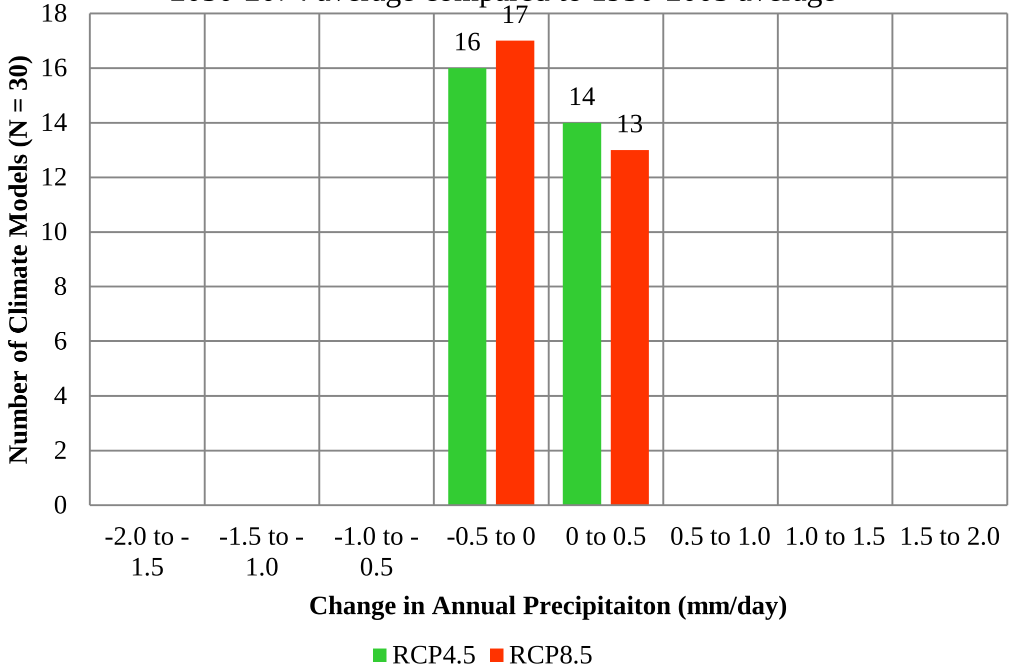
Figure 5. Projected Changes in January Minimum Temperature (C°), Hidalgo County, TX
2050-2074 average compared to 1950-2005 average



RCP4.5 Mean: 1.6° C
RCP8.5 Mean: 2.5° C

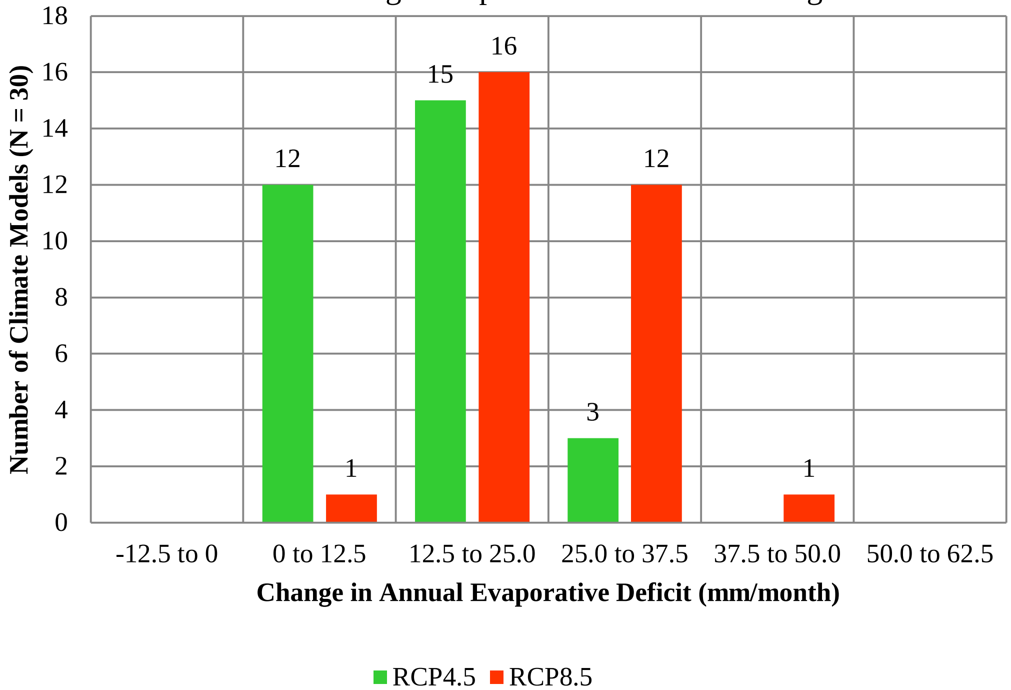
Figure 6. Projected Changes in Annual Precipitation (mm/day), Hidalgo County, TX

2050-2074 average compared to 1950-2005 average



RCP4.5 Mean: -0.1 mm/day (-36.5 mm/year)
RCP8.5 Mean: : -0.1 mm/day (-36.5 mm/year)

Figure 7. Projected Changes in Annual Evaporative Deficit (mm/month),
Hidalgo County, TX
2050-2074 average compared to 1950-2005 average



RCP4.5 Mean: 15.8 mm/month (189 mm/year)
RCP8.5 Mean: : 23.8 mm/month (286 mm/year)

I.7. Conservation Efforts

Habitat Conservation

United States.

By 2012, the South Texas Refuges Complex, consisting of Santa Ana NWR, Laguna Atascosa NWR, and LRGV NWR, had acquired 74,422 ha (183,898 ac) of habitat in Cameron, Willacy, Hidalgo, and Starr Counties, Texas (USFWS 2012). These refuges are authorized by Congress to continue acquiring land up to a total of 116,512 ha (287,902 ac). One of the five extant U.S. populations is protected on a tract of LRGV NWR. The revegetation program at LRGV NWR, from 1982 through 2009, has restored 6,323 ha (15,625 ac) of ecological corridors with native vegetation. TPWD manages another 1,340 ha (3,311 ac) of Wildlife Management Areas in these counties. In 2010, TPWD acquired the former Methodist Camp Thicket, in Hidalgo County, as an addition to Estero Llano Grande State Park; this tract protects another extant U.S. population.

Mexico.

In 2005, PRONATURA established conservation agreements to protect Tamaulipan kidneypetal populations with two landowners at Ejido San José de las Rusias, Soto la Marina, Tamaulipas (Contreras-Arquieta 2005). The Mexican federal agency Comisión Nacional de Areas Naturales Protegidas (National Commission on Natural Protected Areas; CONANP) has recently proposed the creation of a new Protected Natural Area in the Sierra de Tamaulipas (Comisión Nacional de Areas Naturales Protegidas 2006; see map in Figure 2). The proposed reserve would encompass 290,311.19 ha (717,359 ac), of which 71,010.9 ha (175,493 ac) would be a nucleus zone. The proposed reserve's eastern boundary is about 25 km (15.5 mi) west of the Soto la Marina meta-population of Tamaulipan kidneypetal. Martínez-Avalos (2012) reported a population of Tamaulipan kidneypetal (as yet unconfirmed) within the proposed reserve boundaries. Additional, undiscovered populations of Tamaulipan kidneypetal might occur within the proposed reserve (in addition to the documented populations of jaguars, ocelots, margays and other notable wildlife species), and would be protected by the Mexican Federal Government.

Propagation and Pilot Reintroductions

United States.

USFWS personnel collected a total of 93 Tamaulipan kidneypetal seeds from 7 individual plants at the Methodist Camp Thicket in 1992 and 1994. A series of germination trials revealed that the seeds germinate readily after scarification. Thirty-four individual progeny resulted from these trials, which were planted in two seed-increase plots at the restoration nursery at Santa Ana NWR. Plants that were shaded throughout the day grew sparsely and produced few seeds, but others that received several hours of direct sunlight each day grew vigorously and produced over 30,000 seeds within 18 months. All plants exhibited a strong tendency to grow towards direct sunlight, often growing laterally along the ground until reaching sunlight, but none formed adventitious roots even when stems were in contact with the soil for more than a year.

Subsequent trials were conducted at Santa Ana and LRGV NWRs with the progeny of the plants grown from wild-collected seeds. The most cost-effective scarification technique consisted of treating seeds for 5 minutes in technical-grade (93 percent) sulfuric acid, followed by rapid neutralization in a saturated solution of calcium carbonate or sodium bicarbonate, rinsing, and 36 hours of imbibition in aerated water. The treated seeds were then planted in seedling containers at a depth of 0.5 cm (0.2 in), yielding 70 percent germination after 7 days.

Twenty Tamaulipan kidneypetal plants were displayed in a landscape at the Santa Ana NWR visitor center from 2001 until July 2004. All 20 of these plants were then removed, along with 15 progeny that had established spontaneously in this landscape, and were provided to the North American Butterfly Association (NABA) National Butterfly Center, south of Mission, Hidalgo County (USFWS 2004). Subsequently, seeds of the original 20 plants continued to germinate from the soil seed bank and establish in the same landscape and adjacent mowed lawn; 120 Tamaulipan kidneypetal plants were observed there on October 30, 2009. This site receives six to eight hours of direct sunlight per day.

Reintroduction is a component of many recovery plans of federally-listed plants (Falk et al. 1996). Prior to initiating large-scale reintroductions, the feasibility may be tested and the techniques perfected through smaller-scale "pilot" reintroductions. USFWS initiated pilot reintroductions of Tamaulipan kidneypetal at four tracts of LRGV NWR in Hidalgo and Cameron Counties in 1998 – 1999. The refuge was concurrently revegetating these former row-crop fields with native subtropical trees and shrubs. USFWS personnel grew Tamaulipan kidneypetal seedlings, which were progeny of the Methodist Camp Thicket population, at the restoration nursery at Santa Ana NWR. The seedlings were grown for 6 to 8 months in air-pruned 3.8 by 20 cm (1.5 by 8 in.) biodegradable Plant Band containers (obtained from Monarch Manufacturing, Inc., Salida, CO). When transplanted to reintroduction sites, the stem height of these seedlings was 15 to 25 cm (6 to 10 in.). At each site, five replicate rows of Tamaulipan kidneypetal seedlings were planted and mapped with d-GPS. The first pilot reintroduction was attempted at La Coma tract in April 1998. Subsequent monitoring confirmed that all seedlings perished during the ensuing exceptional drought. No measurable precipitation was recorded at the Weslaco meteorological station, 16 km (10 mi) north-east of the site, from April through June 1998, and only 2.8 cm (1.12 in) was recorded from March through July (National Climate Data Center 2010a). Pilot reintroductions were successfully established at Phillips Banco, Resaca de los Fresnos, and Villa Nueva tracts on October 21, November 1, and December 12, 1999, respectively. Qualitative monitoring on October 9, 2008 confirmed that Tamaulipan kidneypetal plants had survived and reproduced *in situ* at Resaca de los Fresnos and Villa Nueva tracts. Quantitative data (summarized in Table 6) collected from the Phillips Banco site on October 10 - 11, 2008 show that the initial planting of 84 seedlings had by then increased to 295 individuals. The highest survival and 99.6 percent of net reproduction occurred in replicates 1, 2, and 3, which were partially shaded in 2008. Rows 4 and 5 were deeply shaded at that time.

Table 6. Size and reproductive state of Tamaulipan kidneypetal plants detected at Phillips Banco tract pilot reintroduction, October 10 – 11, 2009.

Replicate	No. Individuals Planted in 1999	No. Individuals observed in 2008	Ave. Height (m)	Average Canopy Diameter (m)	Percent with Fruit	Percent with Flowers	Percent Reproductive (Fruit or Flowers)
1	17	72	1.17	1.45	100	96	100
2	17	171	1.12	1.19	95	97	97
3	17	27	1.01	1.01	74	93	93
4	17	8	0.63	0.44	63	63	63
5	16	17	0.95	0.94	76	76	76
Total	84	295					
Average		59	0.98	1.01	82	85	86
Standard Deviation		60	0.19	0.33	14	13	14

I.8. Biological Constraints and Needs.

The following biological constraints are the synthesis of information presented above:

- Tamaulipan kidneypetal is a constituent of intact stands of native shrublands of the Tamaulipan ecosystem, near the Gulf of Mexico, and possibly other vegetation types in Coahuila and Durango. The currently occupied habitat relicts may not be optimal for this species. Historical accounts indicate that woody plant cover has increased in many habitats in this region. Sustainable populations of Tamaulipan kidneypetal may require periodic wildfire in order to maintain the optimal composition and structure of associated vegetation.
- Tamaulipan kidneypetal appears best adapted to partially shaded niches, such as the edges of shrub mottes or along arroyos, rather than full sun or full shade.
- The species probably requires out-crossing, and therefore must live in habitats that also sustain populations of its insect pollinator(s) - as yet unknown.
- Positive identification requires observation of flowers and fruits. Therefore, surveys must be conducted when the species is in a reproductive state; this generally follows significant rainfall during the growing season (approximately March through November).
- The potential range of the species appears to be limited to a sub-humid, subtropical climate, since known populations in the wild are damaged by extended drought and by freezing temperatures. Climate changes may alter the potential range in unpredictable ways.
- Introduced invasive grasses, particularly guineagrass, compete directly with Tamaulipan kidneypetal, severely limiting its growth and reproduction, and may contribute to the extirpation of populations.
- Many of the known populations and most of the species' range in both countries are privately owned; additionally, many of the Mexican populations occur on *ejido* lands. It will probably not be possible to recover the species without significant involvement and collaboration of private landowners and *ejidos*.

II. RECOVERY STRATEGY, GOALS, OBJECTIVES, AND CRITERIA.

II.1 Recovery Strategy

The recovery of Tamaulipan kidneypetal faces interesting challenges. Since the species' range spans the U.S. - Mexico border, successful recovery will depend on close binational coordination. The few extant populations occur in isolated habitat fragments spared where nearly all the region's native vegetation was cleared or drastically altered. Throughout the species' range, the understory niche has often been displaced by a monoculture of introduced, invasive grass species. The U.S. range is limited to three south Texas counties, where more than 90 percent of the land is privately owned; the ESA provides few protections for endangered plants on private land. Tamaulipan kidneypetal is not protected under Mexican law, and currently there are no Protected Natural Areas or other protected land within the species' known range in Tamaulipas. Though reported from two widely disjunct sites in Coahuila and Durango, the species has not been observed at either site in decades.

Fortunately, other factors favor the species recovery, and many of the recovery objectives listed here are already being accomplished. New populations have been discovered in Texas and Tamaulipas; much has been learned about the habitat, reproduction, and ecology; the species has been propagated and pilot reintroductions have had long-term success; and three populations and large amounts of potential habitat have been protected in Texas. Additionally, a Mexican Protected Natural Area has been proposed that would protect nearly 300,000 ha – over 700,000 ac - in the Sierra de Tamaulipas, including one reported (unconfirmed) population.

The goal of this plan is the full recovery of Tamaulipan kidneypetal. The first objective is to mitigate threats to the species' continued survival: To prevent the net loss and degradation of populations and occupied habitats in both the U.S and Mexico, to alleviate fragmentation and genetic isolation of populations, and to reduce the impacts of invasive species, poor rangeland management, pesticide drift and runoff, and other threats. The second objective is to conserve, restore, and manage appropriately the quantity and quality of habitat needed for the species' recovery. The third objective is to conserve, protect, and restore populations of Tamaulipan kidneypetal needed for its recovery. These populations must be self-sustaining and must meet the requirements of resilience, redundancy, and representation (Shaffer and Stein 2000): they must be of sufficient size to endure climatic variation and stochastic events, of sufficient number to recover from catastrophic losses, and must represent the full range of the species' geographic adaptations and genetic variability. The accomplishment of these objectives will require improved documentation of the species' range and monitoring of known populations, increased knowledge of the species' habitat requirements, reproduction, and ecology, and outreach among agencies and landowners.

In synthesis, the strategy for recovery of Tamaulipan kidneypetal will consist of:

- Coordination and collaboration with government agencies, academic institutions, and NGO conservation organizations in both the U.S. and Mexico to share information concerning the species' habitat conditions, locations, and population status, and needs for recovery.

- Outreach, collaboration, and support for conservation-minded private landowners and *ejidos* in the U.S. and in Mexico.
- Protection, conservation, and improved management of extant populations in the U.S. and Mexico.
- Habitat restoration and population augmentation and reintroduction to attain the number and size of populations necessary to assure the continued survival of the species, and to establish ecological corridors necessary for gene flow between and among populations.

II.2. Estimates of minimum viable population, minimum number of populations, delimitation of recovery units, and definitions of protected habitats, populations, and optimal habitats.

Several of the recovery criteria are based on the concepts of minimum viable population (MVP), the number of viable populations per recovery unit, the delimitation of recovery units, and protected habitats and populations. The concepts are derived and discussed as follows:

Minimum Viable Population

Minimum viable population refers to the smallest population size that has a high probability (usually 95 percent) of surviving a prescribed period of time (often 100 years) (Mace and Lande 1991). Determinations of MVP usually take into account the effective population size, rather than total number of individuals; 10 genetically identical individuals (for example, clones) would have an effective population size of 1. We do not possess the data necessary to calculate effective population size for Tamaulipan kidneypetal, but assume that the effective population size is considerably less than the total population of reproductive individuals. Unfortunately, the calculations of MVP also require data that we do not currently possess for Tamaulipan kidneypetal, and that we are unlikely to obtain soon enough to benefit its recovery (see discussion in Pavlik 1996, p. 135). As a practical alternative, we estimate the MVP by comparing the life history of Tamaulipan kidneypetal with the following guideline adapted from Pavlik (1996).

Table 7. Minimum viable population guidelines applied to Tamaulipan kidneypetal (adapted from Pavlik 1996).

