Texas Ayenia
(Tamaulipan Kidneypetal)
Ayenia limitaris Cristóbal

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Corpus Christi Ecological Services Field Office
Corpus Christi, Texas
Austin Ecological Services Field Office
Austin, Texas

5-YEAR REVIEW
Texas Ayenia (Tamaulipan Kidneypetal)/*Ayenia limitaris* Cristóbal

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Southwest (Region 2)
Contact: Wendy Brown, Recovery Coordinator, (505) 248-6664;
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Lead Field Office: Corpus Christi Ecological Services Field Office
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1.2 Methodology used to complete the review:

The public notice for this review was published in the *Federal Register* on March 20, 2008 (73 FR 14995). This review considers both new and previously existing information from Federal and state agencies, non-governmental organizations, academia, and the general public. Information used in the preparation of the review includes the Texas Parks and Wildlife Department's (TPWD) Natural Diversity Database (NDD), final reports of section 6-funded projects, monitoring reports, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and Internet web sites. This five-year review was prepared by personnel of Austin Ecological Services Field Office (ESFO) without peer review and in coordination with Corpus Christi ESFO.

1.3 Background:

Ayenia limitaris was federally-listed as endangered without critical habitat on August 24, 1994 (59 FR 43648). The State of Texas listed the species as endangered on January 30, 1997.

For brevity, this report uses the abbreviation "AYELIM" where *Ayenia limitaris* is referred to repeatedly. 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 at the end of this document.

1.3.1 FR Notice citation announcing initiation of this review:

73 Federal Register 14995, March 20, 2008.

1.3.2 Listing history

Original Listing

FR notice: 59 FR 43648
Date listed: August 24, 1994
Entity listed: *Ayenia limitaris* (Texas Ayenia)
Classification: Endangered without Critical Habitat

1.3.3 Associated rulemakings: n/a

1.3.4. Review History.

No previous 5-year review has been conducted for this species. Other review documents include a status report by Damude and Poole (1990).

1.3.5 Species' Recovery Priority Number at start of 5-year review:

The Recovery Priority Number at the start of this review is 5, meaning there is a high degree of threat, the recovery potential is low, and the listed entity is a species.

1.3.6 Recovery Plan or Outline

Name of plan or outline: n/a
Date issued: n/a
Dates of previous revisions, if applicable: n/a

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy.

The Distinct Population Segment policy applies only to vertebrate animals.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan?

No.

2.2.1.1 Does the recovery plan contain objective, measurable criteria?

n/a

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

n/a

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

n/a

However, an internal, draft recovery plan was initiated in 1995, but never completed. We began preparing a new recovery plan concurrently with this five-year review. A draft recovery outline has been written, which we give below, but it has not previously published. The first six actions are practical and appropriate (if not comprehensive) steps toward recovery.

1. Protect Texas ayenia populations in the U.S. and Mexico.
    - 11. Contact landowners and land managers of all known Texas ayenia sites.
        - 111. Educate landowners about the extreme rarity and significance of the Texas ayenia populations on their property.
        - 112. Encourage the establishment of stewardship agreements.
    - 12. Work with landowners to develop and implement management plans for the species.
        - 121. Determine landowner short-term and long-term land use goals and the effect of those goals on Texas ayenia.
        - 122. Develop and implement management plans that are beneficial to the species and acceptable to landowners.
        - 123. Develop a monitoring program to be implemented with voluntary landowner assistance.
    - 13. Enforce applicable laws and regulations.
2. Initiate studies to gather biological information needed for effective management and recovery.
    - 21. Determine habitat requirements.
        - 211. Study soils and underlying geology.
        - 212. Determine the community structure.
        - 213. Study community dynamics/ecology.
            - 2131. Study response to past land use practices.
            - 2132. Study response to fire.
            - 2133. Study interactions with other species (beneficial and negative).
            - 2134. Study the species' response to periodic freezing temperatures.

22. Study population biology.
    221. Do a demographic analysis of populations that are large enough to show some demographic structure.
    222. Characterize phenology and assess most vulnerable stages of this life cycle.
    223. Determine the primary means of reproduction in the wild.
    224. Study pollination biology and determine pollination requirements.
    225. Study seed production and dispersal.
    226. Study seedling recruitment.
23. Study cultivation requirements.

3. Search for new populations.
4. Establish a botanical garden population and seed bank.
5. Conduct a reintroduction program on the Lower Rio Grande Valley National Wildlife Refuge (LRGV NWR) and any state or private lands with suitable habitat volunteered for use.
    51. Appoint a coordinating team to help plan and oversee the reintroduction program.
    52. Incorporate the plan for the reintroduction program into applicable agency land management plans.
    53. Propagate plants for reintroduction.
    54. Do experimental plantings of seeds and various aged individuals at a selected natural site as a pilot project.
    55. Based on the results of Tasks 53 and 54, establish at least twelve reintroduced populations on refuge, state, or private lands.
    56. Develop a long-term monitoring program to assess reintroduction success.
6. Develop a public information and awareness program.
7. Once downlisting is achieved, develop delisting criteria and a post-recovery monitoring plan.

This review documents significant progress over the last 15 years that address or contribute to these recovery actions, which are identified here in italics (*recovery action xxx*).

Recovery team.

The South Texas Plant Conservation Alliance, an informal consortium of botanists and conservation professionals, met on January 22, 2010, to discuss the formation of a south Texas regional multi-species plant recovery team. This multi-species team will focus on recovery of all federally-listed plant species (eight endangered species and one proposed for delisting) in the 34 south Texas counties administered by the Corpus Christi Ecological Services Field Office (*recovery action 51*). Fourteen individuals, representing academic institutions, state and Federal conservation agencies, non-profit conservation organizations, private environmental consultants, and private landowners, have volunteered to

serve on the team; we expect that this team will be officially formed during 2010. Among the first responsibilities of this team will be to review and submit recommendations on the revised draft recovery plan and a controlled propagation and reintroduction plan (*recovery action 52*).

Section 7 consultations.

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973 (as amended through the 108th Congress) states: "Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary…to be critical…" There have been no formal section 7 consultations that involved AYELIM as of the publication of this review.

Section 6-funded grants.

"The Cooperative Endangered Species Conservation Fund (section 6 of the ESA) provides grants to states and territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to states and territories for species and habitat conservation actions on non-Federal lands" (U.S. Fish and Wildlife Service 2009). TPWD and U.S. Fish and Wildlife Service (USFWS) have supported five section 6 grants in Texas that address AYELIM conservation (*recovery actions 11, 111, 112, 121, 21, 3, 6*).

Carr (1995) conducted a two-year survey of plant species of concern at LRGV NWR, but did not observe any populations of AYELIM on refuge tracts at that time. However, one population was later found by refuge personnel in 1998. Poole and Janssen (1997) investigated rare plant species at 150 high-potential sites on Texas highway rights-of-way. They documented 26 species of concern at these sites, including 11 federally-listed plant species, but no AYELIM. Contreras-Arquieta (2005) conducted a three-year survey of U.S.-listed plant species, and other rare plant species, in northeast Mexico (discussed in more detail in section 2.3.1.2). He documented 57 new populations of 6 federally-listed plant species in the States of Tamaulipas and Nuevo León, including 13 new sites for AYELIM. Williams (2006) conducted a 4-year study of rare plants on 50 properties in 6 south Texas counties; 45 of these properties were privately-owned, and the rest were owned by local municipalities. Williams documented AYELIM at one site each in Cameron, Hidalgo, and Willacy Counties, and obtained a signed conservation agreement for a population at C.B. Wood Park, in Harlingen. Section 6 grant no. E-1 (Project WER71) contributed to the creation of Rare Plants of Texas (Poole et al. 2007), an invaluable compilation of data on 232 rare, threatened and endangered plants of Texas, including AYELIM.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Robert Runyon collected AYELIM at least six times in Cameron County, Texas from 1924 to 1963 (University of Texas 2010). His herbarium specimen labels indicate flowering or fruit development in the months of June, July, September, October, and November. He described the habitat as open ground, the edges of thickets, or within thickets, on dry, alluvial clay soils. (*Recovery actions 211, 212, 222*)

Ideker (1994) provided abundant notes on associated plant and insect species, growth rates, and phenology of 22 individual AYELIM plants at the Methodist Camp Thicket, Hidalgo County, Texas (*recovery actions 111, 211, 212, 221, 222*). The United Methodist Church, owner of the property, has provided open access to botanists to survey and investigate this population, and has been an active participant in the conservation of the species and its habitat. Ideker described the 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 described by Diamond et al. (1987). AYELIM and associated shrubs appeared to favor partially shaded niches, rather than growing under either dense or open canopy cover. Guineagrass (*Urochloa maxima*), an introduced, invasive grass, occupied much of the understory and is a serious threat to the AYELIM population. The entire population occurs on Hidalgo sandy clay loam, 0 to 1 percent slope (U.S. Department of Agriculture 1981). Ideker observed 22 arthropod species on AYELIM 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 AYELIM by feeding on aphid parasites. From January 10 to July 15, 1994, 8 AYELIM plants grew an average of 16.0 cm (6.3 in.) taller, while 11 lost an average of 16.1 cm (6.3 in.) in height. During the period of study, plants repeatedly generated new stems and leaves after stems were cut, broken, or defoliated by frost, drought or herbivorous insects.