Factor	50 Individuals	2,500 Individuals
Longevity	**Perennial**	Annual
Breeding System	Selfing	**Outcrossing**
Growth Form	**Woody**	Herbaceous
Fecundity	**High**	Low
Ramet Production	Common	**Rare or None**
Survivorship	High	Low
Seed Duration	Long	Short
Environmental Variation	Low	**High**
Successional Status	**Fire Disclimax**	Seral or Ruderal

As indicated in bold letters in the table, Tamaulipan kidneypetal is a perennial, outcrossing, woody plant with relatively high fecundity. The known populations occur in a wide range of relatively undisturbed habitats; however, it is possible that fire or other forms of natural disturbance may play a beneficial role in the species' ecology. We have no information yet on survivorship or the duration of seed viability in the wild. Given that three factors require more individuals, and three or four factors require fewer individuals, it is rational to estimate the MVP at an intermediate value. We concur with the recommendation of the South Texas Plant Recovery Team (2011) to adopt a provisional MVP value of 250. However, considering that effective population size is probably much less than the total number of reproductive individuals (N. Fowler, comments received, 2014), we estimate that this will require 500 mature individuals; we will revise this figure in the future if accumulated data permits a more precise calculation. For this purpose, a mature individual is one that has flowered at least once or is judged capable of flowering. The criterion is based only on mature individuals because the vast majority of recently-germinated seedlings die before they are able to reproduce and therefore do not contribute to the effective size of the population. Furthermore, population surveys that do not distinguish mature plants from seedlings would appear to fluctuate wildly, depending on the season and rainfall patterns at the time of survey. The South Texas Plant Recovery Team (2013) also recommended that at least one population per recovery unit should have at least 1,000 mature individuals to meet criteria for downlisting and delisting; we have adopted this recommendation in the current plan.

Number of Viable Populations

The South Texas Plant Recovery Team (2011) recommended that multiple populations are essential to the species' recovery, and that more relatively small populations have greater benefit than fewer large ones. Furthermore, the population criterion must consider both the total number of populations as well as the number per recovery unit. We concur with the Team's recommended recovery criterion of no fewer than 5 populations per recovery unit, and no fewer than 20 total populations. To meet the criterion, these populations: must have at least 500 mature individuals; one population per recovery unit must have at least 1,000 mature individuals; and all must be protected by one of the means described below.

The Recovery Team also recommends that gene flow between the neighboring units of a meta-population or spatial cluster of populations be enhanced or restored through augmentation of existing populations, reintroduction of intervening populations, or restoration of contiguous habitat. While this would probably benefit the species recovery, it might allow two or more sub-populations to coalesce into one larger population, thus making it harder to attain the criterion of five or more populations per recovery unit. For this reason, we will continue to recognize formerly isolated populations that, through the success of recovery efforts, have coalesced, and these sub-populations may individually count toward fulfilling the criterion if they each have more than 500 mature individuals. Alternatively, the coalition of small populations may be used to create one population that meets the MVP criterion for recovery.

Recovery Units

The known extant populations of Tamaulipan kidneypetal form three distinct meta-populations, described below (see map in Figure 2). These disjunct population clusters have different geomorphological features, climate, and associated plant and animal communities, and probably support different ecotypes of Tamaulipan kidneypetal; therefore, we have designated a separate recovery unit for each meta-population.

Recovery Unit 1.

Holocene delta of the Rio Grande: This recovery unit spans the United States and Mexico. It is defined by the Holocene alluvial soils of the Rio Grande delta and floodplain and its distributary channels in Hidalgo and Cameron Counties, Texas, and the *municipios* of Reynosa, Rio Bravo, Valle Hermoso, and Matamoros, in Tamaulipas, Mexico. However, extant populations are currently known only on the Texas side of the delta. This area is referred to as the recent delta in Hathcock et al. (2012).

Recovery Unit 2.

Pleistocene delta of the Rio Grande: This recovery unit occupies the alluvial soils of the Rio Grande's Pleistocene delta, in northern Hidalgo and Willacy Counties, Texas. The unit may extend for some unknown distance north, near the Gulf of Mexico. This area is referred to as the Beaumont delta in Hathcock et al. (2012).

Recovery Unit 3.

Soto la Marina/González/Sierra de Tamaulipas: This recovery unit consists of a cluster of populations in the *municipios* of Soto la Marina and González, Tamaulipas, and may extend further north and south along the Gulf of Mexico, or elsewhere in the Sierra de Tamaulipas. Although USFWS has no legal authority to protect endangered species outside the U.S., we can promote conservation of species and habitats through communication and collaboration with Mexican state and federal agencies, academic institutions, and non-profit conservation organizations. Additionally, we support species and habitat conservation through grants from the USFWS Wildlife Without Borders – Mexico program, administered by the USFWS Office of International Affairs (https://www.fws.gov/international/wildlife-without-borders/mexico/). Surveys and conservation of U.S.-listed endangered plants, including Tamaulipan kidneypetal, have also been supported through a grant from the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA), administered by TPWD (see Contreras-Arquieta 2005).

Recovery criteria must be met for each of these recovery units for the full recovery of the species. However, the apparent distinction between the Pleistocene and Holocene delta ecotypes may be due to habitat loss dividing formerly contiguous populations. It is also possible that undiscovered populations may still link these population clusters, but this is unlikely since more than 95% of the old-growth vegetation of the Rio Grande Holocene delta has been cleared. Genetic analyses may help elucidate the relationships between these apparent ecotypes.

We have no evidence of extant populations in the disjunct sites of Múzquiz, Coahuila, and Topia, Durango, but will designate recovery units in those or other sites if extant populations are confirmed there.

Protected Habitats and Populations

Habitat and populations may be protected by a variety of means, including but not limited to:

- Fee title acquisition or management by a U.S. federal, state, or municipal conservation agency;
- Declaration of an *Area Natural Protegida* (Protected Natural Area) or equivalent by a Mexican federal, state, or municipal conservation agency;
- Acquisition or management by a non-profit conservation organization for the intended purpose of biodiversity conservation;
- Management for biodiversity conservation by an academic institution;
- Conservation easements with private landowners or *ejidos*;
- Voluntary conservation agreements (VCA) with private landowners or *ejidos*. VCAs generally have fixed time lengths and may be revoked by either party. Individually, VCAs do not represent permanent protection for populations and habitat, but in the aggregate multiple VCAs together with other forms of protection may provide the best opportunities to recover the species where there is little or no publicly-owned land. A VCA is considered valid if its term has not expired and if the terms of the agreement have been faithfully performed by all parties.

Optimal habitats

The criterion for recovery objective 2 requires that at least some populations occur in optimal habitats. Habitats with the following characteristics are considered optimal for Tamaulipan kidneypetal:

- Protected for conservation purposes;
- managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal;
- have less than 10% cover of introduced invasive plant species,
- consist of at least 400 ha (988 ac) of contiguous habitat;
- Tamaulipan kidneypetal populations are observed to be stable or increasing.

Populations that occur in protected habitats, as described above, should have a greater probability of long-term survival, and are therefore essential for the species' recovery; populations in unprotected habitats that are subject to development or other disturbances may still contribute to recovery, but due to their vulnerability should not be considered optimal. In addition to protection, habitats may be managed in a variety of ways and for different purposes. We do not currently know what form of management is best for Tamaulipan kidneypetal, although anecdotal evidence suggests that the species requires partial shade, such as found at the edges of shrub or forest stands. Therefore, to be considered optimal for Tamaulipan kidneypetal, we must observe and learn empirically the effects of our practices, and these practices must be adapted as necessary to promote the species survival; furthermore, the intent to manage such habitats to benefit Tamaulipan kidneypetal must be clearly stated in a management plan or similar document. This process may be enhanced through well-designed scientific trials.

Invasive, introduced grasses are prevalent throughout the range of Tamaulipan kidneypetal; however, known populations have remained stable or have increased in sites where there is less than 10 percent cover of invasive grasses. Habitat may be considered contiguous for the purpose stated here if larger areas are joined by corridors, such as strips of vegetation along rivers or drainages, or by blocks of restored habitat, that allow for the passage of pollinator species. Effective pollinator corridors must have intact native understory vegetation (in other words, must not be completely dominated by introduced grasses). Thus, many smaller areas may be linked by corridors and restored habitat to meet the 400-ha (988-ac) size requirement. This size requirement is itself based on empirical observations of extant habitats within the species' range in south Texas and northeast Mexico: Habitats that possess stable populations of a high diversity of native plants, including rare plant species, and their pollinators, typically occur on areas of at least this size. However, this size requirement may be revised in the future if scientific evidence demonstrates that the long-term survival of Tamaulipan kidneypetal requires larger or smaller habitat areas.

II.3. Recovery Goal.

The goal of this plan is the recovery of Tamaulipan kidneypetal: Assurance of the continued survival of the species through the accomplishment of the recovery objectives, such that federal protection under the ESA is no longer needed.

II.4. Recovery Objectives.

This recovery plan has three major objectives, as discussed in Section II.1:

1. Threat-based objective: Mitigate habitat loss and degradation, invasive species competition, poor rangeland management, and other threats to the continued survival of Tamaulipan kidneypetal.

2. Habitat-based objective: Conserve, restore, and manage appropriately the quantity and quality of habitat needed for the continued survival of Tamaulipan kidneypetal.

3. Population-based objective: Conserve, protect, and restore populations of Tamaulipan kidneypetal needed for its continued survival. Populations must be self-sustaining, of sufficient size to endure climatic variation and stochastic events, of sufficient number to endure catastrophic losses, and must represent the full range of the species' geographic and genetic variability.

<u>Detailed Objectives:</u>

1. Threat-based objectives.

Listing Factor A (habitat loss and degradation).

1.1 Prevent the net loss or significant degradation of habitat in sites that support documented populations. Loss or degradation of some occupied habitats may be mitigated by a proportional increase or improvement of other occupied habitats; this may be accomplished through improved management and protection of existing occupied habitat, successful habitat restoration, or the discovery of new occupied habitats.

1.2 Reduce impacts from invasive species. Currently, the principal invasive species threat to Tamaulipan kidneypetal is guineagrass and other introduced invasive grasses. Optimal Tamaulipan kidneypetal habitat has less than 10% cover of introduced invasive plant species.

1.3 Minimize risk of impacts from pesticide drift and runoff.

Listing Factor B (over-utilization).

1.4 Prevent depletion of extant populations and their soil-seed banks. Seed collection, propagation, establishment of refugium populations, augmentation, and reintroduction efforts must comply with USFWS policy on controlled propagation of endangered species (USFWS and NMFS 2000), including the prior establishment of a controlled propagation and reintroduction plan.

Listing Factor C (disease and predation).

1.5 Prevent degradation of existing habitats and populations from excessive browsing impacts from both domesticated and wild browsing animals (primarily goats and deer).

Listing Factor D (The inadequacy of existing regulatory mechanisms).

1.6 Protect Tamaulipan kidneypetal in the U.S. through the federal ESA. When delisted, the continued status of the species should be tracked according to the post-delisting monitoring plan (see Action 10).

1.7 Collaborate and communicate with Mexican government agencies, scientists, and conservation organizations to promote the species' conservation in Mexico; seek information on the species status and protection (if any) in Mexico.

Listing Factor E (other natural or man-made factors).

The population-based objectives below apply also to Factor E.

2. Habitat-based objectives.

2.1 Determine the optimal habitat types, including the climate, soils, hydrology, and associated vegetation of known population sites.

2.2 Increase the amount of protected optimal habitat through acquisition of land for conservation purposes, successful habitat restoration on protected lands, and improved management and protection of existing habitat. See the discussions of protected habitat and populations (section II.1) and baseline conditions (III.c.1).

2.3 Alleviate habitat fragmentation and isolation. Tamaulipan kidneypetal populations appear to thrive where shrubs are beginning to recolonize gaps created by fires, floods, or other disturbances; hence, the probability of long-term survival is greater in larger habitat areas that can support a range of seral stages. Additionally, habitats must be large enough to support healthy pollinator populations and allow for gene flow between neighboring populations. Optimal habitat for Tamaulipan kidneypetal is at least 400 ha (988 ac) of contiguous intact or restored habitat managed for conservation of native flora and fauna. Groups of smaller habitats may be suitable through linkage by intact or restored ecological corridors. The dimensions and vegetation composition of ecological corridors must be sufficient to allow passage of the insect pollinators of Tamaulipan kidneypetal (currently unknown) between habitat blocks.

2.4 Determine the best Tamaulipan kidneypetal habitat management practices, including the effects of both spontaneous and induced actions, such as wildfire, invasive plants and animals, and herbivory. Promote these practices where occupied habitat is not under federal jurisdiction. Implement them on lands under U.S. federal jurisdiction or through voluntary conservation agreements with private landowners, *ejidos*, or other landowners in the U.S. and Mexico.

3. Population-based objectives.

3.1 Increase knowledge of the species' abundance, distribution, and ecology. Conduct surveys by qualified individuals in potential habitats throughout south Texas and northeast Mexico to demonstrate the species' presence and abundance or absence, and describe the associated species, habitats, and ecology; surveys may be conducted on public lands and where private landowners and *ejidos* have granted permission for this purpose.

3.2 Improve documentation and monitoring of populations throughout the species' range. Quantitatively monitor the documented populations throughout south Texas and northeast Mexico to determine long-term population trends; monitoring may be conducted on public lands and where private landowners and *ejidos* have granted permission for this purpose.

3.3 Prevent a net loss or decline of documented populations below a value established for Minimum Viable Population (MVP). However, the loss or degradation of some populations may be mitigated by a proportional increase or improvement of other populations, which may be accomplished through improved management, protection, and augmentation of existing populations, successful reintroduction of populations, or the discovery of new populations. Augmentation and reintroduction must comply with USFWS policy on controlled propagation of endangered species (USFWS and NMFS 2000), including the prior establishment of a controlled propagation and reintroduction plan.

3.4 Prevent the depletion of genetic diversity within and among populations resulting from inbreeding depression, outbreeding depression, genetic swamping, or other factors. This objective requires a thorough understanding of the species' reproductive biology, pollination and pollinators, breeding system, and genetic variation within and among populations.

3.5 Increase the number and size of protected populations to confer the resiliency, redundancy, and geographic and genetic representation necessary for the continued survival of Tamaulipan kidneypetal. This objective may be reached in part by augmenting natural populations and by reintroducing viable populations on protected land, within the species' range and known habitat types, in accordance with a controlled propagation and reintroduction plan.

3.6 Determine the best population management practices, and implement these practices where this is possible. Document the effects on Tamaulipan kidneypetal populations by both spontaneous and induced actions, such as wildfire, invasive plants and animals, and herbivory; implement best management practices where populations occur on lands under U.S. federal jurisdiction, and promote these practices on populations not under federal jurisdiction.

II.5. Recovery Criteria.

Recovery criteria are the objective, measurable criteria that, if met, provide a basis for determining whether a species can be considered for reclassification (downlisting to threatened status or removing [delisting] from the list of threatened and endangered species). Because the same five statutory factors must be considered in delisting as in listing (16 U.S.C. § 1533 (a),(b),(c)) the USFWS, in designing objective, measurable criteria, must address each of the five statutory delisting factors and measure whether threats to the Tamaulipan kidneypetal have been ameliorated (see *Fund for Animals v. Babbitt*, 903 F. Supp. 96 [D.D.C. 1995]). Below we describe four combined criteria to downlist and to recover the Tamaulipan kidneypetal.

II.5.1. Baseline conditions.

The baseline for determining these criteria is the amount of occupied habitat and number and size of populations in the U.S. and in Mexico documented at the time the 5-year review was approved (June 2, 2010). Several of the criteria for downlisting and delisting are based on the determinations of MVP and minimum number of viable populations per recovery unit, the designation of recovery units, and the definitions of protected and optimal habitats and populations. These concepts are discussed in more detail in section II.1, above.

II.5.2. Downlisting to Threatened.

1. Threat-based objective: Reduce or mitigate habitat loss and degradation, invasive species competition, poor rangeland management, and other threats to the continued survival of Tamaulipan kidneypetal.

   Criterion 1: The successful accomplishment of threats reduction and mitigation is demonstrated by a stable or improving status of Tamaulipan kidneypetal, compared to the baseline conditions described above, throughout its known range over a period of at least 10 years.

   Justification: Most populations and potential habitats occur on private or *ejido* lands, and much of the species' known range is in Mexico, and are therefore not under U.S. federal jurisdiction. Consequently, accomplishment of this criterion depends on successful promotion of habitat conservation and population management as well as pro-active measures that offset losses from predicted land-use changes or development of private lands. These measures may include strategic habitat restoration and augmentation or reintroduction of populations on protected lands. The discovery and protection of additional populations will also contribute to improving the known status of Tamaulipan kidneypetal.

2. Habitat-based objective: Conserve, restore, and manage appropriately the quantity and quality of habitat needed for the recovery of Tamaulipan kidneypetal.

   Criterion 2: At least 10 populations of Tamaulipan kidneypetal, and at least 1 per recovery unit, are documented in optimal habitats for a period of at least 10 years. Habitat is considered optimal when: It is protected for conservation purposes; it is managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal; it has less than 10% cover of introduced invasive plant species; it consists of at least 400 ha (988 ac) of contiguous habitat; and where Tamaulipan kidneypetal populations are observed to be stable or increasing.

   Justification: Tamaulipan kidneypetal populations that occur in optimal habitats, as defined above and in section II.1., should have the greatest resilience to climatic extremes, such as prolonged drought or severe freezing temperatures, and perhaps other threats that are currently unknown. We expect that optimal habitats will have healthy pollinator populations that enable gene flow within and between Tamaulipan kidneypetal populations, thus maintaining their long-term genetic diversity. Tamaulipan kidneypetal populations in optimal habitats may serve as the best seed sources for the reintroduction of populations that have been lost or may be lost in the future. Since each recovery unit represents an ecotype with unique genetic adaptations to specific soils and climatic conditions, this recovery criterion requires that at least one population per recovery unit occurs in optimal habitat. We believe the 10-year time frame is the minimum period necessary to judge whether a population is stable, increasing, or decreasing (as discussed under Criterion 3). See section II.1 for additional description of optimal habitats.

3. Population-based objective: Conserve, protect, and restore populations of Tamaulipan kidneypetal needed for its recovery. Populations must be self-sustaining, of sufficient size to endure climatic variation and stochastic events, of sufficient number to endure catastrophic losses, and must represent the full range of the species' geographic and genetic variability.

   Criterion 3: Conserve, protect, or restore at least 20 populations, including no fewer than 5 populations per recovery unit. Conservation of recovery units in Mexico may be accomplished through cooperative efforts with Mexican agencies and organizations. Quantitative monitoring conducted in at least 5 different years over a period of at least 10 years demonstrates that protected populations have no fewer than 500 mature individuals, and are stable or increasing over this time frame. Furthermore, at least one population per recovery unit must have at least 1,000 mature individuals.

   Justification: A mature individual is one that is capable of flowering and producing viable seed. Only mature individuals are considered in meeting this criterion, since large numbers of Tamaulipan kidneypetal seeds may germinate following sporadic rainfall but not live long enough to reproduce. The 10-year length of this time frame reflects the minimum period required to judge whether a population is stable, declining, or increasing. Due to the wide variation in the region's annual rainfall and the frequencies of severe droughts and freezes, populations will naturally fluctuate. The numbers of individuals during a single year or short span of years may provide a skewed representation of a population's longer-term trends. The 10-year period is based on the age at reproductive maturity (probably 1 to 3 years), average life span in the wild (unknown, but assumed to be about 10 years), and the frequency of years in which rainfall amounts and patterns are conducive to successful reproduction (probably 3 to 5 years per decade). Quantitative monitoring protocols are described in Section VI.

   Although it is preferable to monitor populations once per year, this may not be possible due to site access restrictions, lack of personnel, or other factors. Therefore, this criterion may be met when each population has been quantitatively monitored in at least 5 different years over a span of not less than 10 years. Since these time frames are based on assumptions, this recovery plan may be amended and the time frame changed to reflect empirical demographic data as it becomes available. Three extant recovery units are described in section II.1 (see map on page 10).

II.5.3. Delisting.

4. Objective: After accomplishing all objectives for downlisting to threatened, Tamaulipan kidneypetal may be removed from the endangered species list when its overall habitat and population status continues at the same or an improved level for an additional 10 years.

   Criterion 4: 20 or more protected populations, including no less than 5 per recovery unit, have maintained stable or increasing populations of at least 500 mature individuals, and at least 1 population per recovery unit maintains 1,000 or more individuals, for a total of at least 20 years.

III. RECOVERY PROGRAM.

III.1. Recovery action outline (Table 8).

Priority	Action	Description	Objectives Addressed		
			1	2	3
1	1	Protect and conserve the known populations and their habitats in the U.S. and Mexico.	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7	2.2	3.3, 3.4, 3.6
1	1.1	Protect populations and habitats on publicly-owned land in the U.S.	1.1, 1.2, 1.3, 1.4, 1.5, 1.6	2.2	3.3, 3.4, 3.6
1	1.2	Promote conservation of populations and habitats on privately-owned land in the U.S.	1.1, 1.2, 1.3, 1.4, 1.5, 1.7	2.2	3.3, 3.4, 3.6
1	1.3	Promote conservation of populations and habitats in Mexico.	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7	2.2	3.3, 3.4, 3.6
1	2	Develop a monitoring plan, and monitor known populations and habitats.	1.1	2.4	3.2
1	2.1	Monitor known populations on public land in the U.S.	1.1	2.4	3.2
1	2.2	Monitor known populations on private land in the U.S., with landowner permission.	1.1	2.4	3.2
1	2.3	Monitor known populations on public, private, and *ejido* lands in Mexico, with permission from landowners and appropriate authorities.	1.1	2.4	3.2
1	3	Develop partnerships with Mexican government agencies, academic institutions, and NGOs to promote investigation, conservation, and recovery of the species in Mexico.	1.7		
2	4	Improve management of known populations and habitats, based on the conclusions of scientific investigations (adaptive management).		2.4	3.6
2	4.1	Implement invasive grass control and prevention and other management actions on publicly-owned occupied habitats in the U.S.	1.2	2.4	3.6

Priority	Action	Description	Objectives Addressed		
			1	2	3
2	4.2	Promote appropriate management of populations and habitats on private land in the U.S. and on public, private, and *ejido* lands in Mexico.	1.2	2.4	3.6
2	4.21	Provide public and private landowners (with their permission) with precise maps of populations on their lands, and provide recommendations on appropriate management.	1.2, 1.3, 1.5, 1.7	2.4	3.1, 3.6
2	4.3	Minimize risk of impacts from pesticide drift and runoff.	1.3	2.4	
2	5	Conduct public outreach in the U.S. and Mexico to promote the species' conservation and recovery.	1.3, 1.5, 1.7	2.4	3.1, 3.2, 3.6
2	5.1	Prepare outreach materials in English and in Spanish.	1.3, 1.5, 1.7	2.4	3.1, 3.2, 3.6
2	6	Conduct scientific investigations necessary for conservation and recovery.		2.1, 2.4	3.1, 3.2, 3.4, 3.6
2	6.1	Investigate reproductive biology, pollination, and population dynamics.			3.1, 3.4
2	6.2	Investigate the genetic variability within and between populations, and the phylogenetic relationship to other *Ayenia* species.			3.4
2	6.3	Investigate the species' ecology and distribution.		2.1, 2.4	3.1
2	6.31	Determine the optimal requirements for light and shade.		2.1, 2.4	3.1
2	6.32	Investigate the soils, hydrology, climate, and associated vegetation of known populations, including invasive species and herbivore impacts.		2.1, 2.4	3.1
2	6.33	Investigate the fire ecology.		2.1, 2.4	3.1
2	6.34	Search for evidence of populations outside the currently known geographic range and range of habitats.			3.1
2	6.4	Seek funding to support scientific investigation in the U.S. and Mexico.		2.1, 2.4	3.1, 3.2, 3.4, 3.6

Priority	Action	Description	Objectives Addressed		
			1	2	3
2	7	Search for new and historic populations in U.S. and Mexico.	1.7		3.1
2	7.1	Conduct surveys of publicly-owned land in the U.S. and Mexico.	1.7		3.1
2	7.2	Conduct surveys on private and *ejido* lands in the U.S. and Mexico, with permission from landowners.	1.7		3.1
2	7.3	Search potential habitats in the vicinities of Múzquiz, Coahuila, and Topia, Durango, for extant populations of *A. limitaris* and other *Ayenia* species.	1.7		3.1
3	8	Restore native vegetation within the Rio Grande delta recovery units to increase the amount of available habitat and to establish functioning ecological corridors that reconnect isolated habitat fragments.	1.1	2.2, 2.3	
3	9	Augment and reintroduce populations in appropriate habitats within known range in U.S. and Mexico.	1.4, 1.7		3.3, 3.4, 3.5
3	9.1	Establish a controlled propagation and reintroduction plan.	1.4		3.3, 3.4, 3.5
3	9.2	Collect seeds from extant populations for seed banking, augmentation, and reintroduction.	1.4		3.3, 3.4, 3.5
3	9.3	Conduct pilot reintroductions to determine the most effective techniques.	1,4		3.3, 3.4, 3.5
3	9.41	Augment extant populations with progeny of the same populations to meet or exceed the established MVP.	1.4		3.3, 3.4, 3.5
3	9.42	Reintroduce populations within the species known range and habitat types (including restored vegetation) to meet the minimum number of populations per recovery unit, and to improve gene flow among sub-populations.	1.4		3.3, 3.4, 3.5
3	10	Prepare post-delisting monitoring plan.	All	All	All

III.2. Recovery Action Narrative.

Priority 1: Actions necessary to prevent extinction or irreversible decline in the species' status.

1. Protect and conserve the known populations and their habitats in the U.S. and Mexico. Promote cooperative efforts to conserve occupied habitats and protect known populations from invasive grass competition, excessive browsing, trampling, and other potential threats. Seek sources of financial and technical assistance to support these efforts. This action faces the following challenges: 1) Several known populations in the U.S. occur on private land; 2) a majority of the known populations, and almost all of the species' global range, occur in Mexico; 3) the known Mexican populations all occur on private or *ejido* land. Consequently, the U.S. ESA confers no authority to enforce the degree of population and habitat protection that is necessary to prevent a significant decline (jeopardy) of the species. Therefore, this action must rely heavily on voluntary conservation efforts and on close collaboration with Mexican agencies and conservation organizations. Furthermore, since it is probable that some populations on private and *ejido* lands will be destroyed or deteriorated through urban and agricultural development or other causes, this action addresses an objective of no *net* loss of populations and habitats; losses and deterioration of some populations and habitats may be offset through successful habitat restoration, improved management and protection of existing occupied habitat, or the discovery of new occupied habitats.

   1.1 Protect populations and habitats on publicly-owned land in the U.S. Communicate with managers and personnel of LRGV NWR, Estero Llano Grande State Park, the City of Harlingen Parks and Recreation Department, and other public land owners and managers (if new populations are discovered on other public lands), regarding the Tamaulipan kidneypetal populations present on land owned and managed by these public entities and the applicable protections under the federal ESA and TPWD regulations. Identify ongoing and potential threats to the known populations and habitats, and implement corrective or preventive management accordingly (see action 6).

   1.2 Promote conservation of populations and habitats on privately-owned land in the U.S. Communicate with the private landowners of known Texas populations of Tamaulipan kidneypetal, and provide them with information about the habitats, conservation, and status of Tamaulipan kidneypetal (see action 5.1 on the development of outreach materials). Establish a productive working relationship with those landowners who are interested in conserving the species, and with their permission, monitor and protect known populations and habitats on private lands. Identify ongoing and potential threats to the known populations and habitats, and implement corrective or preventive management accordingly (see action 4). Potential sources of support include the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) and the USFWS Partners for Fish and Wildlife (PFW) program.

1.3 Promote conservation of populations and habitats in Mexico. Although USFWS has no authority to enforce endangered species protection outside the U.S., conservation and recovery may be accomplished through cooperative efforts with Mexican counterparts. Communicate with representatives of Mexican federal environmental agencies, such as Secretaría de Medio Ambiente y Recursos Naturales (Secretary of Environment and Natural Resources; SEMARNAT), CONANP, and the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (National Commission on the Knowledge and Use of Biodiversity; CONABIO), as well as Mexican state environmental agencies, botanists, and non-profit conservation organizations, regarding known and potential populations in Mexico. Promote binational cooperative efforts to protect Tamaulipan kidneypetal populations and occupied habitats in Mexico. Establish partnerships to conduct outreach (see action 5), seek *ejido* and private landowners who are interested in conserving the species, and with their permission, monitor and protect known populations and habitats on private and *ejido* lands. Identify ongoing and potential threats to the known populations and habitats, and implement corrective or preventive management accordingly (see action 4). Potential sources of support include the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) and the U.S. - Mexico Wildlife Without Borders grants program.

2. Develop a monitoring plan, and monitor known populations and habitats. The objectives and requirements of the monitoring plan are discussed in II.1. Visit known populations at least once per year, if possible, to make qualitative observations of habitat conditions and the growth and reproduction of Tamaulipan kidneypetal. Determine if there are any new or existing threats to the population and recommend actions to alleviate threats. Collect quantitative data on population size and reproduction at least 5 times every 10 years to track long-term population dynamics.

2.1 Monitor known populations on public land in the U.S. Populations are currently known at LRGV NWR, Estero Llano Grande State Park, and the City of Harlingen Parks and Recreation Department, and may in the future be discovered on other public lands. Potential sources of support include the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) and Cooperative Recovery Initiatives with National Wildlife Refuges.

2.2 Monitor known populations on private land in the U.S., with landowner permission. Potential sources of support include the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA), the USFWS Partners for Fish and Wildlife (PFW) program, and voluntary efforts by landowners themselves.

2.3 Monitor known populations on public, private, and *ejido* lands in Mexico, with permission from landowners and appropriate authorities. Potential sources of support include the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) and the U.S. - Mexico Wildlife Without Borders grants program.

3. Develop partnerships with Mexican government agencies, academic institutions, and NGOs to promote investigation, conservation, and recovery of the species in Mexico. Potential Mexican agency partners include the Secretaría de Desarrollo Urbano y Medio Ambiente (Secretary of Urban Development and Environment, State Government of Tamaulipas; SEDUMA) and SEMARNAT, CONANP, and CONABIO (federal). Academic institutions may include Universidad Autónoma de Tamaulipas, Universidad Autónoma de Nuevo León (particularly the Facultad de Ciencias Forestales [Forestry Sciences Department]), and the Instituto Tecnológico y de Estudios Superiores de Monterrey (Monterrey Institute for Technology and Advanced Studies; ITESM). Pronatura Noreste a.c., based in Monterrey, Nuevo León, is a Potential NGO partner.

Priority 2. Actions necessary to prevent a significant decline in the species' status.

4. Improve management of known populations and habitats, based on monitoring data and the conclusions of scientific investigations (adaptive management).

4.1 Implement invasive grass control and other management actions on publicly-owned occupied habitats in the U.S. Invasive grass control may be accomplished through spot application of glyphosate herbicide (or other appropriate herbicides) to individual invasive grass plants, or through broadcast application of a grass-specific herbicide, as appropriate; repeat applications following re-sprouting or re-emergence until the soil seed bank is depleted of invasive grass seeds. Investigate the potential of prescribed grazing as an invasive grass management tool as well as potential damage from livestock browsing and trampling. Apply the knowledge gained from scientific investigations to develop and implement best management practices.

4.2 Promote appropriate management of populations and habitats on private land in the U.S. and on public, private, and *ejido* lands in Mexico. The role of livestock grazing and trampling and ungulate browsing is particularly important for managing populations on private and *ejido* lands, as most remaining natural vegetation is used as livestock pasture in both the U.S. and Mexico.

4.21 Provide public and private landowners (with their permission) with precise maps of populations on their lands, and provide recommendations on appropriate management. Use GPS and digital orthographically-corrected aerial images, and provide maps and data to each landowner in a format that will be useful to them (for example, paper maps, ArcGIS Shapefiles, Google Earth KMZ files, etc.).

4.3 Minimize risk of impacts from pesticide drift and runoff. Provide owners or managers of each documented Tamaulipan kidneypetal population with accurate maps of the populations and occupied habitats that occur on their lands and written guidance on how best to avoid impacts from pesticides to Tamaulipan kidneypetal and to pollinating insects.

5. Conduct public outreach in the U.S. and Mexico to promote the species' conservation and recovery. Disseminate outreach materials, attend public meetings, communicate with interested members of the public, and meet interested landowners to discuss conservation and recovery of Tamaulipan kidneypetal.

   5.1 Prepare outreach materials in English and in Spanish. Provide updated images and information to websites such as the USDA PLANTS on-line database, the TPWD Wildlife Diversity website, the Lady Bird Johnson Wildflower Center plant database, and the USFWS Endangered Species website. Publish articles in venues such as the USFWS Endangered Species Bulletin that are oriented to the general public. Conduct interviews with journalists who are interested in conservation of natural resources. Provide outreach materials to TPWD wildlife biologists, Texas A&M AgriLife Extension Service agents, and NRCS Service Centers in Cameron, Hidalgo, Willacy, and Kenedy Counties, Texas. Provide this recovery plan and the most recent 5-year review of Tamaulipan kidneypetal to SEMARNAT and its dependent agencies and to the Secretaría de Desarollo Urbano y Medio Ambiente (Secretary of Urban Development and Environment; SEDUMA) of the state government of Tamaulipas. Exchange information on Tamaulipan kidneypetal and its habitats with botanists and ecologists at academic institutions in the U.S. and Mexico.

6. Conduct scientific investigations necessary for conservation and recovery.

   6.1 Investigate the reproductive biology and population dynamics. Determine the reproductive system, pollinator(s), and longevity of seed viability in storage and in soils. Track individual populations over time to determine the longevity of individual plants, recruitment and mortality rates, causes of mortality, and overall population size trends.

   6.2 Investigate the genetic variability within and between populations, and the phylogenetic relationship to other *Ayenia* species. Determine whether populations are inbred, and provide guidelines for the delimitation of ecotypes and the use of progeny from wild populations for augmentation and reintroduction. Investigate the phylogenetic validity of the species and its relationship to other *Ayenia* species, and the relationship to plant material from Coahuila and Durango, if these become available.

   6.3 Investigate the species' ecology and distribution.

      6.31 Determine the optimal requirements for light and shade.

      6.32 Investigate the soils, hydrology, climate, and associated vegetation of known populations, including invasive species and herbivore impacts. Document the range of tolerance to different soils, temperature extremes, and rainfall amounts and seasonal distribution.

6.33 Investigate the fire ecology. Determine the species' response to fire and the potential effect on maintaining optimal habitat.

6.34 Search for evidence of populations outside the currently known geographic range and range of habitats.

6.4 Seek funding to support scientific investigation in the U.S. and Mexico. Submit proposals for funding through the Cooperative Endangered Species Conservation Fund (Section 6 of the ESA), and other USFWS grant sources. Other possible grant sources include the National Science Foundation and the National Fish and Wildlife Foundation. Communicate with botanists and plant geneticists from the U.S. and Mexico, and facilitate binational scientific partnerships, to promote investigation of these research questions.

7. Search for new and historic populations in U.S. and Mexico. Seek permissions from public, private, and *ejido* landowners to conduct surveys in areas of intact habitat where the climate, soils, and vegetation are similar to known and historic populations.

7.1 Conduct surveys of publicly-owned land in the U.S. and Mexico. Potential habitats exist in Cameron, Willacy, eastern Hidalgo, and possibly Kenedy Counties, Texas. In Mexico, potential habitats range at least from Reynosa to Matamoros and southward to the *municipio* of González, Tamaulipas. However, disjunct populations might also occur in the States of Nuevo León, Coahuila, and Durango. Potential habitats in the U.S. exist at LRGV NWR, Santa Ana NWR, Laguna Atascosa NWR, state parks and Wildlife Management Areas owned by TPWD, and county and municipal parks and natural areas. In Mexico, potential habitats could exist at the Area de Protección de Flora y Fauna (Flora and Fauna Protected Area; APFF) Laguna Madre de Tamaulipas. This 307,894-ha (760,806 ac) area, managed by CONANP, mainly protects coastal bays, salt marshes, and estuaries. However, suitable habitat may exist in the upland margins where shrubland vegetation occurs. Additionally, if the proposed ANP Sierra de Tamaulipas is approved, this will protect one known population and potentially others.

7.2 Conduct surveys on private and *ejido* lands in the U.S. and Mexico, with permission from landowners. Potential habitats exist in Cameron, Willacy, eastern Hidalgo, and possibly Kenedy Counties, Texas. In Mexico, potential habitats range at least from Reynosa to Matamoros and southward to the *municipio* of González, Tamaulipas. However, disjunct populations might also occur in the States of Nuevo León, Coahuila, and Durango.