Damude and Poole (1990) describe the occupied habitat at the Methodist Camp Thicket as a formerly active flood plain formed of Holocene alluvial deposits, and suggest that the species may have been dependent on periodic flooding. However, it should be pointed out that 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 Colorado 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.

More recently (see Section 2.3.1.2), two AYELIM 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. AYELIM plants occurred in the open or in shade, in fine sandy loam soils. Contreras-Arquieta noted that although AYELIM was considered to inhabit the understory of forests, in this study it was found in niches that were more exposed to the sun. Nevertheless, elsewhere he states that the plants were more vigorous in the shade. He subsequently clarified that AYELIM plants favor partially shaded sites where they receive at least some direct sunlight (Contreras-Arquieta, pers. comm. 2005). He documented flowering during the months of March, April, May and August, but did not observe the plants in other months. (*Recovery actions 1, 11, 111, 112, 211, 212, 222, 3*)

A single herbarium specimen from Topia, Durango, Mexico described the habitat as disturbed, grazed, oak woodland with yellow clay soil (see discussion in Section 2.3.1.2). (*Recovery actions 21, 211*)

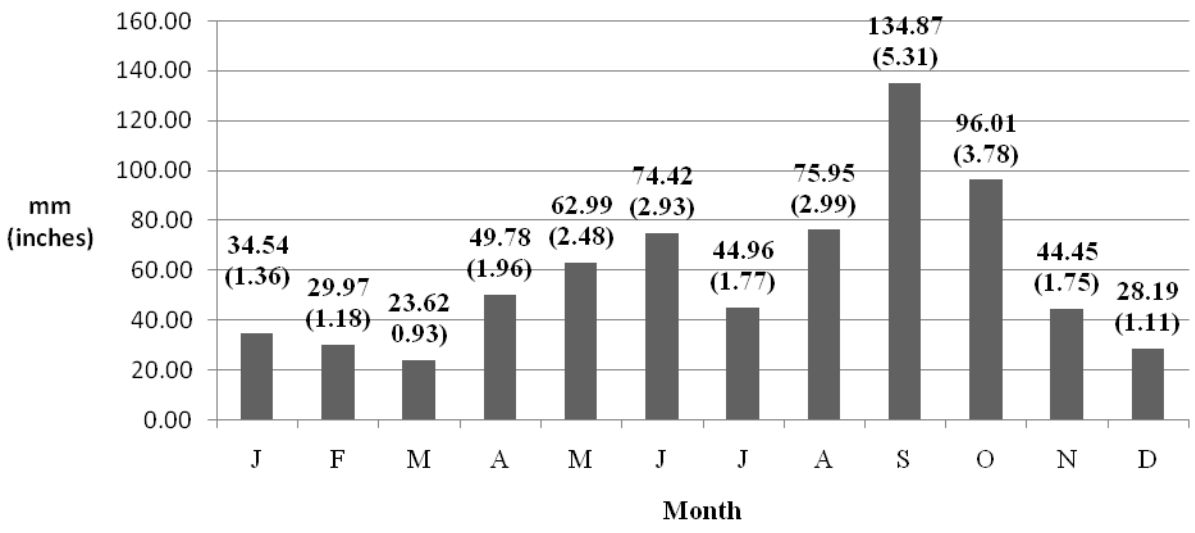
LRGV NWR has been an active participant in efforts to conserve AYELIM since 1992. Refuge personnel collected a total of 93 AYELIM seeds from 7 individual plants at the Methodist Camp Thicket population on November 16, 1992, February 17, 1994, and April 1, 1994 (U.S. Fish and Wildlife Service 1994; Best 2008). A series of germination trials revealed that the seeds germinate readily after scarification. This was initially done with the aid of a dissecting microscope by slicing through the micropylar end or the hilum of the seed coat. Thirty-four individual progeny resulted from these trials, which were planted in 2 seed-increase plots at the restoration nursery at Santa Ana NWR. One of the seed-increase plots was fully shaded; these shaded plants lacked vigor and produced relatively few seeds. The other plot, about 5 m (16.4 ft) from the first plot, received several hours of direct sunlight per day. These plants were much more robust, and produced over 30,000 seeds within 18 months. The main stems of these plants grew horizontally toward areas of direct sunlight; upon reaching sunlight, the lateral branches then grew vertically, functioning as stems. Although the main stems eventually ran along the surface of the ground, and became covered with debris, they did not appear to produce adventitious roots. Within one year, large numbers of AYELIM seedlings began to emerge of their own accord from gravel walkways and surrounding areas of the restoration nursery. (*Recovery actions 225, 4, 53*)

Subsequent germination trials, using seeds produced by these propagated plants, led to a far less labor-intensive seed treatment. This entails treating seeds for 5 minutes in 93% 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. Seeds treated in this way were direct seeded in plant band containers of unsterilized local soil; 70 percent emerged within 7 days. This method enables low-cost propagation of the species for reintroduction. (*Recovery actions 4, 53*)

Twenty AYELIM plants that were propagated at the restoration nursery 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) park, south of Mission, Hidalgo County (U.S. Fish and Wildlife Service 2004). Subsequently, seeds of the original 20 plants continued to germinate from the soil seed bank and establish in the same landscape island and adjacent mowed lawn; 120 AYELIM plants were observed there on October 30, 2009. This site receives six to eight hours of direct sunlight per day. (*Recovery actions 226, 4*)

AYELIM plants in seed-increase plots and the landscape at Santa Ana NWR received no supplemental water after initial establishment. Over a fifteen year period, these plants have exhibited a bimodal phenology. A minor period of flowering and capsule production occurs from May to June, and a more prolific flowering and fruiting lasts from September through November. This pattern coincides with the prevailing bimodal rainfall pattern in the Rio Grande delta (see Table 1.), in which the highest amounts of rainfall occur in May and June and from late August to early November. During seasons when there has been little or no precipitation, AYELIM plants do not flower. (*Recovery actions 222, 4*)

Table 1. Brownsville Normal Precipitation 1971 - 2000 (National Climate Data Center 2010a).



Positive identification of AYELIM plants requires observation of the flowers or capsules. For this reason, the recommended season to conduct field surveys for AYELIM 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, 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.

Several AYELIM pilot reintroduction sites were initiated at LRGV NWR in 1998-1999 (see discussion in Section 2.3.1.2.). Quantitative data collected in October 2008 at the Phillips Banco site indicate that little or no reproduction had occurred at replicates 4 and 5, which are deeply shaded. In contrast, 1.6-fold to 10.1-fold population growth occurred at replicates 1, 2, and 3, where the tree canopy cover is fairly open (see photo 4 in figure 1b). The difference in reproduction could have been due to many factors, but does suggest that optimal AYELIM habitat is not deeply shaded. (*Recovery actions 212, 54*)

The reproductive biology of AYELIM has yet to be investigated. However, 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. Naturally seeded progeny of the propagated plants have been observed up to 21.4 m (70 ft) distant from the nearest planted seedling (see figure L). Intensive searches have not detected any wild AYELIM populations sufficiently close to these propagation sites to have served as sources of unique

pollinators or seed vectors. 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. Therefore, we deduce that AYELIM 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. 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. (*Recovery actions 223, 224, 225, 226, 54*)

In summary, wild populations of AYELIM 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. Propagated AYELIM plants in seed production plots, landscapes and pilot reintroduction sites reproduce successfully in sites that receive at least several hours of direct sunlight daily. Table 2 summarizes the plant species associated with AYELIM at 17 sites reported by Damude and Poole (1990), Ideker (1994), Carr (2002, 2003a, and 2003b) and Contreras-Arquieta (2005) (*recovery action 21*). 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), sugar hackberry (*Celtis laevigata* 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 2. Plant species[1] associated with *Ayenia limitaris*.