7.3. Search potential habitats in the vicinities of Múzquiz, Coahuila, and Topia, Durango, for extant populations of *A. limitaris* and other *Ayenia* species. If relict or disjunct populations are confirmed in these *municipios,* the potential range of the species would be much larger, and the prospects for recovery possibly greater, than was assessed at the time of listing. Additionally, this would justify the creation of new recovery units in those areas. Alternatively, if determined searches fail to detect Tamaulipan kidneypetal in Múzquiz and Topia, it would be plausible that the earlier reports were either misidentified or mislabeled herbarium specimens.

Priority 3. Actions necessary for the species' full recovery.

8. Restore and subsequently manage native vegetation within the Rio Grande delta recovery units to increase the amount of suitable available habitat and to establish functioning ecological corridors that reconnect isolated habitat fragments. Restoration methods must use local ecotypes of native species, and must restore a diverse sub-shrub, native grass, and forb understory and a partially open tree and shrub canopy to be considered suitable for Tamaulipan kidneypetal. Effective habitat restoration will offset unpreventable losses of habitat on private lands, and will make the criterion of no *net* habitat loss more achievable and practical.

   The amount of land that must be revegetated will depend on where natural populations occur (including those that have not yet been discovered), the amount of habitat that remains at those sites, the length of ecological corridors necessary to link isolated populations and fragments, and other factors, and is therefore unknowable at this time. Nevertheless, the criterion for number of populations is 5 per recovery unit, and the criterion for habitat size is 400 ha (988 ac) per population. Therefore, we can estimate an upper limit of 4,000 ha (9,880 ac) of land to be restored in order to meet these criteria for the two Rio Grande delta recovery units.

9. Augment and reintroduce populations in appropriate habitats within the known range in U.S. and Mexico. Augmentation is the supplementation of an existing population with progeny of the same population or another population that is genetically suitable. Reintroduction is the establishment of new populations within the species' known range and habitat types, but where a population currently does not exist. The objective in either case is to attain the criteria of an MVP of 250 or more mature individuals per population, 5 or more populations per recovery unit, at least 1 population per recovery unit with 1,000 or more mature individuals, and a minimum of 20 populations overall. All propagation and reintroduction will conform to the guidelines stipulated in an established controlled propagation and reintroduction plan.

   9.1 Establish a controlled propagation and reintroduction plan. The USFWS and NMFS Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (USFWS and NMFS 2000) addresses controlled propagation of federally listed and candidate species by the agencies. A controlled propagation and reintroduction plan describes how these operations will be done in accordance with the policy. Section E.13 of the policy requires preparation of a controlled propagation and reintroduction plan prior to the reintroduction of federally-listed threatened or endangered species. The policy states, "Controlled propagation protocols will follow accepted standards such as those employed by the … Center for Plant Conservation (CPC), and Federal agency protocols … to the extent practical." The plan should be based on strategies identified in an approved recovery plan, and should include protocols for health management, disease screening and disease-free certification, monitoring and evaluation of genetic, demographic, life-history, phenotypic, and behavioral characteristics, data collection, recordkeeping, and reporting, as appropriate. The controlled propagation and reintroduction plan should be established and approved by the Corpus Christi Ecological Services Field Office prior to commencing additional pilot reintroduction, augmentation, or reintroduction, as described in parts 9.2, 9.3, and 9.4 (below).

9.2 Collect seeds from extant populations for seed banking, augmentation, and reintroduction, following the guidelines established in the controlled propagation and reintroduction plan. The highest priority for collection are populations that are small, isolated, occur in sub-optimal habitats, or are likely to be lost to development or other threats. Seed collection protocols are intended to limit the amount and frequency of collection that might otherwise lead to reduced recruitment, population declines, and the loss of genetic diversity. In the case of populations that are certain to be imminently destroyed through impending development or other factors, these protocols should allow for the collection of all seeds, and also that live plants may be salvaged from such sites and relocated to secure nurseries or refugia. Seed collections that represent the genetic diversity of individual populations may be used to establish seed-increase plots from which seeds for subsequent augmentation and reintroduction may be collected, thus avoiding an accumulation of incremental impacts to wild populations that might occur through continued seed collection.

9.3 Conduct pilot reintroductions to determine the most effective techniques. Pilot reintroductions are used to develop and test methods on a small scale prior to expending larger amounts of valuable seeds, plant materials, funding, and labor on full-scale augmentation or reintroduction. For example, a relatively small number of seeds or plant tissues can be collected from wild populations and planted in seed increase plots under controlled, optimal conditions. Seeds are then harvested from the seed increase plots and used in experimental trials without incurring repeated harvests from the wild populations; investigation of the propagated individuals may generate useful information without detriment to the wild populations. Pilot reintroduction can be used to provide data that cannot be obtained from the remaining wild populations, such as the range of suitable soil types, appropriate light levels, pollinator specificity, response to herbicide exposure, fire, drought, optimal transplant seasons, probability of successful transplanting, etc. Additionally, the results of pilot reintroductions can help design an appropriate scale for a full reintroduction program. For example, the fraction of seedlings or propagules that survive to maturity in pilot reintroduction can be used to calculate the number of propagules required to achieve a future population that meets or exceeds an established population size objective. Successfully established pilot reintroductions can be subsequently expanded into full reintroduction sites to ensuring that the number and genetic diversity of founding individuals are sufficient for long-term population viability, following the guidelines of the controlled propagation and reintroduction plan.

9.4.1 Augment extant populations with progeny of the same populations (or other genetically appropriate populations) to meet or exceed the established MVP. Each wild population contributes potentially unique genetic traits to the species' total genetic diversity that could be lost through introgression and genetic swamping by introducing the progeny of disjunct source populations. Furthermore, the potential threat of outbreeding depression may first appear several generations subsequent to outcrossing events; susceptibility to outbreeding depression is highly variable among species (Edmands 2007). Therefore, augmentations of wild populations should usually only use plant material that descends directly from the same populations. However, augmentations may use progeny of different source populations if it is determined that the population to be augmented lacks sufficient genetic diversity to remain viable (Havens et al. 2004; Edmands 2007). Alleviate threats to an existing wild population, such as invasive grass competition, prior to expending resources to augment the population.

Document all augmentations to indicate:

- the source population(s);
- numbers and types of propagules introduced (seeds or seedlings of specified size and horticultural methods used to produce these propagules);
- existing vegetation, including invasive species;
- site preparations;
- dates planted;
- prevailing soil moisture and weather conditions at the time of introduction;
- site maps;
- GPS coordinates and/or paper maps of the augmentation site and locations of individuals introduced to the site.

Attach permanent identification tags to the introduced individuals so that they can be distinguished from wild plants and from progeny in the future. Quantitatively monitor augmentation sites at least once per month during the first year, or at least until mortality has significantly declined, to determine causes of mortality. Quantitatively monitor the sites annually after the first year to document the surviving population of introduced and wild Tamaulipan kidneypetal and spontaneous progeny (recruitment). Document qualitative observations, such as incidents of flowering and fruiting, invasive plants, response to drought, freezing, or rainfall, insect herbivores, pollinators, etc.

9.4.2 Reintroduce populations within the species known range and habitat types (including restored vegetation) to meet the minimum number of populations per recovery unit, and to improve gene flow among sub-populations. Unlike augmentation, where it is important to conserve the genetic structure of a source population, we recommend using progeny of multiple source populations in each reintroduced population to restore gene flow between recently isolated populations (Frankham et al. 2011), provided that the reintroduction sites are reproductively isolated from extant wild populations (Godefroid et al. 2011). Choose source populations that are within the same recovery unit, and that are closest to the reintroduction site or that most resemble it in terms of soil type and structure, associated vegetation, or other relevant factors. Intersperse, rather than group separately, the progeny of the source populations throughout the reintroduction site (Center for Plant Conservation 1996).

Select reintroduction sites that are owned by public agencies, academic institutions, conservation organizations, or private landowners that: 1) manage the sites for permanent natural resource conservation; 2) voluntarily agree to reintroduce Tamaulipan kidneypetal on the property; 3) support or allow recommended management activities; and 4) allow periodic access to qualified personnel for the purpose of monitoring.

Document all reintroductions to indicate:

- the source population(s);
- numbers and types of propagules introduced (seeds or seedlings of specified size and horticultural methods used to produce these propagules);
- existing vegetation, including invasive species;
- site preparations;
- dates planted;
- prevailing soil moisture and weather conditions at the time of reintroduction;
- site maps;
- GPS coordinates and/or paper maps of the reintroduction site and locations of individuals introduced to the site.

Attach permanent identification tags to the introduced individuals so that they can be distinguished from progeny in the future. Quantitatively monitor reintroduction sites at least once per month during the first year, or at least until mortality has declined, to determine causes of mortality. Quantitatively monitor the sites annually after the first year to document the surviving population of introduced Tamaulipan kidneypetal and spontaneous progeny (recruitment), as well as the cover of plant species that have greater than 5 percent cover. Document qualitative observations, such as incidents of flowering and fruiting, invasive plants, response to drought, freezing, or rainfall, insect herbivores, pollinators, etc.

10. Prepare post-delisting monitoring plan. In accordance with ESA section 4(g)(1), upon recovery and removal from the endangered species list, the status of delisted species must be monitored for not less than five years. In consideration of the potential responses of

Tamaulipan kidneypetal populations, based on its lifespan, reproductive rate, and demography, to the removal of federal protection, monitoring should be continued for at least 10 years to ensure that the populations and criteria upon which delisting are based continue to be secure. Post-delisting monitoring must quantitatively document the extant populations upon which delisting is based, including population sizes, age structures, reproduction, recruitment and mortality, habitat conditions, invasive species impacts, degree and effectiveness of protection, and impacts of threats.

Table 9. Threats tracking table.

Listing Factors.	Threats.	Recovery		Recovery Actions.
		Objectives	Criteria	
A	Habitat destruction in Texas and in Mexico.	1.1, 2.2, 2.4	1, 2, 4	1.1, 1.2, 1.3
A	Habitat fragmentation and isolation.	1.1, 2.3, 2.4	1, 2, 4	6.2, 8
A	Herbicide drift and runoff.	1.3	1, 2, 4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 4.2, 4.21, 4.3, 5, 5.1
A	Competition from introduced invasive grasses.	1.2, 2.4	1, 2, 4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 4.1, 4.2, 4.21, 5, 5.1, 6.32
A	Altered vegetation structure and composition.	1.1, 2.1,2.4, 3.1	1, 2, 4	4.2, 4.21, 6.3, 6.31, 6.32, 6.33, 8
A	Loss of pollinators.	1.1, 1.2, 1.3, 2.3, 2.4, 3.1, 3.4	1, 2, 4	1.1, 1.2, 1.3, 6.1, 6.3, 6.32, 7.2, 7.21, 8
B	Unintended impacts of propagation and reintroduction.	1.4	1, 2, 4	9.1
C	Ungulate browsing	1.5	1, 2, 4	1.1, 1.2, 1.3, 4.2, 4.21, 5, 5.1, 6, 6.32
E	Catastrophic events.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6	1, 3, 4	1.1, 1.2, 1.3, 6.1, 6.34, 8, 9.3, 9.4
E	Drought.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6	1, 3, 4	1.1, 1.2, 1.3, 6.1, 6.3, 6.32, 6.33, 8, 9.3, 9.4
E	Sub-zero temperatures.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6	1, 3, 4	1.1, 1.2, 1.3, 6.1, 6.3, 6.32, 8, 9.3, 9.4
E	Climate change.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6	1, 3, 4	1.1, 1.2, 1.3, 6, 6.1, 6.34, 8, 9.3, 9.4

IV. IMPLEMENTATION TABLE.

The following implementation schedule outlines priorities, potential or responsible parties, and estimated costs for the specific actions for recovering Tamaulipan kidneypetal. It is a guide to meeting the goals, objectives, and criteria from Section IV RECOVERY PROGRAM of this recovery plan. The schedule: (a) lists the specific recovery actions, corresponding outline numbers, the action priorities, and the expected duration of actions; (b) recommends agencies or groups for carrying out these actions; and (c) estimates the financial costs for implementing the actions. These actions, when complete, should accomplish the goal of this plan – recovery of Tamaulipan kidneypetal.

IV.1. Responsible Parties and Cost Estimates

The value of this plan depends on the extent to which it is implemented; the USFWS has neither the authority nor the resources to implement many of the proposed recovery actions. The recovery of Tamaulipan kidneypetal is dependent upon the voluntary cooperation of many other organizations and individuals who are willing to implement the recovery actions. The implementation schedule identifies agencies and other potential "responsible parties" (private and public) to help implement the recovery of this species. This plan does not commit any "responsible party" to carry out a particular recovery action or to expend the estimated funds. It is only recognition that particular groups may possess the expertise, resources, and opportunity to assist in the implementation of recovery actions. Although collaboration with private landowners and others is called for in the recovery plan, no one is obligated by this plan to any recovery action or expenditure of funds. Likewise, this schedule is not intended to preclude or limit others from participating in this recovery program.

The cost estimates provided are not intended to be a specific budget but are provided solely to assist in planning. The total estimated cost of recovery, by priority, is provided in the Executive Summary. The schedule provides cost estimates for each action on an annual or biannual basis. Estimated funds for agencies included only project-specific contract, staff, or operations costs in excess of base budgets. They do not include ordinary operating costs (such as staff) for existing responsibilities.

IV.2. Recovery Action Priorities and Abbreviations

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

<u>Priority 1</u>. An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2. An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3. All other actions necessary to provide for full recovery of the species.

The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

Table 10. Acronyms and Abbreviations in the Recovery Implementation Schedule.

Acronym	Full Name
CONABIO	*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad*
CONANP	*Comisión Nacional de Areas Naturales Protegidas*
ES	Endangered Species Division of U.S. Fish and Wildlife Service
ITESM	*Instituto Tecnológico y de Estudios Superiores de Monterrey*
MVP	Minimum Viable Population
NGO	Non-Governmental Organization
NWRS	National Wildlife Refuge System
SEDUMA-Tam	*Secretaría de Desarrollo Urbano y Medio Ambiente* (State Government of Tamaulipas)
SEMARNAT	*Secretaría de Medio Ambiente y Recursos Naturales*
TAMU	Texas A&M University
TPWD	Texas Parks and Wildlife Department
UANL	*Universidad Autónoma de Nuevo León*
UAT	*Universidad Autónoma de Tamaulipas*
USFWS	U.S. Fish and Wildlife Service
UT	University of Texas
UTRGV	University of Texas Rio Grande Valley

Table 11. Recovery Implementation Table.

Priority No.	Action No.	Action Description	Recovery Criterion No.	Action Duration (Years)	Responsibility: Parties	Responsibility: Is FWS Lead?	Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s): Prior to FY 2014	2016 - 2020	2021 - 2025	2026 - 2039	2031 - 2035
1	1.1	Protect populations and habitats on publicly-owned land in the U.S.	1, 2, 3, 4	Contin-uous	USFWS, TPWD, City of Harlingen, potentially others	Y	2500.0	500.0	500.0	500.0	500.0	500.0
1	1.2	Promote conservation of populations and habitats on privately-owned land in the U.S.	1, 2, 3, 4	Contin-uous	USFWS, TPWD, NGOs, private landowners	Y	22.0	2.0	5.0	5.0	5.0	5.0
1	1.3	Promote conservation of populations and habitats in Mexico.	1, 2, 3, 4	Contin-uous	USFWS, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	N	1002.0	2.0	250.0	250.0	250.0	250.0
1	2.1	Monitor known populations on public land in the U.S.	3, 4	Periodic	USFWS, TPWD, potentially others	Y	21.0	1.0	5.0	5.0	5.0	5.0
1	2	Develop a monitoring plan (see Section VI, below).	3, 4	0.25	USFWS, TPWD, NGOs	Y	5.0	0.0	5.0	0.0	0.0	0.0
1	2.2	Monitor known populations on private land in the U.S., with landowner permission.	3, 4	Periodic	USFWS, TPWD, NGOs, private landowners	Y	22.0	2.0	5.0	5.0	5.0	5.0
1	2.3	Monitor known populations on public, private, and *ejido* lands in Mexico, with permission from landowners and appropriate authorities.	3, 4	Periodic	USFWS, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	N	20.0	0.0	5.0	5.0	5.0	5.0
1	3	Develop partnerships with Mexican government agencies, academic institutions, and NGOs to promote investigation, conservation, and recovery of the species in Mexico.	1, 2, 3, 4	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	25.0	5.0	5.0	5.0	5.0	5.0
2	4.1	Implement invasive grass control and other management actions on publicly-owned occupied habitats in the U.S.	1,2	Periodic	USFWS, TPWD, City of Harlingen, potentially others	Y	60.0	0.0	15.0	15.0	15.0	15.0
2	4.2	Promote appropriate management of populations and habitats on private land in the U.S. and on public, private, and *ejido* lands in Mexico; support management actions with willing landowners.	2, 3, 4	Contin-uous	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	56.0	0.0	14.0	14.0	14.0	14.0

Priority No.	Action No.	Action Description	Recovery Criterion No.	Action Duration (Years)	Responsibility: Parties	Responsibility: Is FWS Lead?	Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s): Prior to FY 2014	2016 - 2020	2021 - 2025	2026 - 2039	2031 - 2035
2	4.21	Provide public and private landowners (with their permission) with precise maps of populations on their lands, and provide recommendations on appropriate management.	2, 3, 4	10	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	Y	8.0	0.5	2.5	5.0	0.0	0.0
2	4.3	Minimize risk of impacts from pesticide drift and runoff.	1, 2	Contin-uous	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	4.0	0.0	1.0	1.0	1.0	1.0
2	5	Conduct public outreach in the U.S. and Mexico to promote the species' conservation and recovery.	2, 3, 4	10	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	Y	20.0	0.0	10.0	10.0	0.0	0.0
2	5.1	Prepare outreach materials in English and in Spanish.	2, 3, 4	0.25	SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	Y	10.0	0.0	10.0	0.0	0.0	0.0
2	6.1	Investigate the reproduction biology and population dynamics.	3, 4	10	UT, UTRGV, TAMU, UAT, UANL, ITESM	N	66.9	1.9	50.0	5.0	5.0	5.0
2	6.2	Investigate the genetic relationship within and between populations, and the phylogenetic relationship to other Ayenia species.	3, 4	3	UT, UTRGV, TAMU, UAT, UANL, ITESM	N	175.0	0.0	175.0	0.0	0.0	0.0
2	6.31	Determine the optimal requirements for light and shade.	2, 3, 4	2	UT, UTRGV, TAMU, UAT, UANL, ITESM	N	50.0	0.0	50.0	0.0	0.0	0.0
2	6.32	Investigate the soils, hydrology, climate, and associated vegetation of known populations, including invasive species and herbivore impacts.	1, 2, 3, 4	1	UT, UTRGV, TAMU, UAT, UANL, ITESM	N	35.0	10.0	25.0	0.0	0.0	0.0
2	6.33	Investigate the fire ecology.	2, 3, 4	5	UT, UTRGV, TAMU, UAT, UANL, ITESM	N	50.0	0.0	50.0	0.0	0.0	0.0
2	6.34	Search for evidence of populations outside the currently known geographic range and range of habitats.	2, 3	5	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	Y	25.0	0.0	25.0	0.0	0.0	0.0

Priority No.	Action No.	Action Description	Recovery Criterion No.	Action Duration (Years)	Responsibility: Parties	Is FWS Lead?	Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s): Prior to FY 2014	2016 - 2020	2021 - 2025	2026 - 2039	2031 - 2035
2	6.4	Seek funding to support scientific investigation in the U.S. and Mexico.	2, 3	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, UT, UTRGV, TAMU, UAT, UANL, ITESM	Y	25.0	5.0	5.0	5.0	5.0	5.0
2	7.1	Conduct surveys of publicly-owned land in the U.S. and Mexico.	2, 3	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	Y	31.2	1.2	10.0	10.0	5.0	5.0
2	7.2	Conduct surveys on private and *ejido* lands in the U.S. and Mexico, with permission from landowners.	2, 3	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	101.0	41.0	20.0	20.0	10.0	10.0
2	7.3	Search potential habitats in the vicinities of Múzquiz, Coahuila, and Topia, Durango, for extant populations of *A. limitaris* and other *Ayenia* species.	2, 3	5	USFWS, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs	N	20.0	0.0	20.0	0.0	0.0	0.0
3	8	Restore native vegetation within the Rio Grande delta recovery units to increase the amount of available habitat and to establish functioning ecological corridors that reconnect isolated habitat fragments.	2	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/ejidos	Y	4440.0	2000.0	610.0	610.0	610.0	610.0
3	9.1	Establish an approved Controlled Propagation and Reintroduction Plan.	3, 4	0.25	USFWS, TPWD	Y	20.0	0.0	20.0	0.0	0.0	0.0
3	9.2	Collect seeds from extant populations for seed banking, augmentation, and reintroduction.	3, 4	5	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	10.5	0.5	10.0	0.0	0.0	0.0
3	9.3	Conduct pilot reintroductions to determine the most effective techniques.	3, 4	5	USFWS, TPWD	Y	7.2	2.2	5.0	0.0	0.0	0.0
3	9.41	Augment extant populations with progeny of the same populations to meet or exceed the established MVP.	3, 4	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	48.0	0.0	45.0	1.0	1.0	1.0

Priority No.	Action No.	Action Description	Recovery Criterion No.	Action Duration (Years)	Responsibility: Parties	Responsibility: Is FWS Lead?	Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s): Prior to FY 2014	2016 - 2020	2021 - 2025	2026 - 2039	2031 - 2035
3	9.42	Reintroduce populations within the species' known range and habitat types (including restored vegetation) to meet the minimum number of populations per recovery unit, and to improve gene flow among sub-populations.	3, 4	20	USFWS, TPWD, SEMARNAT, CONANP, CONABIO, SEDUMA-TAM, NGOs, private landowners/*ejidos*	Y	97.0	0.0	45.0	50.0	1.0	1.0
3	10	Prepare Post-Delisting Monitoring Plan.	3, 4	0.25	USFWS, TPWD	Y	20.0	0.0	0.0	0.0	0.0	20.0
T O T A L S :							8996.8	2574.3	1997.5	1521.0	1442.0	1462.0

1. This column reports recovery actions and costs that were carried out after *Tamaulipan kidneypetal* was listed in 1994, and prior to the establishment of this recovery plan.

Table 12. Recovery Implementation Plan Summary:

	Costs ($1,000s) and Time Frames (Years)					
Action Type	Prior to 2012[1]	1-5	6-10	11-15	16-20	Total
Total Land Acquisition:	502.0	750.0	750.0	750.0	750.0	3502.0
Total Habitat Restoration:	2000.0	610.0	610.0	610.0	610.0	4440.0
Total, Other Recovery Efforts:	72.3	632.5	161.0	82.0	102.0	1049.8

1. This column reports recovery actions and costs that were carried out after Tamaulipan kidneypetal was listed in 1994, and prior to the establishment of this recovery plan.

Table 13. Implementation cost justifications and comments:

Action	Cost justifications and comments
1.1	Based on the assumption that ongoing land acquisition for LRGV NWR and Laguna Atascosa NWR will ultimately acquire at least 400 ha (1,000 ac) of habitat suitable for Tamaulipan kidneypetal recovery at average cost of $2,500 per ac.
1.2	The Lower Rio Grande Valley Candidate Plant Conservation Agreement (Janssen 2006; Price 2006; Williams 2006), funded through Section 6 (2001 to 2006), had a total cost of $229,627. This effort was divided among 37 plant species (including Tamaulipan kidneypetal), and 3 of 71 tracts surveyed supported Tamaulipan kidneypetal populations. About 50% of the effort was directed at surveys and 25% each for monitoring and promoting conservation. Therefore, about $2,000 was directed to promoting conservation of Tamaulipan kidneypetal on private lands. This plan calls for increasing funding of this action to $5,000 for each 5-year period.
1.3	Tamaulipan kidneypetal habitats and populations may occur at APFF Laguna Madre de Tamaulipas and the proposed ANP Sierra de Tamaulipas. Although the Mexican Federal Government does not purchase lands for these protected areas, it is reasonable to assume that the administration and management of these habitats and populations would cost at least $50,000 per year. About $2,000 has been allocated to allocated to conservation of the species on private lands in Mexico (see 4.2, below).
2.1	Assumes about 5 days of monitoring per year by GS-7 and/or GS-9 federal employees or their equivalents. Approximately 5 days of monitoring on public land has been completed to date.
2.2	About $2,000 has been allocated to monitoring populations on private land (see 1.3 above). This plan calls for 5 days of monitoring per year at a rate equivalent to the monitoring of publicly-owned sites.
2.3	This plan calls for 5 days of monitoring populations and habitats in Mexico at a rate equivalent to the monitoring of U.S. sites.
3	The LRGV Candidate Plant Conservation Agreement (mentioned in 1.3 above) allocated about $5,000 to organize and support a U.S. - Mexico rare plant conference, held at Camp Lula Sams, Brownsville, TX, January 29-30, 2002. This plan calls for U.S. - Mexico rare plant conservation conferences to be held once every five years.
4.1	This plan estimates $15,000 every 5 years to suppress guineagrass and other invasive plants on public lands in the U.S.
4.2	This plan estimates $14,000 every 5 years to suppress guineagrass and other invasive plants on private and *ejido* lands in the U.S. and Mexico.

Action	Cost justifications and comments
4.21	This plan calls for $2,500 to develop maps of known populations during the first five years, and twice that amount in the following five years (assuming additional sites are discovered), to aid public, private, and *ejido* landowners to manage the populations and habitats.
4.3	This plan estimates $1,000 every 5 years to conduct outreach and provide owners of private and *ejido* lands in the U.S. and Mexico with written guidance on how best to avoid impacts from pesticides..
5	This plan projects $20,000 over the first 10 years to conduct public outreach work.
5.1	Action 5 requires development of outreach materials, for which an additional $10,000 is projected.
6.1	Work conducted by USFWS ecologists and others totals about $1,900 to date. A typical Section 6-funded grant to fund graduate-level research on this topic would include about $50,000 in total costs. Longer-term tracking of population dynamics includes $5,000 each five years for years 6 to 10, 11 to 15, and 16 to 20.
6.2	A similar investigation of the genetic variability of natural populations of bracted twistflower (*Streptanthus bracteatus*), funded through Section 6, had a total cost of $175,000 over three years (Pepper 2010).
6.31	A typical Section 6-funded grant to fund graduate-level research on this topic would include about $50,000 in total costs.
6.32	Much of this information had been documented already by botanists from USFWS, The Nature Conservancy, Pronatura Noreste a.c., and others, and has an estimated value of $10,000. This plan includes an additional $25,000 to expand this effort.
6.33	A typical Section 6-funded grant to fund graduate-level research on this topic would include about $50,000 in total costs.
6.34	This plan projects $25,000 specifically to conduct field surveys in other potential habitats in Tamaulipas and Nuevo León, Mexico, sufficient to support travel costs and a stipend for a graduate student over several seasons.
6.4	The development of three proposals for funding through Section 6 has required at least $5,000 in staff time to date. This plan assumes that this amount of staff time will be invoked every five years to develop proposals to support the research and recovery efforts called for in the plan.
7.1	The Plant Surveys on the Lower Rio Grande Valley NWR project (Carr 1995), funded through Section 6 from 1993 to 1995, had a total cost of $30,000. Tamaulipan kidneypetal was one of 25 species included, so about $1,200 was allocated to searching for this species on public land. This plan calls for $20,000 to support surveys of public lands in the U.S. and Mexico during the first 10 years and $10,000 during the following 10 years.

Action	Cost justifications and comments
7.2	Francisco González-Medrano of Universidad Nacional Autónoma de México conducted a survey of five U.S.-listed plants in Tamaulipas in 1993 and 1994 with $10,000 in support from USFWS (U.S. Fish and Wildlife Service 1993); therefore, about $2,000 supported surveys for Tamaulipan kidneypetal. Section 6 funds supported the Rare Plants of the Lower Rio Grande in Mexico project from 2003 to 2005. Tamaulipan kidneypetal was one of 3 main species sought, and the total project cost was $91,344. Therefore, $30,448 was allocated for Tamaulipan kidneypetal, of which about $28,500 was used for surveys on private lands in Mexico. The LRGV Candidate Plant Conservation Agreement allocated about $4,000 to survey Tamaulipan kidneypetal on private lands in the U.S. Additional surveys of private lands in the U.S. have been conducted by The Nature Conservancy and by private individuals, with an estimated value of $6,500. Therefore, about $41,000 have been spent to survey private and *ejido* lands in the U.S. and Mexico. This plan calls for $40,000 in additional support during the first 10 years and $20,000 during the following 10 years.
7.3	This plan calls for $20,000 specifically to conduct field surveys in Coahuila and Durango, sufficient to support travel costs and a stipend for a graduate student over several seasons.
8	Beginning in 1982, LRGV NWR has successfully restored at least 2,023 ha (5,000 ac) of habitat that is suitable for Tamaulipan kidneypetal, at an average cost of about $400/ac. Therefore, about 50% of the habitat restoration goal has been met. The plan accounts for continuing habitat restoration of 99 ha (244 ac) per year of Tamaulipan kidneypetal habitat at $500/ac. However, these figures represent an upper limit (see section IV.2.8), so the actual amount of land to be restored and the costs may be lower. Also note that habitat restoration at LRGV NWR benefits multiple trust species, including the federally listed ocelot (*Leopardus pardalis*) and Gulf Coast jaguarundi (*Herpailurus yagouardoundi cacomitli*). Therefore, these habitat restoration costs may be shared by multiple species recoveries.
9.1	The development of a controlled propagation and reintroduction plan for slender rushpea during 2012 cost about $20,000 in staff time from USFWS employees.
9.2	The establishment and subsequent monitoring of a pilot reintroduction project cost about $2,700 in materials and staff time of USFWS employees. Expanding this effort will require about $5,000 during the first five years.
9.3	This plan calls for augmentation of 5 populations at an estimated cost of $10,000 each, including plant materials, site preparation, staff time, and subsequent monitoring, but not including land acquisition. Additional monitoring will require $1,000 once every five years, during years 6 to 10, 11 to 15, and 16 to 20.
9.4	This plan calls for reintroduction at 10 sites during the first 10 years at an estimated cost of $10,000 each, including plant materials, site preparation, staff time, and subsequent monitoring, but not including land acquisition. Additional monitoring will require $1,000 once every five years, during years 11 to 15 and 16 to 20.
10	This plan projects $20,000 in USFWS staff time to prepare a post-delisting monitoring plan at the end of the 20-year recovery time frame.

V. LITERATURE CITED.

Alverson, S.A., B.A. Whitlock, R. Nyffeler, C. Bayer, and D.A. Baum. 1999. Phylogeny of the core Malvales: Evidence from ndhF sequence data. American Journal of Botany 86: 1474-1486.

Anderson, E.F. 2001. The Cactus Family. Timber Press, Portland, OR. 776 pp.

Archer, S., C. Scifres, C.R. Bassham, and R. Maggio. 1988. Autogenic succession in a subtropical savanna: conversion of grassland to thorn woodland. Ecological Monographs 58(2):111-127.

Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. Pp. 3-30 *in* D.A. Falk and K.E. Holsinger (eds.), Genetics and Conservation of Rare Plants. Oxford University Press, New York, New York. 283 pp.

Berlandier, J.L. 1850. Diario de Viage de la Comisión de Límites que Puso del Gobierno de la Republica, Bajo la Dirección del Exmo. Sr. General de División D. Manuel de Mier y Terán. Tipografia de Juan de Navarro. Mexico.

Berlandier, J.L. 1980. Journey to Mexico During the Years 1826 to 1834. Vol. I & II. Trans. S. M. Ohlendorf. The Texas State Historical Association and University of Texas. Austin, Texas.

Best, C. 1994. *Ayenia limitaris*; *Manihot walkerae*; *Esenbeckia runyonii*; *Asclepias prostrata*; NAFTA-Mexico funding. Memorandum to Mike Bryant, Angela Brooks, Doug Ryan, Larry Ditto, and Bill Carr. November 14, 1994. 4 pp.

Best, C. 2004. Native grassland and savanna management plan (draft), Lower Rio Grande Valley NWR. October, 2004. 46 pp.

Best, C. 2005. Rancho Loreto trip report. Internal document submitted to Jeff Rupert (Refuge Manager) et al. April 18, 2005. 8 pp. + Excel spreadsheet.

Best, C. 2007. Email and attached spreadsheet and maps from Chris Best, USFWS, to Rev. Larry Howard, United Methodist Church, et al. *Ayenia limitaris* survey at Methodist Camp Thicket, Oct 30-07. November 9, 2007.

Best, C. 2009. Fighting weeds with weeds: Battling invasive grasses in the Rio Grande delta of Texas. Pp 307-317 *in* T.R. VanDevender, F.J. Espinosa-García, B.L. Harper-Lore, and T. Hubbard (eds.), Invasive Plants on the Move: Controlling them in North America. Based on presentations from the Weeds Across Borders 2006 Conference. Arizona-Sonora Desert Museum, Tucson, AZ.

Blair, W.F. 1950. The biotic provinces of Texas. Texas Journal of Science 2: 93-117.

Bogusch, E.R. 1952. Brush invasion in the Rio Grande plain of Texas. The Texas Journal of Science 1:85-91.

Bureau of Economic Geology. 2005. The Geological Atlas of Texas: McAllen – Brownsville (1976), 1:250,000 maps. University of Texas. Austin.

Carr, W.R. 1995. Section 6 Project 51: Rare plant survey of Lower Rio Grande NWR. Final Report. Texas Parks and Wildlife Department. Austin, TX.

Carr, W.R. 2002. Notes on some plant species of interest at C.B. Wood Park, Harlingen, Cameron County, TX, 26 February 2002. The Kiskadee (Newsletter of the Arroyo Colorado Audubon Society of Harlingen, Texas) 3:4-5.

Carr, W.R. 2003a. Notes on a visit to the **** property, Cameron County, Texas, 19 February 2003. The Nature Conservancy. Internal Document. 10 pp.

Carr, W.R. 2003b. Plant species observed during surveys of private land in Willacy County. The Nature Conservancy. xcerpts of internal reports. 1 p.

Carr, W.R. 2005. Rare plants of the Tamaulipan thornscrub ecoregion of Texas. http://www.abisw.org/tt/plants/index.htm. Accessed: March 3, 2010.

Center for Plant Conservation. 1996. Guidelines for developing a rare plant reintroduction program. pp 453 – 490 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, DC. 505 pp.

Center for Plant Conservation. 2010. *Ayenia limitaris*. http://www.centerforplantconservation.org/collection/NationalCollection.asp. Accessed: March 3, 2010.

Clinton, President William J. 1999. Executive Order 13112 on invasive species. 64 FR:6183-6186. February 3, 1999.

Clover, E.U. 1937. Vegetational survey of the Lower Rio Grande Valley, Texas. Madroño 4: 41-66, 77-100.

Comisión Nacional de Áreas Naturales Protegidas. 2006. Estudio Previo Justificativo para el establecimiento de la Reserva de la Biosfera Sierra de Tamaulipas. México, D.F., 89 pp.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. 2009. Red Mundial de Información sobre Biodiversidad. Search on *Ayenia* and *Ayenia limitaris*. http://www.conabio.gob.mx/remib/doctos/remib_esp.html. Accessed December 15, 2009.

Contreras-Arquieta, A. 2005. Section 6 Project E-34: Status, distribution and conservation of three species of rare plants of the Lower Rio Grande in Mexico. Final Report. Pronatura Noreste a.c. Monterrey, Nuevo León. 101 pp + 7 appendices.

Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. University of Texas at Dallas, Richardson, Texas. 1881 pp.

Cristóbal, C.L. 1960. Revisión del género *Ayenia* L. (Sterculiaceae). Opera Lilloana 4:1-230.

Damude, N. and J. Poole. 1990. Status report on *Ayenia limitaris*. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 41 pp., 4 maps.

Davis, H.B. 1936. Life and Work of Cyrus Guernsey Pringle. University of Vermont. Burlington.

Diamond, D.D., D.H. Riskind, and S.L. Orzell. 1987. A framework for plant community classification and conservation in Texas. Texas Journal of Science 39:203-221.