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
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					+		0.12
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

Family	*Genus*	*Species*	*Origin*[2]	*Damude & Poole 1990*	*Ideker 1994*	*Carr 2002*	*Carr 2003a*	*Carr 2003b*	*Contreras 2005*[3]	*Frequency*[4]
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*	*hamatacanthus* 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
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

Family	*Genus*	*Species*	*Origin*[2]	*Damude & Poole 1990*	*Ideker 1994*	*Carr 2002*	*Carr 2003a*	*Carr 2003b*	*Contreras 2005*[3]	*Frequency*[4]
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
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	*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
Poaceae	*Urochloa*	*maxima*	I	+	+	+	+			0.18
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

Family	*Genus*	*Species*	*Origin*[2]	*Damude & Poole 1990*	*Ideker 1994*	*Carr 2002*	*Carr 2003a*	*Carr 2003b*	*Contreras 2005*[3]	*Frequency*[4]
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	+						0.00
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
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 species found, from a total of 13 *Ayenia limitaris* 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*.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

The TPWD manages the state's NDD, which compiles data on tracked plant and animal species that is submitted by a vast consortium of Federal, state, academic, non-governmental organizations (NGO), private researchers, and consultants. The NDD tracks 232 rare, threatened, and endangered plant species in Texas, including all 33 federally-listed plant species (24 endangered, 6 threatened, and 3 candidate plant species). The geographic, population, and other relevant data for each species are tracked as element occurrences. "An Element Occurrence (EO) is an area of land and/or water in which a species or natural community is, or was, present" (NatureServe 2002). EOs may consist of one or many "sites" as reported by surveyors. In the geographic information system (GIS) component of the NDD, EOs are displayed as points and polygons buffered by their estimated geographic precision. For this reason, historic reports that do not contain precise geographic coordinates are shown as relatively large polygons, while more recent survey data collected with geographic positioning system (GPS) instruments are represented by smaller polygons. Therefore, it must be understood that the tracked species occur within, but not necessarily throughout, the polygons displayed in the GIS. The NDD is an essential tool for the long-term conservation and management of species at risk. The USFWS makes frequent use of the NDD in listing actions, for planning and tracking recovery of listed species, for section 7 consultations, and for Habitat Conservation Plans.

The most recent NDD update on AYELIM, provided to us on October 28, 2009, does not include population data more recent than 2002 (Texas Natural Diversity Database 2009). Table 4 summarizes the known populations reported in the NDD or obtained from other sources. Figure 3 shows the global range of these populations.

Historic populations in Texas and Mexico

Damude and Poole's (1990) status report lists nine historic records for AYELIM in Texas. Cyrus Pringle collected AYELIM (originally described as *Nephropetalum pringlei*) in 1888 in Hidalgo County (Dorr and Barnett 1986); Tom Patterson, citing Pringle's travel notes in Davis (1936), believes the collection site would have been near the town of Hidalgo (Patterson, pers. comm. 2009). Former Brownsville mayor Robert Runyon collected the species in the vicinities of Olmito, Barreda Station, Los Fresnos, and San Benito, Cameron County. V.L. Cory and an unknown collector contributed two specimens from Brownsville, including the site of Runyon's former house at 812 St. Charles St. Damude and Poole (1990) also list two records from Mexico. The first was made by Ernest G. Marsh, Jr. at Yuda Spring, Múzquiz, Coahuila on September 18, 1936. On September 16, 1981, P.A. Fryxell collected the species in the *Municipio* of Soto la Marina, Tamaulipas, along the road to Tepehuajes, 1.5 km east of its

junction with Highway 180. Damude and Poole (1990) conducted a thorough search of all historic sites in Texas, but found only six individuals of the species at a single site, known as the Methodist Camp Thicket, near Weslaco in Hidalgo County. This site was first reported by Dr. James Everitt of the U.S. Departmernt of Agriculture around 1980 (Everitt, pers. comm. 2010). As of 1990, the Coahuila and Tamaulipas sites had not been monitored since 1936 and 1981, respectively.

Updated status of Texas populations

Ideker (1994) conducted surveys of the Methodist Camp Thicket in 1993 and 1994. He documented 22 individuals there within an area of about 250 m^2; his hand-drawn map includes a scale but is not georeferenced. According to an invoice he submitted, he had found 28 individuals there by the end of 1994. On October 30, 2007, seven botanists from USFWS, TPWD, South Texas College, Gorgas Science Foundation, NABA, and The Nature Conservancy (TNC) re-surveyed the Methodist Camp Thicket, using d-GPS with a precision of about 1.0 m (3.3 ft) to map locations of the plants (Best, pers. comm. 2007). They documented 147 AYELIM plants at 51 GPS positions, including a previously unknown cluster of plants that extends into adjacent property of Estero Llano Grande State Park. The AYELIM 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); 42 individuals (29%) had developing or mature seed capsules, but none were flowering at that time (Best, pers. comm. 2007). On December 8, 2009, USFWS personnel observed 49 AYELIM plants with mature seed capsules at this site, but did not determine the number of non-reproductive plants. (*Recovery actions 123, 221, 222, 3*)

Four new Texas populations have been confirmed since AYELIM was listed as endangered in 1994. On November 18, 1999, Forestry Technician Frank González of LRGV NWR discovered a small population on the refuge's Rudman tract, Willacy County (Evans 1999). Evans states that 92 plants were found at that site, but a subsequent survey found less than 20. USFWS personnel observed 118 live AYELIM plants at this site on December 9, 2009, as well as at least 100 dead but identifiable AYELIM plants (Wahl, pers. comm. 2010). They attributed the recent mortality to the exceptional drought of 2009. 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 AYELIM plants (see Figure 1b), but these plants should recover quickly. (*Recovery actions 2134, 221, 3*)

In about 2001, Mike Heep, a biology instructor from University of Texas-Pan American (UTPA), discovered a population of at least 100 AYELIM at C.B. Wood Municipal Park, in Harlingen (Carr 2002, Williams 2006). In 2003, amateur botanist Christina Mild of Harlingen observed a population of AYELIM on privately-owned land in Cameron County, near the Arroyo Colorado north of

Rio Hondo (Carr 2003a). This landowner has enthusiastically participated in the conservation and monitoring of this population and its habitat (Williams 2006). Mild and USFWS personnel visited the C.B. Wood and Rio Hondo sites on December 8, 2009, where they observed mature seed capsules on 31 and 36 AYELIM plants, respectively. (*Recovery actions 222, 3*)

Bill Carr of TNC reported a population consisting of several thousand individual AYELIM plants on a tract of privately-owned land in Willacy County, about 6.5 km (4.0 mi) northeast of the Rudman tract population (Carr 2003b, Williams 2006). This is the largest known population in the U.S. Although the population has not been monitored since 2003, TNC continues to work with the landowner; a survey has been tentatively scheduled for mid-2010, depending on rainfall (Najera, pers. comm. 2010).

In addition to these documented populations, we have occasionally received credible, confidential reports that other small populations of AYELIM 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. It may be possible to obtain seeds of these undisclosed populations for seed banking and propagation, and perhaps to conserve these sites, by working through intermediaries.

Results of AYELIM Pilot Reintroductions at LRGV NWR

Reintroduction is a component of many recovery plans of federally-listed plants (Center for Plant Conservation 1996). Prior to initiating large-scale reintroductions, feasibility may be tested and techniques perfected through smaller-scale "pilot" reintroductions. The USFWS initiated pilot reintroductions of AYELIM at four federally-owned sites in 1998 and 1999. We report here for the first time the 10-year results of these pilot reintroductions. (R*ecovery action 54*)

The pilot reintroduction sites are tracts of LRGV NWR in Hidalgo and Cameron Counties; the refuge was concurrently revegetating these former row-crop fields with native subtropical trees and shrubs. The USFWS personnel grew AYELIM seedlings, which were progeny of the Methodist Camp Thicket population, at the restoration nursery at Santa Ana NWR (see discussion on propagation in section 2.3.1.1). 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 (produced by Monarch Manufacturing, Inc., Salida, Colorado). 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 AYELIM 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

extreme drought. No measurable precipitation was recorded at the Weslaco meteorological station, 16 km (10 mi) northeast 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 2010). 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 AYELIM plants had survived and reproduced *in situ* at Resaca de los Fresnos and Villa Nueva tracts. Quantitative data (summarized in Table 3) collected from the Phillips Banco site on October 10 - 11, 2008, show that the initial planting of 84 seedlings (17 seedlings in rows 1 – 4 and 16 seedlings in row 5) had by then increased to 295 individuals. (*Recovery action 56*)

Table 3. Size and reproductive state of *Ayenia limitaris* plants detected at Phillips Banco tract pilot reintroduction, October 10 – 11, 2009.

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

Updated status of Mexican populations

On November 12, 1994, Mexican Botanist Francisco González Medrano and Chris Best, USFWS, documented 48 AYELIM plants 0.5 km (0.3 mi) west of the site reported by Paul Fryxell along the Tepehuajes Road, Soto la Marina, Tamaulipas (Best 1994). Because we do not know the geographic precision of Fryxell's reported position, this may be the same location.

Pronatura Noreste A.C., a Mexican non-profit conservation organization, conducted a section 6-funded study of U.S.-listed endangered plants in northeast Mexico from 2003 – 2005 (Contreras-Arquieta 2005). The principal investigator, Alberto Contreras-Arquieta, documented up to 4,000 individual AYELIM 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. Because several of these sites are separated from each other by one km (0.6 mi) or less, Contreras-Arquieta's observations probably are equivalent to nine element occurrences

(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 by 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 some sites had a density of as many as 2,000 individuals per ha (4,942 per ac). Contreras-Arquieta's observations on associated vegetation, soils, phenology, and threats are summarized elsewhere in this review. (*Recovery actions 111, 112, 3*)

Contreras-Arquieta also attempted to relocate the population reported by Marsh in 1936 at Yuda (or Yudo) Spring, Múzquiz, Coahuila. Available maps do not show a spring by this name. 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.

With regard to the mysterious "Yuda Spring," one wonders if Marsh, an anglophone, did not misunderstand the Spanish word *Viuda* (widow), as happened in the naming of the town of Buda, Texas.

Tom Patterson alerted USFWS that the UT-Austin herbarium contained a specimen of AYELIM that had previously been overlooked (Patterson, pers. comm. 2009). This was collected by P. Tenorio L., C. Romero de T., J. Ignacio S., and P. Dávila A. on September 19, 1985, in the vicinity of Topia, Durango (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad 2009). (R*ecovery action 3*)

Summary of abundance and population trends

- Seven sites were reported in Cameron and Hidalgo Counties, Texas, between 1888 and 1963, but AYELIM has not been observed at these sites in 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 was extirpated. Another site was reported in Topia, Durango in 1985, but has not been observed since then; its status is unknown.
- Five extant populations have been observed in Cameron, Hidalgo, and Willacy Counties, Texas, within the last seven years. 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 private land (and includes an adjacent state park) that will likely be acquired and managed by Texas Parks and Wildlife Department. 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.

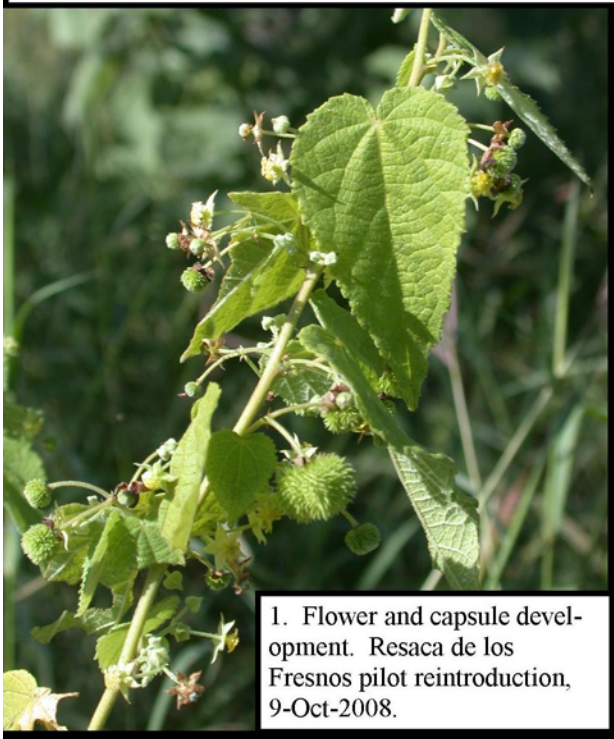
- Three pilot reintroduction sites were successfully established at Lower Rio Grande Valley NWR in 1999. The population at one reintroduction site increased 3.5-fold (from 84 to 295 individuals) by October 2008.

Table 4. Global populations of *Ayenia limitaris*.

Site Name	County / *Municipio*	State, Country	Last Observed	Estimated Population	TPWD NDD E.O. No.	Pronatura Sitio	Citation/Specimen
Hidalgo	Hidalgo	Texas, USA	3-Aug-1888	Unk	n/a	n/a	Pringle 2272, VT; 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	Shiller 103, 765, US 590031, US 590029
Near Olmito	Cameron	Texas, USA	16-Jun-1943	Unk	1	n/a	R. Runyon 3107, TEX 337413
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
Private Property	Willacy	Texas, USA	3-Apr-2003	> 1,000	n/a	n/a	Carr, pers. comm. 2009
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

Site Name	County / *Municipio*	State, Country	Last Observed	Estimated Population	TPWD NDD E.O. No.	Pronatura Sitio	Citation/Specimen
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 pers. comm. 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, pers. comm. 2009
Private Property, N of Rio Hondo	Cameron	Texas, USA	9-Dec-2009	± 100	n/a	n/a	Carr, 2003; this report

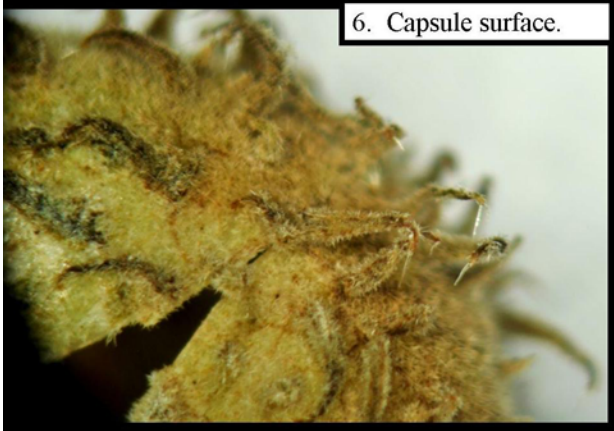
Figure 1a. Identification features of *Ayenia limitaris*.



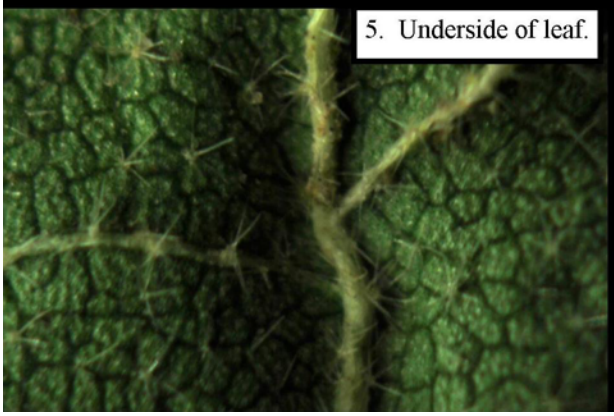
1. Flower and capsule development. Resaca de los Fresnos pilot reintroduction, 9-Oct-2008.

2. Flowers. Restoration nursery at Santa Ana NWR.

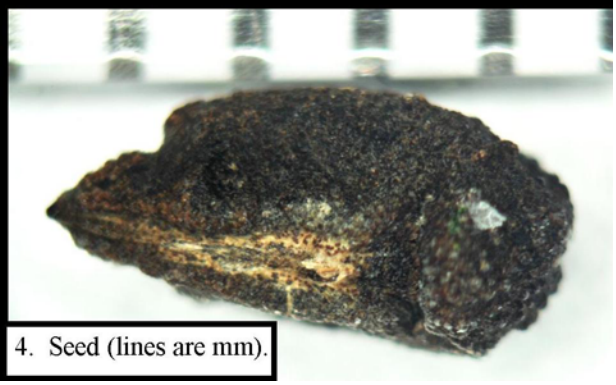
3. Capsules. Methodist Camp Thicket.