Dice, L.R. 1943. The Biotic Provinces of North America. Univ. Mich. Press, Ann Arbor. 78 pp, 1 map.

Dorr, L.J. and L.C. Barnett. 1986. The identity of *Nephropetalum* (Sterculiaceae). Taxon 35:163-164.

Edmands, S. 2007. Between a rock and a hard place: evaluating the relative risks of inbreeding and outbreeding for conservation and management. Molecular Ecology 16:463-475.

Evans, C. 1999. Endangered plants – Texas Ayenia. Interoffice memo from Carol Evans, USFWS, to Tom Serrota, Field Supervisor, USFWS. 1 p.

Everitt, J. 2010. Email from James Everitt, USDA (retired) to Chris Best, USFWS. RE: *Ayenia limitaris* @ Methodist Camp Thicket. January 15, 2010.

Falk, D.A., C.I. Millar, and M. Olwell (eds.). 1996. Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington D.C. 505 pp.

Frankham, R., J.D. Ballou, M.D.B. Eldridge, R.C. Lacy, K. Ralls, M.R. Dudash, and C.B. Fenster. 2011. Predicting the probability of outbreeding depression. Conservation Biology 25:465-475.

French, C.D. and C.J. Shenk. 2005. Geology of the Gulf of Mexico Region (Geolmexg) shapefile. U.S. Geological Survey, Central Energy Resources Team. Denver, CO. http://energy.cr.usgs.gov/. Accessed: October 29, 2008.

Godefroid, S., C. Piazza, G. Rossi, S. Buord, A.-D. Stevens, R. Aguraiuja, C. Cowell, C.W. Weekley, G. Vogg, J.M. Iriondo, I. Johnson, B. Dixon, D. Gordon, S. Magnanon, B. Valentin, K. Bjureke, R. Koopman, M. Vicens, M. Virevaire, and T. Vanderborght. 2011. How successful are plant species reintroductions? Biological Conservation 144:672-682.

Hathcock, C.R., C.J. Perez, and R.X. Barry. 2012. Physiographic zones of the Lower Rio Grande Valley, Texas. U.S. Fish and Wildlife Service, South Texas Refuge Complex, Alamo, Texas. 17 pp.

Havens, K., E. O. Guerrant Jr., M. Maunder, and P. Vitt. 2004. Appendix 3. Guidelines for Ex Situ Conservation Collection Management: Minimizing risks. Pp. 454-473 *in* E.O. Guerrant Jr., K. Havens, and M. Maunder (eds.), Ex-Situ Plant Conservation: Supporting species survival in the wild. Island Press, Washington DC. 504 pp.

Ideker, J. 1994. Field observations on *Ayenia limitaris*, an endangered species. Report submitted for U.S. Fish and Wildlife Service Contract no. 20181-3-0974. Edinburg, Texas. 21 pp.

Inglis, J.M. 1961. A history of vegetation on the Rio Grande Plain. Bulletin No. 45. Texas Parks and Wildlife Department. Austin, Texas. 122 pp.

Integrated Taxonomic Information Service. 2009. *Ayenia limitaris* Cristóbal. http://www.itis.gov. Accessed 15 December, 2009.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Intergovernmental Panel on Climate Change. 2013. Summary for Policymakers. *In* T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 29 pp.

Jahrsdoerfer, S.E. and D.M. Leslie, Jr. 1988. Tamaulipan brushland of the Lower Rio Grande Valley of South Texas: Description, human impacts, and management options. U.S. Fish and Wildlife Service, Biological Report. 88. 63 pp.

Janssen, G.K. 2006. Section 6 Project E-28: Lower Rio Grande Valley Candidate Conservation Agreements. Final Report, August 2006. 42 pp.

Johnston, M.C. 1963. Past and present grasslands of southern Texas and northeastern Mexico. Ecology 44(3):456 – 466.

Lehman, V.W. 1969. Forgotten Legions: Sheep in the Rio Grande Plain of Texas. Texas Western Press, El Paso.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: Toward re-evaluation of IUCN threatened species categories. Conservation Biology 5:148-157.

Martínez-Avalos, J.G. 2012. Email from José Guadalulpe Martínez-Avalos, Universidad Autónoma de Tamaulipas, to Chris Best, USFWS. RE: Información actualizada sobre ANP Sierra de Tamaulipas. December 29, 2012.

Mayr, E. 1942. Systematics and the Origin of Species. Columbia University Press, New York.

McClintock, W.A. 1930. Journal of a trip through Texas and northern Mexico in 1846-47. Southwestern Historical Quarterly 34(1-3):20-27, 141-158, and 231-256.

Mier y Terán, M. 2000. Texas by Terán: The diary kept by General Manuel de Mier y Terán on his 1828 inspection of Texas. Edited by J. Jackson, translated by J. Wheat. Botanical notes by S. Cheatham and L. Marshall. The University of Texas Press. Austin, Texas.

National Climate Data Center. 2010a. Climatological Data Annual Summary, Texas, 1998. Volume 103, no. 13. ISSN 0364-6041. http://www1.ncdc.noaa.gov/pub/orders/C30183E3-9A13-8A2D-038A-C640A398520E.PDF. Accessed February 12, 2010.

National Climate Data Center. 2010b. Normal Precipitation 1971 – 2000. http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmpcp.txt. Accessed February 23, 2010.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1990. Endangered and threatened species; listing and recovery priority guidelines. 55 FR:24296-24298. June 15, 1990.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2010. Interim endangered and threatened species recovery planning guidance. Version 1.3. http://www.nmfs.noaa.gov/pr/recovery/. Accessed: January 10, 2011.

Natural Resources Conservation Service. 2009. The PLANTS Database. *Ayenia limitaris* Cristóbal. Rio Grande Ayenia. http://plants.usda.gov/. Accessed: 15 December, 2009. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

NatureServe. 2002. NatureServe Element Occurrence Standard. http://www.natureserve.org/prodServices/eodata.jsp. Accessed: June 26, 2009.

NatureServe. 2009. *Ayenia limitaris* Cristobal. http://www.natureserve.org/explorer. Accessed: 15 December, 2009.

NatureServe. 2010. Glossary. http://www.natureserve.org/explorer/glossary/gloss_a.htm. Accessed: March 5, 2010.

NatureServe. 2013a. *Ebenopsis ebano - Ehretia anacua* / *Condalia hookeri* Forest. http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol. Accessed: April 1, 2013.

NatureServe. 2013b. *Ebenopsis ebano - Phaulothamnus spinescens* Scrub. http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol. Accessed: April 1, 2013.

Pavlik, B.M. 1996. Defining and Measuring Success. Pp. 127-155 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Pepper, A. 2010. Section 6 Project TX E-89-R: The genetic status of the bracted twistflower, *Streptanthus bracteatus* (Brassicaceae), an imperiled species of the Balcones canyonlands. Final Report. 24 pp.

Poole, J., W. Carr, D. Price, and J. Singhurst. 2007. The Rare Plants of Texas. Texas A&M University Press. College Station, Texas. 640 pp.

Price, D.M. 2006. Section 6 Project E-28: Lower Rio Grande Valley Candidate Conservation Agreements. Attachment A: Summary of Final Report. August 31, 2006. 6 pp.

Robinson, B.L. and J.M. Greenman. 1896. A new genus of Sterculiaceae, and some other noteworthy plants. Botanical Gazette (Crawfordsville) 22:168-170.

Scifres, C.J. and W.T. Hamilton. 1993. Prescribed Burning for Brushland Management: The south Texas example. Texas A&M University Press. College Station, Texas. 246 pp.

Secretaría de Medio Ambiente y Recursos Naturales. 2010. Normas Oficiales Vigentes Ordenadas por Materia. NOM-059-ECOL-2001. http://www.semarnat.gob.mx/leyesynormas/Pages/normasoficialesmexicanasvigentes.aspx. México, D. F. Accessed March 5, 2010.

Shaffer, M.L. and B.A. Stein. 2000. Safeguarding our precious heritage. Pages 301–321 in B.A. Stein, L.S. Kutner, and J.S. Adams, eds. Precious Heritage: The Status of Biodiversity in the United States. Oxford (UK): Oxford University Press.

South Texas Plant Recovery Team. 2011. Meeting notes summary of meeting held at the North American Butterfly Center, January 18, 2011. 6 pp.

South Texas Plant Recovery Team. 2013. Meeting notes summary of meeting held at Estero Llano Grande State Park, November 20, 2013.

Stevens, P.F. 2012. Angiosperm Phylogeny Website. Version 12, July, 2012. http://www.mobot.org/MOBOT/research/APweb. Accessed December 10, 2013.

Texas Agricultural Extension Service. 1980. Prescribed range burning in the coastal prairie and eastern Rio Grande Plains of Texas. Proceedings of a symposium held October 16, 1980 at Kingsville, Texas. Edited by C.W. Hanselka.

Texas Natural Diversity Database. 2009. Element occurrence printouts for *Ayenia limitaris*. Wildlife Diversity Program of Texas Parks and Wildlife Department. October 28, 2009.

Tropicos. 2009. Missouri Botanical Garden. *Ayenia limitaris* Cristóbal. http://www.tropicos.org/NameDetails.aspx?nameid=30400648. Accessed: December 15, 2009.

Tropicos. 2013a. *Ayenia berlandieri* S. Watson. http://www.tropicos.org/Name/30401667. Accessed: April 1, 2013.

Tropicos. 2013b. *Ayenia mexicana* Turcz. http://www.tropicos.org/Name/30400417. Accessed: April 1, 2013.

Tropicos. 2013c. *Ayenia jaliscana* S. Watson. http://www.tropicos.org/Name/50151652. Accessed: April 1, 2013.

University of California. 2010. Museum of Paleontology. UCMP Glossary. www.ucmp.berkeley.edu/glossary/glossary/html. Accessed: March 11, 2010.

University of Texas. 2010. Flora of Texas Database. Plant Resources Center. Specimen search on *Ayenia limitaris*. http://www.biosci.utexas.edu/prc/Tex.html. Accessed March 10, 2010.

U.S. Congress. 1988. Endangered Species Act of 1973, as amended through the 100th Congress. U.S. Government Printing Office, Washington, D.C.

U.S. Department of Agriculture. 1981. Soil Survey of Hidalgo County, Texas. Soil Conservation Service. 171 pp. and 126 maps.

U.S. Department of Agriculture. 1982. Soil survey of Willacy County, Texas. Soil Conservation Service. 137 pp and 42 maps.

U.S. Department of Homeland Security, U.S. Customs and Border Protection, and U.S. Border Patrol Rio Grande Valley Sector. 2008. Biological Resources Plan for Construction, Operation, and Maintenance of Tactical Infrastructure for Rio Grande Valley Sector, Texas. Prepared in July 2008.

U.S. Fish and Wildlife Service. 1993. U.S. Fish and Wildlife Service Cooperative Programs with Mexico 1992 – 1993. 34 pp.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered status for the plants *Ayenia limitaris* (Texas Ayenia) and *Ambrosia cheiranthifolia* (South Texas Ambrosia). Final rule. 59 FR:43648-43652, August 24, 1994.

U.S. Fish and Wildlife Service. 1995. *Ayenia limitaris* recovery plan. Technical/agency draft – April 1995. Prepared by Sarah L. Kowalski. 12 pp.

U.S. Fish and Wildlife Service. 2004. Intra-Service Section 7 Biological Evaluation Form. Submitted to Corpus Christi Ecological Services Field Office, July 2, 2004.

U.S. Fish and Wildlife Service. 2009. Cooperative Endangered Species Conservation Fund (Section 6 of the ESA). http://www.fws.gov/endangered/factsheets/Sec6_Factsheet_2009.pdf. Accessed June 20, 2009.

U.S. Fish and Wildlife Service. 2010a. Species Profile: Texas ayenia (*Ayenia limitaris*). http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q2XW. Accessed: March 3, 2010.

U.S. Fish and Wildlife Service. 2010b. Five-year review of Texas Ayenia (Tamaulipan kidneypetal) *Ayenia limitaris* Cristóbal. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 49 pp.

U.S. Fish and Wildlife Service. 2012. Annual report of lands under control of the fish and wildlife service as of September 30, 2012. Appendix Table 3: National Wildlife Refuges. Division of Realty, U.S. Fish and Wildlife Service. 56 pp.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2000. Policy regarding controlled propagation of species listed under the Endangered Species Act. 65 FR:56916-56922. September 20, 2000.

U.S. Geological Survey. 2016. National Climate Change Viewer. http://www.usgs.gov/climate_landscape/clu_rd/nccv/viewer.asp. Accessed: January 20, 2016.

Wahl, K. 2010. Email from Kim Wahl, USFWS and attached Excel file and Shapefile sent to Chris Best, USFWS. Re: Teniente Ayenia. January 15, 2010.

White, P.S. 1996. Spatial and Biological Scales in Reintroduction. Pp. 49-86 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Whitlock, B.A., C. Bayer, and D.A. Baum. 2001. Phylogenetic relationships and floral evolution of the Byttnerioideae ("Sterculiaceae" or Malvaceae s.l.) based on sequences of the chloroplast gene, ndhF. Systematic Botany 26:420 – 437.

Whitlock, B.A. and A.M. Hale. 2011. The Phylogeny of *Ayenia* , *Byttneria*, and *Rayleya* (Malvaceae s. l.) and its Implications for the Evolution of Growth Forms. Systematic Botany 36:129-136.

Wikipedia. 2013. http://www.wikipedia.org. Accessed March 28, 2013.

Williams, L. 2006. Section 6 Project E-28: Lower Rio Grande Valley Candidate Plant Conservation Agreements. Final Report, May 1, 2002 – August 31, 2006. 12 pp.

VI. MONITORING PROTOCOLS.

Tamaulipan kidneypetal often has an irregular, patchy distribution within habitats, which makes it difficult to quantify population sizes accurately and consistently. Assessments of habitat composition and structure also require detailed descriptions of appropriate methods and parameters. Therefore, the development of a monitoring plan is included within recovery action 2, and guidance is given below.

Quantitative monitoring.

The purpose of quantitative monitoring, as described in the criterion for Objective 3, is to determine the number of mature individuals in populations and demonstrate whether populations are stable, increasing, or decreasing over a specified period of time. Monitoring must be conducted when the plants can be positively identified, and therefore must have living, recognizable foliage; furthermore, at least some individuals in a population must be flowering or fruiting. Quantitative monitoring cannot be conducted effectively when extended drought, freezing weather, excessive browsing, or other factors have induced a dormant condition without identifiable features. In the Rio Grande delta, quantitative monitoring can most often be conducted from late September into early December, but may also be possible from April to July if rainfall has stimulated growth and flowering. The effective monitoring season may extend over longer periods at the southern extent of the species' known range in Tamaulipas, where the climate is more tropical and precipitation is greater. Different monitoring methods, as described below, may be used for relatively small populations (less than approximately 500 individuals), in which every individual may be counted, and for relatively large populations (more than approximately 1,000 individuals), where appropriate sampling methods may be used; see discussion below on the development of a monitoring plan. The area covered by populations and the dispersal through these areas will also influence whether a total count or a sampling method may be used; the choice of methods is at the discretion of field personnel conducting the monitoring.

The following data should be recorded from each small or less dispersed population:

- Site name, ownership, date, personnel conducting the monitoring, and other relevant background information.
- Total count of individuals in the population.
- The geographic coordinates of each plant as determined with a GPS. The estimated precision of the GPS instrument should be indicated on data sheets. Since plants may be clustered within areas that are smaller than the precision of the instrument in use, a single GPS point may be taken for all plants that occur within the radius of precision. A tagged locator stake may be used to indicate the exact position of the GPS point.
- Length of the longest stem of each plant (measured from ground level along the stem to the apical meristem).
- The number of main stems of each individual plant, as characterized by lignified (woody) tissue.
- The reproductive state of each individual plant (vegetative, flowering, or fruiting).

The following data should be recorded from each large or widely dispersed population:

- Site name, ownership, date, personnel conducting the monitoring, and other relevant background information.
- Narrative description of the methods used enabling other personnel in the future to replicate the monitoring consistently.
- The geographic coordinates of polygon(s) encompassing the population, as determined with a GPS. The estimated precision of the GPS instrument should be indicated on data sheets.
- The geographic coordinates of each sampling unit (plot, transect, etc.)
- The number, sizes, and reproductive state of individual plants, as described for small populations, within each sampling unit.
- Description of the sampling and statistical methods used. The methods must be statistically valid for estimating population size.
- Estimates of total population size, the distribution of sizes and reproductive states of individuals, and the statistical confidence intervals of these data.

Optional data that may be collected:

- Reproductive output. An accurate assessment of the reproductive output of individual plants requires multiple visits throughout a fruiting season, since at any given time fruits may be in different developmental stages. Although the number of mature fruit capsules is a convenient indicator, the only direct measure of reproductive output is the number of viable seeds produced in a given span of time (typically one year). Like many plants of regions of sporadic rainfall, Tamaulipan kidneypetal plants may produce mature capsules in which some or all seeds have aborted. This is assumed to be due to insufficient soil moisture, although other factors may be involved. One method for collecting the total seed output is to enclose the developing capsules in nylon mesh (bridal veil) bags that are attached to the stem with fine wire. The nylon bags and capsules are then collected after all capsules have matured.
- Demographic studies require that individual plants are tracked over their life spans. This usually requires that individual plants are labeled with permanent identification tags. Tags may be wired to plant stems, or attached to stakes placed near the base of stems. However, tags tend to attract the attention of persons who might then accidentally or maliciously harm the plants. Therefore, tagging should be done with discretion in areas that are not likely to be visited by the public.
- Assessments of the health and vigor of individual plants may be useful, although dependent on subjective determinations and greatly influenced by recent weather patterns.
- Quantitative investigation of the structure and composition of occupied habitats can reveal important information about the associated vegetation, optimal levels of exposure to sunlight, and the range of suitable habitats. These studies require careful planning of sampling methods and statistical analyses, and the field data collection requires a high level of botanical expertise and is relatively-time consuming. Due to limitations of personnel, time, and funding, it may be feasible to conduct these studies at relatively few sites; therefore, study sites should be chosen carefully.

VII. PHOTOGRAPHIC CREDITS, SCIENTIFIC UNITS, AND ACRONYMS.

Photographic Credits.

Figure 3 Photograph c: Chris Pérez, USFWS.
All other photographs: Chris Best, USFWS.

Scientific Units and Abbreviations.

Ac	Acres	in	inches
Cm	centimeters	km	kilometers
Ft	Ft	m	meters
Ha	Hectares	mi	miles

Acronyms.

Acronym	Full Name
ANP	*Area Natural Protegida*
APFF	*Area de Protección de Flora y Fauna*
CONABIO	*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad*
CONANP	*Comisión Nacional de Areas Naturales Protegidas*
CPC	Center for Plant Conservation
DHS	Department of Homeland Security
ESA	Endangered Species Act
FR	Federal Register
GPS	Global Positioning System
ITESM	*Instituto Tecnológico y de Estudios Superiores de Monterrey*
KMZ	Keyhole Markup language Zipped, a geographic file format used by Google Earth.
LRGV NWR	Lower Rio Grande Valley NWR
MVP	Minimum Viable Population
NABA	North American Butterfly Association
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
PFW	Partners for Fish and Wildlife Program, a USFWS program
RPN	Recovery Priority Number
SEDUMA-Tam	*Secretaría de Desarrollo Urbano y Medio Ambiente* (State Government of Tamaulipas)
SEMARNAT	*Secretaría de Medio Ambiente y Recursos Naturales*
TAMU	Texas A&M University

Acronym	Full Name
TPWD	Texas Parks and Wildlife Department
UANL	*Universidad Autónoma de Nuevo León*
UAT	*Universidad Autónoma de Tamaulipas*
UNAM	*Universidad Nacional Autónoma de México*
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UT	University of Texas
UTPA	University of Texas-Pan American
VCA	Voluntary Conservation Agreement

VIII. GLOSSARY OF SCIENTIFIC AND TECHNICAL TERMS.

Term	Definition
Adventitious	Plant organs that arise from tissues that normally do not produce them (often referring to roots that grow from stems or leaves).
Air-pruned	Silvicultural technique that prevents deformation of the root systems of containerized seedlings by exposing the base of the container to open air.
Allogamy	Sexual reproduction between different, unrelated individuals (out-crossing).
Alluvium	Loose, unconsolidated (not cemented together into a solid rock), soil or sediments, eroded, deposited, and reshaped by water in some form in a non-marine setting (Wikipedia 2013).
Arthropod	Invertebrate animal having an exoskeleton (external skeleton), a segmented body, and jointed appendages; member of the Phylum Arthropoda (Wikipedia 2013).
Augmentation	Introduction of additional individuals or propagules to an existing population.
Axil	Upper angle formed by a leaf or branch with the stem (Correll and Johnston 1979).
Bimodal	Having two distinct probability peaks.
Biotic province	"Considerable and continuous geographic area characterized by the occurrence of one or more ecologic associations…" (Dice 1943). Roughly equivalent to an ecological region.
Browsing	Herbivory of the leaves and stems of woody plants (as opposed to grazing).
Bunch-grass	Grass that reproduces vegetatively through the proliferation of tillers from basal bud primordia.
Chloroplast	A double-membrane organelle found in higher plants in which photosynthesis takes place.
Chromosome	An organized structure of consisting of DNA and protein containing a cell's genes, regulatory elements, and other nucleotide sequences. (Wikipedia 2013).
Clade	The scientific classification of living and fossil organisms to describe a monophyletic group, defined as a group consisting of a single common ancestor and all its descendants (Wikipedia 2013).
Cleistogamy	Sexual reproduction of plants through self-pollination of specialized flowers that do not open.
Cover	See vegetative cover.
Crenate	Having the margin cut with rounded teeth; scalloped (Correll and Johnston 1979).

Term	Definition
Critical habitat	"…(i) the specific areas within the geographical area occupied by the [threatened or endangered] species, at the time it is listed in accordance with the provisions of section 4 of [the ESA], on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of [the ESA], upon a determination by the Secretary that such areas are essential for the conservation of the species." U.S. Congress 1988.
Deciduous	Perennial plants that shed leaves (or other organs) during a portion of the year.
Decumbent	Lying down, but with the tip ascending (Correll and Johnston 1979).
Dehiscent	Structure that naturally splits open along lines of mechanical weakness.
Delist	Remove a species from the list of threatened and endangered species.
Demography	Scientific study of populations.
Dentate	Having the margin cut with sharp salient teeth not directed forward (Correll and Johnston 1979).
Diploid	Organism possessing two replicate sets of chromosomes.
Disjunct	Widely separated portions of a species' range.
Downlist	Reclassify a species from endangered to threatened.
Ecological corridor	A span of habitat that connects larger habitat areas and allows for passage of individuals or gene flow between these areas.
Ecological region	Ecologically and geographically defined area that is smaller than an ecozone and larger than an ecosystem (Wikipedia 2013).
Ecotype	A genotype that is specifically adapted to a particular ecological area.
Effective population size	The size of an idealized population in which individuals contribute equally to the gamete pool and have the same variation in allele frequencies and levels of inbreeding as the observed population (Barrett and Kohn 1991).
Ejido	Collectively-owned agricultural cooperative in Mexico.
Element Occurrence	An area of land and/or water in which a species or natural community is, or was, present (NatureServe 2002).
Endangered	"…any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." U.S. Congress 1988.
Endemic	An organism restricted to a specific habitat or geographic range.
Forb	A broad-leafed herbaceous plant.
Forest	Vegetation composed of 60% to 100% cover of trees (woody plants having a single main bole).
Gene	A specific region of a chromosome that controls a single heritable trait.

Term	Definition
Gene flow	The transfer of alleles or genes from one population to another (Wikipedia 2013).
Genetic swamping	Overwhelming one genotype of a species with far greater numbers of individuals from another genotype.
Geomorphology	The scientific study of landforms and the processes that shape them (Wikipedia 2013); in particular, the surface geology, soils, and drainage.
GPS, d-GPS	Global Positioning System; electronic system for calculating geographic position using satellite data. D-GPS is differentially-corrected GPS, which uses a reference position of known geographic location to increase accuracy.
Habitat	Ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism (Wikipedia 2013).
Historic population	A previously-documented population that has been extirpated or can no longer be found.
Holocene	Geological epoch which began approximately 12,000 years ago (Wikipedia 2013).
Imbibition	Absorption of water by living tissues.
Inbreeding depression	The reduction of fitness caused by mating between relatives (Edmands 2007).
Inflorescence	A plant structure bearing two or more flowers.
Infra-species	A sub-species, variety, ecotype, form, or other recognized subdivision of a species into distinct taxonomic entities.
Introgression	Gene flow from one species into the gene pool of another by the repeated backcrossing of an interspecific hybrid with one of its parent species (Wikipedia 2013). In the context of this plan, introgression may also occur between infra-species.
Invasive	Species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Clinton 1999).
Lenticel	Corky spots on young bark, arising in relation to epidermal stomates (Correll and Johnston 1979).
Lignified	Possessing elevated amounts of lignin, a glue-like substance that characterizes woody tissues of plants.
Meta-population	A group of spatially separated populations of the same species that interact at some level (Wikipedia 2013).
Minimum viable population	The fewest individuals required for a 95% probability of survival over 100 years (Pavlik 1996; Mace and Lande 1991).
Monitor	In the context of this plan, monitoring is the collection of qualitative or quantitative data on known populations of a species or its habitats.

Term	Definition
Monoecious	Plant species that produce both male and female reproductive organs in the same individual.
Monograph	Comprehensive treatise on all the known taxa within a specific taxonomic group.
Monophyly	A group of organisms which consists of all the descendants of a single common ancestor.
Municipio	(Spanish) A political subdivision of a Mexican state; roughly equivalent to a county in the U.S.
ndhF gene	A specific chloroplast gene. The variability of the ndhF gene is useful for studies of the phylogeny of plants.
Niche	The portion of the environment that a species occupies, defined in terms of the conditions under which an organism can survive, and the presence of other competing organisms (University of California 2010).
Node	The joint of a stem; the point of insertion of a leaf or leaves (Correll and Johnston 1979).
Outbreeding depression	The reduction in reproductive fitness in the first or later generations following attempted crossing of populations (Frankham et al. 2011, p. 466).
Pedicel	The stalk of a single flower in a flower cluster or of a spikelet in grasses (Correll and Johnston 1979).
Peduncle	The stem of an inflorescence.
Phenology	Seasonal pattern of plant growth, development and reproduction.
Phylogeny	The study of evolutionary relatedness among various groups of organisms (e.g., species, populations), which is discovered through molecular sequencing data and morphological data matrices (Wikipedia 2013).
Pleistocene	Geological epoch beginning about 2,588,000 years ago and ending about 11,700 years ago (Wikipedia 2013).
Population	Collection of inter-breeding organisms of a particular species (Wikipedia 2013).
Ramet	An individual, genetically-identical plant reproduced as a clone of the parent plant.
Recovery criterion	Value established for each recovery objective to determine when that objective has been reached (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2010).
Recovery priority system.	The system used for assigning recovery priorities to listed species and to recovery tasks. Recovery priority is based on the degree of threat, recovery potential, taxonomic distinctness, and presence of an actual or imminent conflict between the species' conservation, adverse human activities, and other threats (NMFS and USFWS 1990; USFWS and NMFS 2000).
Recovery team	A team of experts appointed by USFWS or NMFS to make recommendations on the recovery of federally-listed species.

Term	Definition
Recovery unit	"...a special unit of the listed entity that is geographically or otherwise identifiable and is essential to the recovery of the entire listed entity." (NMFS and USFWS 2010).
Reintroduction	Restoration of populations of a species where it is currently absent but within its former range and habitat.
Reproduction biology	The scientific study of the reproduction of an organism.
Rhizome	Horizontal stems that grow under the surface of the ground.
Ruderal	Early stage of succession (colonization).
Savanna	Mosaic of trees or shrubs and grassland; between 40% and 10% cover by trees and shrubs (NatureServe 2010).
Scarification	Degradation of an impervious seed coat by physical, chemical, or biological means to allow imbibition.
Section	In botany, a section is a taxonomic rank below the genus and subgenus, but above series and species (Wikipedia 2013).
Section 6	Cooperative Endangered Species Conservation Fund (Section 6 of the ESA). (USFWS 2009)
Semi-arid	Climatic region intermediate between mesic and arid, where moisture is insufficient for plant growth for a portion of the growing season.
Sepal	A leaf or segment of the calyx (Correll and Johnston 1979).
Seral	An intermediate developmental stage in ecological succession (Wikipedia 2013).
Shrubland	Vegetation composed of shrubs (many-stemmed woody plants, generally less than 6 m tall) (NatureServe 2010).
Site	Fairly precise geographic location where one or more individuals of the species have been found.
Soil seed bank	Dormant and non-dormant seeds present in the soil that are able to germinate.
Species	One of the basic units of taxonomic identity (Wikipedia 2013). Multiple species definitions exist, including the biological, phylogenetic, evolutionary, etc. The biological definition ("... groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups" (Mayr 1942)) is adopted in the ESA but does not apply well to all organisms.
Stellate	Star-shaped.
Stratification	Seed treatment consisting of maintaining specific conditions, such as temperature and moisture levels, for specified periods of time.
Sub-population	A distinct portion of a larger population or meta-population.
Sub-shrub	Multi-stemmed woody plant of small stature.
Subtropical	Climatic region intermediate between tropical and temperate, where freezing temperatures occur infrequently and are of limited duration and intensity.

Term	Definition
Survey	In the context of this plan, surveying is the search for new individuals or populations of a species or new habitat occurrences (as distinguished from monitoring).
Synecology	Ecology of groups of coexisting organisms.
Tamaulipan shrubland	The semi-arid, subtropical ecological region of northeast Mexico and south Texas characterized by shrub vegetation.
Taxon	(Plural, taxa). A natural group of organisms at any rank in the taxonomic hierarchy (Anderson 2001).
Taxonomy	Scientific classification of living organisms.
Terminal	Occurring at the distal end of a stem or branch.
Tetraploid	Organism possessing four replicate sets of chromosomes.
Thorn forest	Plant community characterized by spiny trees. As used here, thorn forest is an ecotone between the Tamaulipan shrubland of more arid sites and the mesic riparian forests of river valleys and deltas along the Gulf of Mexico.
Threatened	"…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." U.S. Congress 1988.
Vegetative cover	The proportion of an area that is intercepted vertically by tissues of a specified taxon or type of plants; may exceed 1 due to multiple layers.

Appendix A. Comments on Draft Recovery Plan and Responses

On June 25, 2014 (79 FR 36087), we announced that the Draft Recovery Plan for Tamaulipan Kidneypetal (Texas Ayenia) (*Ayenia limitaris*) was available for public review. We also emailed notifications to 57 individuals and organizations in the U.S. and Mexico that are concerned with native plant conservation. Other peer reviewers are members of the recovery team, and we received and incorporated their comments. We received only one review, from Dr. Norma Fowler, University of Texas-Austin, who would have been invited to be an official peer reviewer of this plan. All other experts are on the recovery team at this time. Dr. Fowler's comments are listed below, followed by our responses (where necessary) in italics; note that page numbers referred to in the draft plan may be different in the final plan.

* * * * * * *

To: Chris Best, USFWS From: Norma Fowler, Ph.D. Date: 23 July 2014

This is a review of the Texas ayenia recovery plan, specifically the draft released 25 June 2014 entitled 'Draft Recovery Plan for the Tamaulipan Kidneypetal (Texas Ayenia) (*Ayenia limitaris*)'.

My review is based upon a careful reading of the document and on my expertise as a conservation biologist and plant ecologist. In that capacity I have been a faculty member of the University of Texas at Austin since 1979; have taught courses in ecology (undergrad), population ecology (grad students), statistics for biology grad students, and conservation biology (grad and undergrad); and have conducted research in the fields of plant population ecology, plant community ecology, and plant conservation biology. These research projects have included studies of several endangered plant species, studies of several non-native invasive plant species, including King Ranch bluestem, studies of the effects of herbivores (deer, cattle) on plants and plant communities, studies of the effects of fire on plants and plant communities, and studies of plant community dynamics. I have not, however, had any direct experience with *Ayenia limitaris*.

My overall evaluation is that this is an excellent recovery plan.

My most serious concern is that the time periods (10 years of monitoring for down-listing, 20 year for de-listing, 10 years for post-de-listing monitoring) are each too short. Given the very large year-to-year and decade-to-decade variation in rainfall in this region, and the long-term nature of the necessary habitat management for this species, these time periods are not sufficiently long to ensure that the species is out of danger.

The number of populations, number of recovery units, and population sizes required by this recovery plan are probably minimal and may be too small. There is little chance that they are too large. See comments below on stochastic population loss and on N_e.

I have also made some technical corrections and suggestions. These do not alter the general reasoning and recommendations of this plan.

My specific comments follow, by page.

p. iii. Note that current habitats may not be optimal. This is a very important point and I was glad to see it made. When a species has declined to this level of rarity, it is very likely that the remaining occupied sites are not optimal habitat, but instead are merely those that have survived by chance. It is also likely that there may be no optimal habitat left, due to decades or even centuries of over-grazing, fire suppression, conversion to agriculture, and non-native invasive species.

Because of this, and because we do not really know the best way to manage Tamaulipan thorn scrub, I strongly support adaptive management for this species: try different management practices, see what works, implement what works, and then repeat the process, over and over. In particular we need to try different methods of invasive species control, and different amounts of woody plant cover.

p. iv. Clarify that the 20 populations must all be protected, either by ownership by an agency that makes their management the top priority, or by long-term conservation agreements.

There is no point in counting unprotected populations on private land. A change in ownership, a change in economic conditions, or a change in residents can lead to the rapid destruction of a population. But perhaps enough (five? ten?) less-than permanent agreements with private land owners could substitute for one protected population, as suggested later in the document.

There is also no point in counting populations on sites on public land (US or Mexican) where *Ayenia* management will be compromised by the use of the land for recreation, management for other endangered species, border enforcement, grazing, and any other uses of public land not fully compatible with management for *Ayenia*. I have, unfortunately, first-hand experience with public land on which recreation or management for other endangered species is leading to the extirpation of ostensibly protected plants.

USFWS response: The recovery criteria listed in the Executive Summary are necessarily brief. Section II.2. (p. 35) defines protected habitats and populations in greater detail.

p. 1. Reword sentence 2 so that 'respectively' refers to Interior versus Commerce, not to threatened versus endangered species.

USFWS response: We clarified by removing the word "respectively".

p. 1. How much protection do the State Park and the County Park population actually have? State and county parks have other priorities, such as recreation, that can harm and even extirpate plant species.

USFWS response: We added statements to section 1.3 to respond to this question.

p. 3. I understand the taxonomic situation with regard to families, but I think many readers will not. The first complete paragraph on this page says *Ayenia* is in the Sterculiaceae. The next paragraph refers to co-occurring species in the Malvaceae. The third paragraph says that Whitlock et al. analyzed plants in the Sterculiaceae, and then says that Stevens put *Ayenia* in Malvaceae. Confusing! All this can be easily sorted out for the reader if somewhere early in this section you say something like this: "some authors put *Ayenia* into the family Sterculiaceae, and others put *Ayenia* into the family Malvaceae, either in tribe Sterculieae (Bayer et al. 1999) or alternatively in the subfamily Sterculiodeae (Wilkie et al. 2006) within the Malvaceae." Check the references; I took them from a different paper.

USFWS response: We added two sentences to the first paragraph mentioned and one to the last to make clear that Ayenia was formerly placed in Sterculiaceae and the family and genus are currently under revision, but the species limitaris is still considered valid.

p. 25. An ongoing problem with allowing compensation (mitigation) for impacts via restoration is that it is very difficult, if not impossible, to restore most kinds of habitat. This problem is by no means limited to *Ayenia*. For example, see J. Zedler's scientific publications about the impossibility of restoring or creating most kinds of wetland habitat (she is probably the country's leading expert in the science of wetland restoration). I, or any other plant conservation biologist, can provide many other examples. Since we don't know exactly what habitat *Ayenia* requires, we don't have a reliable method for controlling or eradicating invasive grasses, and we don't know how to use fire to create or maintain *Ayenia* habitat, I don't think compensation or mitigation by restoring habitat should be included. If it is to be included, then very strict requirements, such as 20 yrs of successful occupation of the site by *Ayenia* without repeated re-planting should be required.