6. Capsule surface.

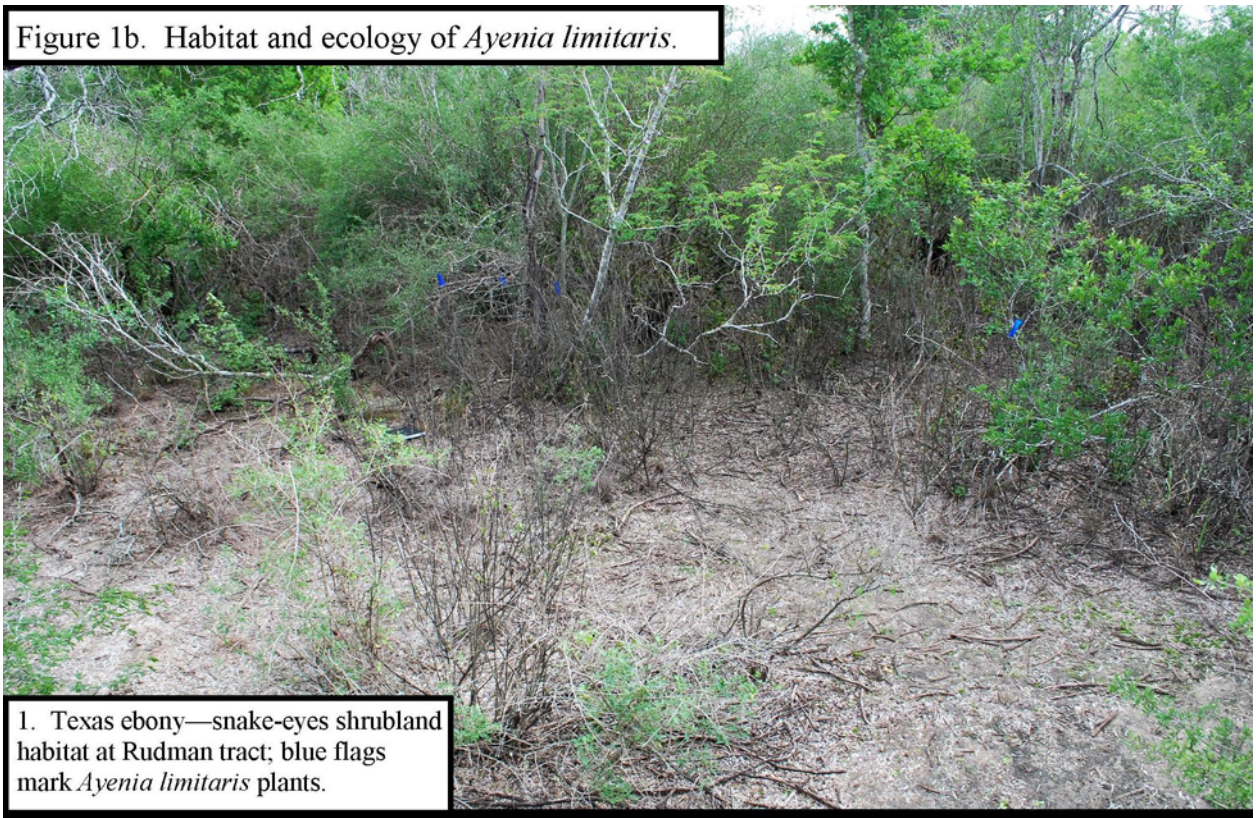


5. Underside of leaf.

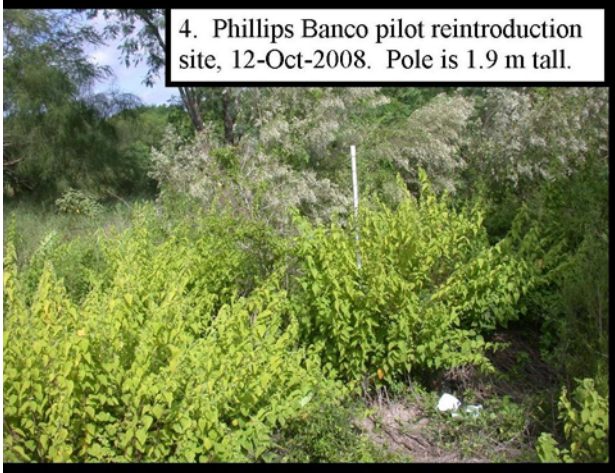


4. Seed (lines are mm).

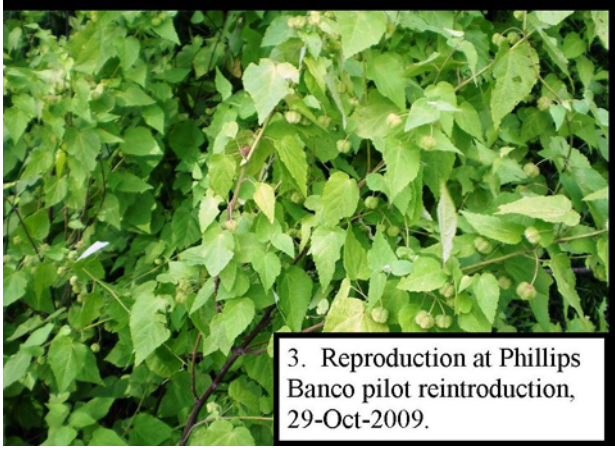
Figure 1b. Habitat and ecology of *Ayenia limitaris*.



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



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



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

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


Figure 2. *Ayenia limitaris* Pilot Reintroduction
Phillips Banco Tract
LRGV NWR
Row 1
Row 2
Row 3
Row 4
Row 5
Native Vegetation
Restoration Site:
6.1 ha (15.1 ac)
Drainage ditch
excavated in 2007
AYELIM Clusters
(1 or more plants)
GPS positions ± 3.0 m
Observed 12-Oct-2008
AYELIM seedlings
planted on 21-Oct-1999
Satellite Image: Google 2010
Image Date: 31-Dec-2008
0 10 20 30 40 50
Meters
1:1,500
5 Replicate Rows:
52 m long
56 m apart
Plant spacing ± 3.3 m