I am strongly in favor of the Refuge's habitat restoration work. I just don't want to have restoration count as mitigation for habitat destruction.

USFWS response: The statements Dr. Fowler refers to (now pp. 25-26) are quoted from the Department of Homeland Security Biological Resource Plan (U. S. Department of Homeland Security et al. 2008) for border wall construction in south Texas. This is described under threat category D as an example of the inadequacy of existing regulations; note that the Real ID Act of 2005 gives DHS authority to waive ESA regulations. Although augmentation and reintroduction are included in the recovery program (recovery actions 9.1 through 9.42), compensation for habitat and population loss is not actually described under this recovery plan; compensation for adverse effects to listed species is normally accomplished through consultations under section 7 of the ESA.

p. 32. The data to calculate effective population size (N_e) do not exist. But whatever N_e is, it is << the number of reproductive individuals. For N_e to equal $N_{\text{reproductive individuals}}$, every individual would have to have the same number of offspring. Reproduction in almost any plant population is highly skewed (log-normally distributed at best; typically even more skewed than that) with a few individuals doing most of the reproduction. As a result, $N_e <<< N_{\text{reproductive individuals}}$ in plant populations.

USFWS response: We agree and have revised this statement to: "We do not possess the data necessary to calculate effective population size for Tamaulipan kidneypetal, but assume that the effective population size is considerably less than the total population of reproductive individuals."

p. 32. Please don't suggest that *Ayenia* is a climax species, even with a question mark. This could be mis-interpreted or mis-used to imply that active management is not required. I agree with the author of this Recovery Plan that *Ayenia* probably requires shrub savanna, not shrubland, and hence requires some sort of repeated disturbances, probably fire or a substitute for fire. If it has to be assigned a successional status, then "fire-disclimax?" would be the appropriate one.

USFWS response: We adopted the term "fire disclimax" for this MVP estimation (now pp. 32-33). The other choice in this method of estimation would be "seral or ruderal", which is clearly less appropriate.

p. 33. The number of viable populations, number of recovery units, and population sizes are probably minimal and may be too small.

Among other reasons for this statement, there is no allowance made for the stochastic loss of populations over time, either by catastrophe or by other types of environmental stochasticity or by demographic stochasticity. Sooner or later, populations will be lost. How will new populations take their place? For any endangered species, we need to think about founding new populations, either naturally (by providing extensive, near-contiguous, suitable but unoccupied habitat into which the species can disperse naturally) or by assisted migration in suitable but unoccupied habitat.

See also comments above about $N_e <<< N_{\text{reproductive individuals}}$.

USFWS response: (Pp. 33-34) The number of recovery units is based on the 3 (or possibly 2) ecologically distinct areas where the species occurs (see discussion in section 11.2, p. 34). If new populations are discovered in new ecologically distinct areas, we will establish additional recovery units. Based on Dr. Fowler's discussion of effective population size (N_e), we have increased the estimated MVP to 500 mature individuals. With regard to the number of populations, we are not aware of a scientific method to determine the minimum number needed to assure long-term survival of a species; in general, more populations (greater redundancy) are better. Although greater population redundancy reduces extinction risk, the degree of separation between populations is also important; there are both advantages and disadvantages to population independence (White 1996). Considering the relatively small scale of the 3 designated recovery units, multiple populations within each unit are not geographically independent. For example, a catastrophic event such as an extended drought or hurricane would probably effect all the populations within a unit. Taking into account the increased MVP criterion of 500 mature individuals, and lacking evidence to the contrary, we believe the criterion of 5 populations per recovery unit, and 20 populations in all, is attainable, realistic, and sufficient for species recovery. Nevertheless, we will revise this criterion to include more populations if, at a future date, we receive data specific to Ayenia limitaris that this number of populations is not sufficient for full species recovery.

p. 33. "The South Texas Plant Recovery Team (2011) recommended that multiple populations are essential to the species' recovery, and that more relatively small populations have greater benefit than fewer large ones." This will not be true if the small populations are too small, so this recommendation should be used with caution. Unfortunately there is no way to know "how small is too small" with available data, but I suspect 250 reproductive individuals is close to "too small."

USFWS response: See our previous response.

p. 33. The last sentence of the second full paragraph should be reworded. As written, it implies that only one population per recovery unit must be protected. Each population of the required 20 populations, and each of the required 5 populations per recovery unit, must be protected.

USFWS response: We inserted "all" before "must be protected...".

p. 33. The term *meta-population* is often used loosely in conservation biology to mean *a spatial cluster of populations*. However it also has a strict definition: a set of populations that have independent dynamics (hence, are not merely sub-populations of a single population) AND have a migration rate among them high enough for recolonization of a site after extinction of the population that was there. This is a difficult criterion to meet: migration rates must not be too high (or you have a single population) or too low (or you just have multiple, separate populations). Since the migration rate of *Ayenia* is not known, I strongly suggest replacing the term *metapopulation* with *spatial cluster of populations* or some such term. This will guard against the inappropriate use of assumption, hypotheses, and results from the metapopulation literature.

USFWS response: We are obliged to preserve the language of the recovery team's recommendation, and additionally, have defined our use of the term "meta-population" in the glossary. As a work-around, we revised the sentence to a more inclusive meaning: meta-population or spatial cluster of populations.

p. 34. See my remarks above about federal, state, or municipal agencies (US or Mexican) that have multiple priorities in land management, some of which may not be fully compatible with *Ayenia.* A population in a park that is being trampled by hikers or dirt-bikers, or over-browsed by deer or goats, is not protected. A population whose habitat cannot be managed successfully because another endangered species with different habitat needs takes priority is not protected. A population that is being trampled, driven-on, etc. due to border issues or due to oil and gas development is not protected. Therefore the first two items in the bulleted list at the bottom of the page should explicitly state that ".... conservation agency that can and will make *Ayenia* conservation and *Ayenia* habitat conservation its top priority in each site occupied by *Ayenia*." I repeat that these are not hypothetical concerns, but come directly from my own first-hand experiences.

USFWS response: We agree. Note that in section II.2 (now pp. 35-36) we defined "protected populations and habitats" as well as "optimal habitats". These are both incorporated into downlisting criterion 2: "At least 10 populations of Tamaulipan kidneypetal, and at least 1 per *recovery unit, are documented in optimal habitats for a period of at least10 years. Habitat is considered optimal when: It is protected for conservation purposes; it is managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal; it has less than 10% cover of introduced invasive plant species; it consists of at least 400 ha (988 ac) of contiguous habitat; and where Tamaulipan kidneypetal populations are observed to be stable or increasing." Criterion 3 (as revised) states: "Protect at least 20 populations, including no fewer than 5 populations per recovery unit. Quantitative monitoring conducted in at least 5 different years over a period of at least 10 years demonstrates that protected populations have no fewer than 500 mature individuals, and are stable or increasing over this time frame. Furthermore, at least one population per recovery unit must have at least 1,000 mature individuals." Thus, downlisting requires at least 20 protected populations, as defined; at least 10 of those must also be in optimal habitats, as defined. We did not require that all 20 populations be in "optimal habitat", since this might exclude protected but not optimal populations on private land, ejidos, or publicly-owned land where Ayenia populations are nevertheless stable or increasing over a period of 10 years. We acknowledge that Ayenia limitaris may be able to maintain healthy populations on lands managed for other purposes; the largest known populations in both the U.S. and Mexico are on well-managed cattle ranches. We don't want to discourage landowners from contributing to the species' recovery.*

Additionally, we do not want to state that conservation agencies will "make Ayenia conservation and Ayenia habitat conservation its top priority in each site occupied by Ayenia." More than one endangered species may be present in the same habitats; indeed, if Ayenia limitaris is confirmed in the Sierra de Tamaulipas, it will share habitats with a number of species protected by the Mexican federal government. Prioritizing the management of one endangered species over another occupying the same habitat is often counter-productive – and endangered plants almost always rank below charismatic megafauna. We prefer statements such as the one from p. 35 (below) that Dr. Fowler concurs with.

p. 35. "managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal" (first full paragraph). I strongly concur. It needs to be emphasized. It is fairly useless to buy land, walk away, and let woody plants and/or non-native grasses take over the site. This is not a hypothetical concern; it has been happening to at least one other endangered Texas plant.

p. 35. "....these practices must be adapted as necessary to promote the species survival; furthermore, the intent to manage such habitats to benefit Tamaulipan kidneypetal must be clearly stated in a management plan or similar document." I strongly concur.

p. 36. Minor technical point. Consider a curving stem. If one observer measures stem length from where it enters the ground to its tip as the chord of the arc, and the other straightens the stem out before measuring it, you can get quite different lengths, which causes data from different years not to be comparable. Specify one or the other.

USFWS response: We agree and edited the protocol (note that this is now on p. 72).

p. 36. Not-so-minor technical point. "Description of the statistical methods used" must include a description of the sampling method, and the sampling must be done in a way that is statistically valid for estimating population size. For example, a common practice which results in useless data is to identify a plant cluster as a polygon around the outermost plants, record its extent (polygon size), and then count the plants in a sample plot in the middle. The true density of plants in the cluster is very much less than the density of plants in the sample plot, but how much less is impossible to know, so despite all the hard work, we have no idea of how many plants are in the cluster. Comparable problems arise at the clusters/population level of sampling, too.

USFWS response: We agree and have revised the protocol (note that this is now on page 73).

p. 37. Technical suggestion. Since light level appears to be very important, and requires less expertise than other vegetation data collection, it should be given priority. It does not have to be measured every year because it probably does not change much between years. The easiest reliable method to assess cover is to use a densiometer held at *Ayenia* plant height, that is, either at the top of an average adult *Ayenia* plant, or halfway between the top of an average plant and the ground. (Record the height at which the reading was taken, and use the same height each year.) Visual estimates of cover are very unreliable and probably not worth doing. Image analysis of photographs requires a special camera lens and special software and is expensive and slow. In any case, we need an *Ayenia*-eye view of the world, which may or may not be human (waist) height.

USFWS response: Assessment of sunlight exposure is included in a non-prioritized list of optional monitoring data (now on pp. 73-74).

p. 40. "2.2. Increase the amount of protected optimal habitat through acquisition of land for conservation purposes, successful habitat restoration on protected lands, or improved management and protection of existing habitat." Both habitat acquisition AND management (and probably restoration, too) will be needed. See comment above the danger of acquiring land and then failing to manage it.

USFWS response: We changed "or" to "and". Also, note that optimal habitat, as defined, is "managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal." Recovery objective 2.2 is now on p. 37-38.

p. 40. "2.4. Determine the best habitat management practices, and implement these practices where this is possible." Former habitat that has been allowed to become a monoculture of non-native grass is useless. So is habitat that has been degraded by over-grazing, over-browsing, trampling, vehicle tracks, etc. into non-habitat. So is habitat that is so dense that light levels are no longer suitable. The phrase "where this is possible" could be mis-used to justify letting this sort of habitat degradation happen. This needs stronger wording, stating that habitat appropriate management is essential.

USFWS response: We revised Objective 2.4 (now on p. 38) as follows:

> *Determine the best Tamaulipan kidneypetal habitat management practices, including the effects of both spontaneous and induced actions, such as wildfire, invasive plants and animals, and herbivory. Promote these practices where occupied habitat is not under*

federal jurisdiction. Implement them on lands under U.S. federal jurisdiction or through voluntary conservation agreements with private landowners, ejidos, or other landowners in the U.S. and Mexico.

While we agree with Dr. Fowler, we want to be careful not to imply that we have authority over private lands or foreign lands where there are endangered plants and their habitats. Although the ESA does not give USFWS this authority, the implication could alarm private landowners and make it more difficult to establish trust with many potential conservation partners.

<u>p. 41.</u> Augmenting natural populations is apparently appealing to many people, but it is rarely useful unless the available habitat has been increased. If the habitat has not been improved, then the added plants will be competing with the existing plants, and density-dependent population dynamics (typically, via competition for resources) will keep the population from growing. Time, money, etc. would be much better directed towards improving and increasing habitat or to creating new populations in suitable habitat. I recommend deleting the reference to augmentation of natural populations.

Augmentation can be useful in certain quite specific situations, usually to increase genetic variation in populations that have suffered from severe loss of genetic variation due to genetic drift and resulting inbreeding depression (e.g., Florida panther). But we have no evidence of this in *Ayenia*. Or you might continue to "augment" an otherwise inviable population in a visitor center garden, where it is maintained for public education rather than conservation.

USFWS response: We agree regarding the constraints of augmentation and the importance of habitat quantity and quality. However, we include augmentation in the recovery plan since it may prove to be an important tool for recovering small or genetically-depleted populations that would otherwise perish. If not included in the plan, it will be much more difficult to obtain funding and approval to conduct augmentation if and when it is needed. The pilot reintroductions carried out at LRGV NWR (section 1.7, pp. 28-30) demonstrate the feasibility of facilitated reintroduction.

<u>p. 42 - 44.</u> Given the natural variability in Texas weather and resulting variability in plant population dynamics, ten years to downlist seems much too short a time period. Likewise, 30 years to delist also seems much too short a time period.

USFWS response: The time frames for downlisting and delisting (now on p. 41) begin once all other recovery objectives are met. Delisting requires that the populations that meet the recovery criteria have been stable or increasing for 20 years. If the plan is fully funded, we project that recovery objectives will be accomplished over a 20-year period; thus, federal protection will extend at least 40 years into the future. Post-delisting monitoring will continue (as described in Recovery Action 10, pp. 53-54) to document populations of Tamaulipan kidneypetal for an additional period of time to be determined at delisting, but not less than (and possibly more than) 10 years. If for some reason populations decline after delisting, the species may again be listed for federal protection.

<u>p. 51.</u> I strongly recommend translating the Recovery Plan into Spanish, for distribution in

Mexico.

Respuesta del USFWS: Estamos de acuerdo con esta recomendación. En caso de que no existieran los recursos para la traducción completa de este Plan, entonces sería de alta prioridad publicar al menos una traducción del resumen ejecutivo.

p. 53. item 8. Something about habitat suitability and the necessity of ongoing management seems to be needed here.

USFWS response: We revised this action (now on p. 50) to include habitat suitability and ongoing management.

p. 54. item 9.3. "Pilot reintroduction can be used to provide data that cannot be obtained from the remaining wild populations, such as the range of suitable soil types, appropriate light levels, pollinator specificity, response to herbicide exposure, fire, drought, etc." I would add to this list: the best season for transplanting, and what proportion of years are likely to result in transplant failure. I would expect winter (Dec-Jan) to be the best season for transplanting, and at best 50% of the years to be suitable for transplanting, probably less. Seeds should be sown whenever they would fall naturally, and the success rate with seeds is likely to be much less than 50% of years.

USFWS response: We added optimal transplant seasons and probability of successful transplanting to the list of potential benefits of pilot reintroductions (now on p. 51).

p. 54. "For example, the fraction of seedlings or propagules that survive to maturity in pilot reintroduction can be used to calculate the number of propagules required to achieve a future population that meets or exceeds the MVP." This is not correct. While the survival rate from seedling to maturity is a very interesting value in its own right, and an important value in any population model used to calculate MVP, it is certainly not sufficient information to calculate MVP. To calculate MVP (i.e., the smallest value of N that results in geometric mean λ $1.0), you must construct and parameterize a full population model. That means that you need estimates for all stages of the life cycle. For example, you have to mark individual plants and record survival/death of each 12 months later. I do this sort of modeling and would be glad to elaborate on the data requirements for such models, but it is rather technical.

USFWS response: Dr. Fowler misinterprets the intent of this statement (now on p. 51). We are not suggesting that the survival percent of seedlings would be used to calculate MVP; rather, it would be used to estimate how many seedlings would be required to reach that objective. To clarify, we revised this sentence, replacing "the MVP" with "an established population size objective."

p. 55. 9.41. See my comments above on why augmenting extant populations is probably a waste of time. You may be able to temporarily increase N via augmentation, but without an increase in resources (habitat), survival and/or fecundity will decrease in a density-dependent fashion, and the increase in N will not be permanent. On the other hand, if you increase resources (perhaps by thinning the overstory and/or removing non-native grasses) the population will increase on its own; this is also part of density-dependent population behavior. The literature on densitydependence in plant populations is substantial, and there is no reason to expect that *Ayenia* will somehow be different from other plant species and be unaffected by resource limitation.

In the same paragraph, it says "....if it is determined that the population to be augmented lacks sufficient genetic diversity to remain viable..." This is essentially impossible to determine without extensive experimentation. Molecular data can tell us how much genetic variation is present, but not whether that genetic variation is in traits that affect the phenotype in ways that increase fitness. Some plant species have successfully survived a genetic bottleneck and do fine with practically no genetic variation, including some weeds. Low genetic variation in a population is a concern, and it is reasonable to introduce additional variation just in case inbreeding depression is occurring, but to determine that inbreeding depression is actually occurring in any given species requires an expensive, extensive research effort.

USFWS response: Recovery Action 9.4.1 is now on p. 52. See our previous response on augmentation.

<u>p. 56.</u> "1) manage the sites for permanent natural resource conservation;" See my comment above about the need to give *Ayenia* management priority over other endangered species, recreation, etc.

USFWS response: (Now on p. 53). As we stated in a previous response, we believe that prioritizing the management of one endangered species over another occupying the same habitat is often counter-productive. We prefer "managed in a manner that promotes the long-term survival of Tamaulipan kidneypetal." This is implied under the third requirement in the list.

<u>p. 56-57.</u> "In consideration of the potential responses of Tamaulipan kidneypetal populations, based on its lifespan, reproductive rate, and demography, to the removal of federal protection, monitoring should be continued for at least 10 years to ensure that the populations and criteria upon which delisting are based continue to be secure." In view of the variability of weather and the need for long-term management, ten years is not enough time to be sure that the species is secure.

USFWS response: Recovery Action 10 (now on pp. 53-54) stipulates that post-delisting monitoring should be continued for <u>at least</u> 10 years, but does not preclude longer monitoring periods. The post-delisting monitoring plan would be established when Tamaulipan kidneypetal is delisted. By that time we will have much more knowledge of the species' population dynamics and other factors that affect its survival, and can make a more rational assessment of the duration of post-delisting monitoring.