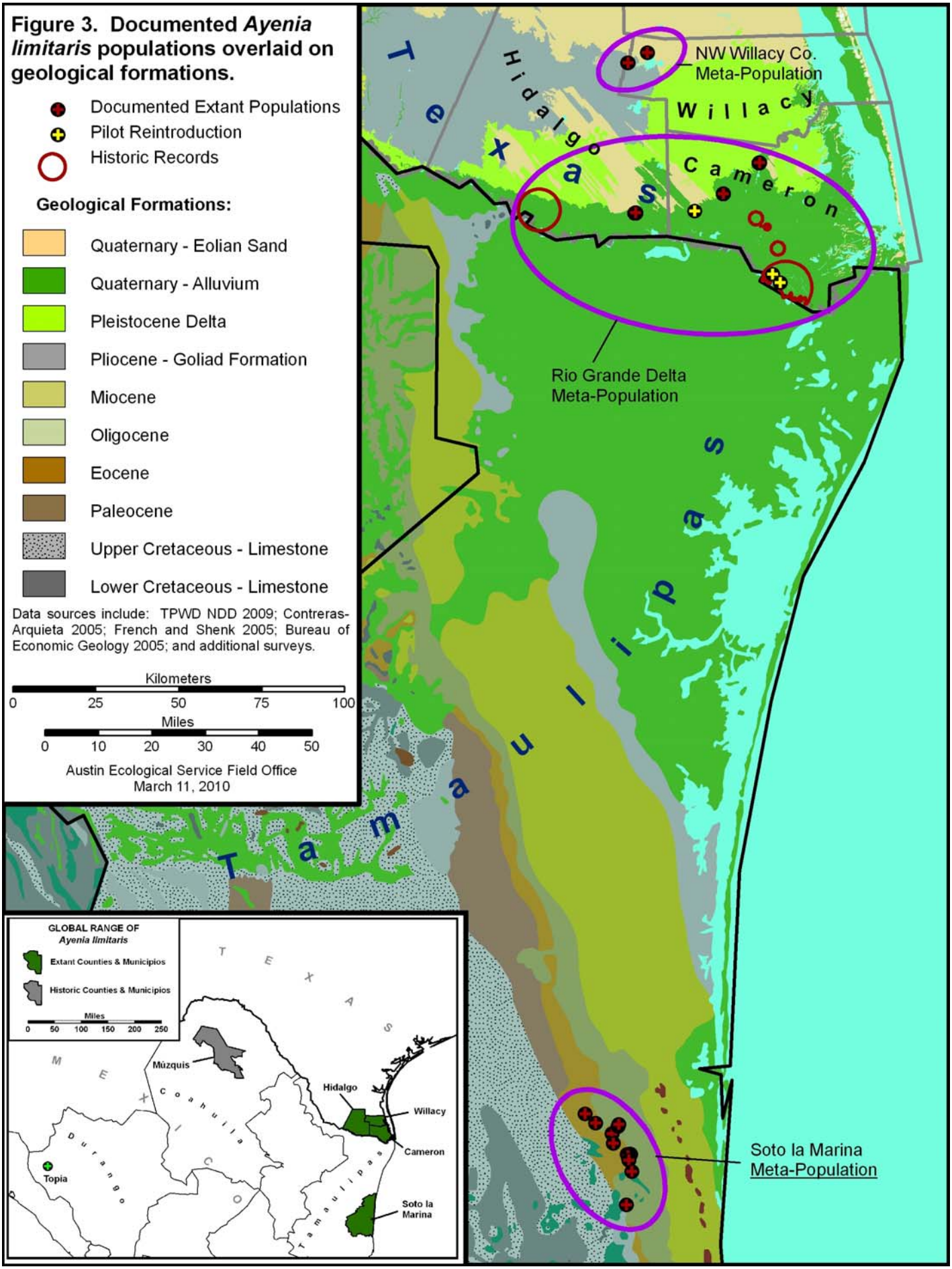


Figure 3. Documented Ayenia limitaris populations overlaid on geological formations.
Documented Extant Populations
Pilot Reintroduction
Historic Records
Geological Formations:
Quaternary - Eolian Sand
Quaternary - Alluvium
Pleistocene Delta
Pliocene - Goliad Formation
Miocene
Oligocene
Eocene
Paleocene
Upper Cretaceous - Limestone
Lower Cretaceous - Limestone
Data sources include: TPWD NDD 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
March 11, 2010
NW Willacy Co. Meta-Population
Rio Grande Delta Meta-Population
Soto la Marina Meta-Population
Texas
Hidalgo
Willacy
Cameron
Tamaulipas
GLOBAL RANGE OF Ayenia limitaris
Extant Counties & Municipios
Historic Counties & Municipios
Miles
0 50 100 150 200 250
Múzquis
Hidalgo
Willacy
Cameron
Topia
Soto la Marina

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Genetic variation within *Ayenia limitaris* 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 10, while the remainder, with 2n = 20, were determined to be tetraploid. Whitlock et al. (2001) analyzed chloroplast *ndhF* gene sequences to determine the phylogeny of a group of plants within the Sterculiaceae (cacao family). They identified a monophyletic clade, which they named Byttnerioideae, which includes the genus *Ayenia*.

2.3.1.4 Taxonomic classification or changes in nomenclature:

Cristóbal's 1960 monograph on the genus *Ayenia*, which first described the species *limitaris* (Cristóbal 1960), continues to be the authoritative treatment of the genus (Tropicos 2009). Dorr and Barnett (1986) established that *Nephropetalum pringlei*, which was collected by C.G. Pringle (Pringle no. 2272) in 1888 and named by Robinson and Greenman (1896), is synonymous with *Ayenia limitaris.* These sources were cited in the status report (Damude and Poole 1990) and the listing (59 FR 43648); there have been no subsequent taxonomic revisions within the genus *Ayenia*. However, because the traditionally circumscribed Sterculiaceae is polyphyletic (Alverson et al. 1999), we may anticipate future taxonomic revisions at the family level.

A number of common names are currently used for *Ayenia limitaris*, with no clear consensus (see Table 5). At a recent meeting of the South Texas Plant Conservation Alliance (see discussion in Section 2.2.3), several botanists who are familiar with the species noted that "Texas Ayenia" and "Rio Grande Ayenia" are misleading, since there are four *Ayenia* species in Texas, and most of the range of *A. limitaris* is in Mexico. They prefer "Tamaulipan kidneypetal," which refers both to the Tamaulipan ecosystem, and to its former genus *Nephropetalum*.

Table 5. Common names used for *Ayenia limitaris*.

Common Name	Citation
Texas Ayenia	Poole et al. 2007, Integrated Taxonomic Information Service 2009, Center for Plant Conservation 2010, NatureServe 2009, U.S. Fish and Wildlife Service 2010
Rio Grande Ayenia	Poole et al. 2007, Integrated Taxonomic Information Service 2009, Natural Resource Conservation Service 2009
Tamaulipan Kidneypetal	Carr 2005, Poole et al. 2007
Kidneypetal	Center for Plant Conservation 2010

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The few reported populations of AYELIM are widely distributed over a geographic range of about 250,000 km^2 (96,525 mi^2) (see Figure 3). The known range in Texas is about 1,760 km^2 (680 mi^2), or about 0.7% 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, but it is considerably more arid and is likely to be very different from the Tamaulipan shrubland habitat of the more recently documented populations. We know only that the Topia site is grazed, degraded oak woodland with yellow clay soil, which is clearly distinct. 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 AYELIM may exist within the known geographic range. The species is easily overlooked, as it resembles many common mallows (Malvaceae). Botanists have intensively searched for AYELIM in the Rio Grande delta for more than 20 years, yet 4 of the 5 known Texas sites were found only in the last 10 years. More than 99% of the species' geographic range lies in Mexico, where botanists have yet to survey vast, remote regions. The AYELIM might also have been misidentified as the more common *A. berlandieri* or another similar species.

Hypothesis 2. The AYELIM 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 undescribed species of *Ayenia* that are similar in appearance to *limitaris*. This hypothesis could be tested through genetic analyses.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

The known Texas populations of AYELIM occur in the *Ebenopsis ebano – Ehretia anacua*/*Condalia hookeri* (Texas ebony – anacua/brasil) forest association and the *Ebenopsis ebano – Phaulothamnus spinescens* (Texas ebony – snake-eyes) shrubland association, as defined by NatureServe (2010). The known Tamaulipan populations occur in essentially the same types of vegetation. The NatureServe conservation status of these vegetation associations is G1 and G2, respectively. A status of G1 indicates that the association is critically imperiled, often with five or fewer global occurrences. A status of G2 stands for globally imperiled, often with 20 or fewer occurrences. 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. The amount of native vegetation that is estimated to be 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 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.

Within the Tamaulipan ecological region, stands of native vegetation on uncleared 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 AYELIM to wildfire has not been investigated. However, we have observed that the species establishes well and reproduces rapidly in disturbed soils. Furthermore, wild populations frequently occur in partial shade, or at the edge of shrub canopies, rather than under dense shrub or forest canopies. It is possible that AYELIM 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 (*Urochloa maxima*) and Kleberg bluestem (*Dichanthium annulatum*) are frequently present in occupied and potential AYELIM habitat. Most guineagrass varieties are erect, heliophilous 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 AYELIM, in partially-shaded niches (Best 2009).

Mexico's Federal agency *Comisión Nacional de Areas Naturales Protegidas* (National Commission on Natural Protected Areas) has recently proposed the creation of a new biosphere reserve in the Sierra de Tamaulipas (Comisión Nacional de Areas Naturales Protegidas 2005). 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 AYELIM. It is possible that additional, undiscovered populations of AYELIM 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 Mexico's Federal government.

The LRGV NWR has actively restored native vegetation on 6,323 ha (15,625 ac) of refuge-owned cropland between 1982 and 2009 (Ewing and Best 2004; Twedt and Best 2004; Best, pers. comm. 2010). The refuge currently owns 2,995 ha (7,400 ac) of cropland, which is revegetated at an annual rate of 172 ha (425 ac); ongoing land acquisition will eventually acquire an additional 14,570 ha (36,000 ac), much of which is likely to be cropland (Barry, pers. comm. 2010). A significant proportion of the land yet to be revegetated at LRGV NWR has soils and general site characteristics suitable for reintroduction of AYELIM. Personnel from LRGV NWR and Austin Ecological Services Field Office met on October 30, 2009, to discuss potential reintroduction of AYELIM and other rare plant species on the refuge. The successful implementation of three pilot

reintroductions on the refuge in 1999 underscores this potential. We concur that a comprehensive reintroduction program at the refuge should be an important component of the species' recovery.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms).

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The single greatest threat to AYELIM is the loss of habitat to agricultural and urban development, as described in Section 2.3.1.6. In the Rio Grande delta of Texas and Tamaulipas, as little as 1% of the original habitat remains intact. In addition to habitat loss, habitat fragmentation and isolation may prevent gene flow among populations and lead to a depletion of genetic diversity. Currently, an unknown 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, however, is subject to destruction driven by economic incentives.

For example, one of five AYELIM populations known in the U.S. occurs at the Methodist Camp Thicket, Hidalgo County, Texas. The United Methodist Church, owner of the property, announced in 2009 that it intended to sell the property. This site borders residential areas of Weslaco and Mercedes, Texas, and is adjacent to a country club and Estero Llano Grande State Park. If the current economic recession had not stemmed recent real estate development, this unique habitat remnant would likely have been lost. In public hearings held on January 26-27, 2010, the TPWD Commission approved acquisition of the property for addition to Estero Llano Grande State Park (Kuhlmann, pers. comm. 2010); TPWD must still raise the necessary funds to complete the acquisition (Keyes, pers. comm. 2010).

Introduced, invasive grass species are extremely abundant throughout the known range of AYELIM, and are a major threat to many plant species as well as entire natural ecosystems. In particular, guineagrass has been recorded at most sites in Texas, and is probably present at all sites in Texas and Tamaulipas. Guineagrass competes directly with AYELIM for the same partially-shaded niches.

Numerous authors (see Section 2.3.1.6) believe that savannas of the Tamaulipan ecological region were converted to dense shrubland and forest as a consequence of poor rangeland management and fire suppression beginning in the mid-eighteenth century. This dramatic shift in vegetation composition and structure and fire dynamics may also have contributed to the decline of the species.

Mexico's Federal government has proposed the establishment of a 290,311-ha (717,359-ac) biosphere reserve in the Sierra de Tamaulipas, near the known meta-

population of AYELIM in the *municipio* of Soto la Marina. If established, this reserve might protect additional populations of AYELIM.

Three of the five known Texas populations of AYELIM occur on private land. The potential threat of the catastrophic loss of any of these populations could be diminished by reintroducing progeny of these populations in appropriate sites at LRGV NWR, in coordination with the refuge's revegetation program. Pilot reintroductions initiated in 1999 demonstrated the feasibility of reintroduction, and the refuge has expressed support for this proposal.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

The AYELIM has no known commercial, recreational, scientific, or educational uses. If the proposed reintroduction program at LRGV NWR is implemented (see Section 2.3.1.6), adherence to the USFWS's policy on controlled propagation of endangered species (65 FR 56916), including the prior approval of a reintroduction plan, will allay potential risks to remaining wild populations.

2.3.2.3 Disease or predation:

Ideker (1994) documented a Homopterid insect called the mealy flata feeding on AYELIM leaves. Damage incurred by this insect appears to be insignificant, and has not been reported subsequently. Contreras-Arquieta (2005) observed several AYELIM 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. However, we have no information on the palatability of AYELIM to livestock, or their impacts on its populations and habitat.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

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 AYELIM 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.

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. The AYELIM was listed as endangered by the State of Texas on January 30, 1997. The State of Texas prohibits taking and/or possession for commercial sale of all or any part of an endangered, threatened, or protected plant from public land. The 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 education purposes. In addition to state endangered species regulations, other state laws may apply. State law prohibits the destruction or removal of any plant species from state lands without a TPWD permit. Three AYELIM populations are known from public lands in the U.S.; one is a municipal park, one occurs in a state park and adjacent private land, and the third is a National Wildlife Refuge (see Section 2.3.1.2).

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 2008). Some of these proposed projects could affect populations and habitat of AYELIM and other endangered plants and animals, both on and off the refuge. The DHS, under authority of the Real ID Act of 2005 (Section 102 of H.R. 1268), waived consultation with the USFWS as 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. The Best Management Practices specific to AYELIM 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 Texas ayenia populations and occupied habitat. Surveys should be conducted on all intact Texas ayenia 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 Texas ayenia 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 Texas ayenia populations and habitat.

Compensation may be accomplished by, but is not limited to, the following methods:

- Texas ayenia habitat that has been destroyed shall be replaced through acquisition and donation of similar quantity and quality of habitat to an approved conservation organization.
- Texas ayenia 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 Texas ayenia population.
- Individual Texas ayenia plants that have been destroyed may be replaced through propagation and reintroduction of Texas ayenia 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 Lower Rio Grande Valley NWR. Compensation for destroyed individuals of Texas ayenia shall consist of five or more propagated, reintroduced plants for each individual destroyed.

About 99% of the potential range of AYELIM occurs in Mexico. However, this species is not listed under Mexico's protected species regulations (Secretaría del Medio Ambiente y Recursos Naturales 2010).

2.3.2.5 Other natural or manmade factors affecting its continued existence:

According to the Intergovernmental Panel on Climate Change (IPCC) (2007, p. 1) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." It is very likely that average Northern Hemisphere temperatures were higher during the second half of the 20th century than during any other 50-year period in the last 500 years; it is also likely that average temperatures during this period were the highest in at least the last 1,300 years (IPCC 2007, p. 1). It is very likely that over the last 50 years, cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007, p. 1). It is likely that heat waves have become more frequent over most land areas, and also that the frequency of heavy precipitation events has increased over most areas (IPCC 2007, p. 1).

The IPCC (2007, p. 6) predicts that changes in the global climate system during the 21st century are very likely to be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C (0.4°F) per decade is projected (IPCC 2007, p. 6). Afterwards, temperature projections increasingly

depend on specific emission scenarios (IPCC 2007, p. 6). The range of emission scenarios suggest that by the end of the 21st century, average global temperatures may increase from 0.6°C to 4.0°C (1.1°F to 7.2°F) with the greatest warming expected over land (IPCC 2007, p. 6-8). Localized projections suggest that the southwestern U.S. may experience the greatest temperature increase of any area in the lower 48 states (IPCC 2007, p. 8). The IPCC says it is very likely that hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007, p. 8). There is also high confidence that many semi-arid areas like the western U.S. will suffer a decrease in water resources due to climate change (IPCC 2007, p. 8). Milly et al. (2005) project a 10 to30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

We do not know whether the climate changes that have already occurred have affected AYELIM populations or distribution, and we cannot predict how the species might be affected by the type and degree of climate changes forecast by the range of models. The currently documented populations all occur within 80 km (50 miles) of the Gulf of Mexico. Rising temperatures might enable the species to survive further north than at present, but might also reduce the southern limit of the range. Similarly, changes in the frequency and amount of precipitation could favor a shift in geographic range or habitat type. However, the discontiguous nature of the populations and potential habitat, the limited seed dispersal range, and the existence of new, anthropogenic barriers to migration could impede alteration of the range. Some climate change models also predict increased precipitation along the Gulf Coast, largely due to increased tropical storm activity and severity (Twilley et al. 2001). The species' range in south Texas and central Tamaulipas could experience both decreased annual precipitation as well as increased storm severity. Changes in temperature and rainfall amounts and patterns could alter the species' competitive advantage in the unique micro-habitats it now inhabits. Regardless of how these changes may affect the autecology of AYELIM, the altered synecology may be far more significant. For example, higher winter temperatures could increase competition from invasive guineagrass. Conversely, higher temperatures and altered rainfall patterns might also stimulate guineagrass parasites and pathogens, thereby reducing competition. At present, we cannot predict how the infinitely complex aggregation of climate change effects will affect the synecology of the species and its habitat. Therefore, we will continue to monitor the species and its habitat, and will adapt our recovery and management strategies when necessary to address the changing conditions.

2.4 Synthesis.

When *Ayenia limitaris* was listed as endangered in 1994, botanists could confirm only a single extant site with six individuals in Texas. Herbarium specimens had also been collected in Mexico's States of Coahuila and Tamaulipas in 1936 and 1981, respectively, but the size and status of those populations was unknown. We learned more recently of another herbarium

specimen from Mexico, collected in Topia, Durango in 1985. In the last decade, botanists have documented populations of *Ayenia limitaris* at 5 sites in Texas, ranging from 100 to over 1,000 individuals, and 15 sites in Tamaulipas (equivalent to 9 element occurrences) totaling about 4,000 individuals. One population, at the Methodist Camp Thicket in Weslaco, Texas, increased from 28 individuals in 1994 to 147 in 2007. Two Texas sites are on protected municipal or Federal conservation land, and three are well-managed private lands whose owners voluntarily protect the habitat (one privately-owned site may be acquired by TPWD for a state park). The Tamaulipas sites are private ranches and *ejidos*; none of these sites are legally protected, nor is the species protected in Mexico. However, a large biosphere reserve has been proposed nearby in the Sierra de Tamaulipas, where additional populations may occur. The Coahuila and Durango sites have not been observed in 74 and 25 years, respectively. The climate, soils, and associated vegetation of these disjunct sites appears to be very different from the sites in Texas and Tamaulipas. If these sites are confirmed as valid populations, the potentially vast geographic and habitat range in Mexico includes many remote regions that have probably not been intensively surveyed.

The known threats to the species are habitat loss for agricultural and urban development, and competition from invasive grasses (principally guineagrass). A region-wide shift in vegetation from shrub savannas to dense shrubland and forest during the last 250 years may also have contributed to the species' decline. Other potential threats include browsing by livestock (principally goats), genetic isolation, and a wide array of potential climate change impacts. Because *Ayenia limitaris* is only known from a few sites in Texas and Mexico, as little as 1% of the original habitat remains intact, and all known populations are still faced with a moderate degree of threats, we recommend that *Ayenia limitaris* continue to be classified as endangered.

Pilot reintroductions at LRGV NWR demonstrate that reintroduced populations can be effectively established at relatively low cost at former cropland sites where native vegetation is being actively restored. If implemented on a larger scale, this would create self-sustaining refugium populations that replicate the genetic compositions of wild populations and reduce the risk of catastrophic loss.

Although we do not recommend a change in classification at this time, additional information as recovery actions are implemented may warrant a recommendation for downlisting to threatened in the next five-year status review.

3.0 RESULTS

3.1 Recommended Classification:

___ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
_ X _ No change is needed

3.2 New Recovery Priority Number: 8C.

Brief Rationale: When listed as endangered in 1994, the only known U.S. population consisted of six individuals, and the status of the only other extant population, in the *municipio* of Soto la Marina, Tamaulipas, was unknown. We have now confirmed 5 sites in the U.S. with populations ranging from 100 to over 1,000 AYELIM plants. In Tamaulipas, a Mexican collaborator documented at least 4,000 individuals in a cluster of sites in Soto la Marina, representing about 9 element occurrences. The species will probably not go extinct in the immediate future, but most of the known sites face a considerable threat to agricultural and urban development; all known populations are also seriously threatened by competition from guineagrass and other introduced invasive grasses. Therefore, the degree of threat is moderate. The discovery of new populations increases the likelihood that the remaining populations have sufficient genetic diversity for long-term survival. Successful pilot reintroductions indicate that a comprehensive reintroduction program could be a valuable tool for recovery. Therefore, the recovery potential is high. *Ayenia limitaris* continues to be recognized as a distinct species. Since most populations occur on private land that is subject to development, "C" indicates that economic pursuits potentially conflict with the species' recovery.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS.

The USFWS is preparing a draft recovery plan for *Ayenia limitaris*. The plan's recovery objectives and criteria will be specific, measurable, achievable, realistic, and time-referenced, in accordance with the revised recovery planning guidance (National Marine Fisheries Service 2007).

The most important recovery actions during the next five years include, but are not limited to, the following:

1. Complete an approved recovery plan for the species.
2. Continue periodic monitoring and surveys of the known populations in Texas and Tamaulipas to track demographic trends, and to detect and attempt to alleviate threats to these populations.
3. Conduct surveys of high-potential habitat within the known range of the species in south Texas and Tamaulipas, focusing on sites that have not previously been surveyed.
4. Survey existing habitats in the *municipios* of Múzquiz, Coahuila and Topia, Durango to attempt to confirm extant populations at those sites.
5. Collect seeds from the known populations and implement a reintroduction program at LRGV NWR, in accordance with USFWS policy on controlled propagation of endangered species (65 FR 56916).
6. Conduct scientific investigations of the species' reproductive biology, the genetic structure of known populations, and the genetic relationship between *Ayenia limitaris* and closely related species.
7. Conduct scientific investigation of the species' ecology, with emphasis on vegetation structure and fire ecology.
8. Conduct public outreach efforts to encourage conservation of the species and its habitat on private lands; establish a private landowner support group.

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PHOTOGRAPHIC CREDITS

Figure 1b. Photograph 3: Chris Pérez, U.S. Fish and Wildlife Service.
All other photographs: Chris Best, U.S. Fish and Wildlife Service.

GLOSSARY OF TECHNICAL TERMS

Adventitious	Plant organs that arise from tissues that normally do not produce them (often referring to roots that grow from stems or leaves).
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 2010).
Arthropod	Invertebrate animal having an exoskeleton (external skeleton), a segmented body, and jointed appendages; member of the Phylum Arthropoda (Wikipedia 2010).
Autecology	Ecology of individual species.
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 (q.v.).
Bunch-grass	Perennial 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	A threadlike linear strand of DNA and associated proteins in the nucleus of eukaryotic cells that carries the genes and functions in the transmission of hereditary information (Farlex, Inc. 2010).
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 2009).
Cleistogamy	Sexual reproduction of plants through self-pollination of specialized flowers that do not open.
Deciduous	Perennial plants that shed leaves (or other organs) during a portion of the year.
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.
Diploid	Organism possessing two replicate sets of chromosomes.
Direct seeding	Direct placement of seeds for germination in a growth medium or a field site (as opposed to transplantation of a germinated plant).
Disjunct	Marked by separation of or from usually contiguous elements (Farlex, Inc.).
Ecological region	Ecologically and geographically defined area that is smaller than an ecozone and larger than an ecosystem (Wikipedia 2010).
Ejido	Collectively-owned agricultural cooperative in Mexico.
Forest	Vegetation composed of 60 to 100 percent cover of trees (woody plants having a single main bole).
Gene	A specific region of a chromosome that controls a single heritable trait.
Georeference	Transformation of a map or image of the Earth's surface to represent the correct geographic positions and scale corresponding to a specified frame of reference.
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 2010).
Heliophily	Requiring full exposure to the sun.
Hilum	Scar on a seed coat at its former point of attachment to the placenta.
Holocene	Geological epoch which began approximately 12,000 years ago (Wikipedia 2010).
Imbibition	Absorption of water by living tissues.
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 (Executive Order 13112 - 64 FR 6183).
Meta-population	A group of spatially separated populations of the same species which interact at some level (Farlex, Inc. 2010).
Micropyle	A pore in the outer layers of a plant ovule through which the pollen tube enters during pollination (Wikipedia 2010). During germination, the radicle may emerge through this pore.
Monograph	Comprehensive treatise on all the known taxa within a specific taxonomic group.
Monophyly	A group of organisms which consists of all the descendents of a single common ancestor.
Municipio	(Spanish) A political subdivision of a Mexican state; roughly equivalent to a county in the U.S.
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).
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 2009).
Polyphyly	A group of organisms whose last common ancestor is not a member of the group (Wikipedia 2009).
Reintroduction	Establishment or restoration of populations of a species within its former range and habitat.
Rhizomatous	Producing rhizomes (horizontal stems that grow under the surface of the ground).
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.
Seed coat	The outer protective layer (testa) of a seed.
Semi-arid	Climatic region intermediate between mesic and arid, where moisture is insufficient for plant growth for a portion of a typical growing season.
Shrubland	Vegetation composed of shrubs (many-stemmed woody plants, generally less than 6 m tall) (NatureServe 2010).
Subtropical	Climatic region intermediate between tropical and temperate, where freezing temperatures occur infrequently and are of limited duration and intensity.
Synecology	Ecology of groups of coexisting organisms.
Taxonomy	Scientific, systematic classification of living organisms.
Tetraploid	Organism possessing four replicate sets of chromosomes.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *AYENIA LIMITARIS*

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Chris Best, Austin Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 03-01-2010

REGIONAL OFFICE APPROVAL:

Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service

Approve _____ Date 6-2-2010
Acting