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# Case studies of building collaborative partnerships for conservation of endangered and threatened cacti in Texas

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*Summary*: *Echinocereus fitchii* subsp. *albertii* is a federally and state endangered cactus endemic to Texas that occurs exclusively on private lands. *Sclerocactus brevihamatus* subsp. *tobuschii* is a federally threatened and state endangered cactus occurring on private lands, as well as protected lands in Texas. Although listed under both federal and state laws, these laws give very limited protections to listed plants on private land. Nevertheless, section 7 of the Endangered Species Act requires federal agencies to ensure that their actions do not harm listed species. This paper provides case studies demonstrating how section 7 consultations lead to collaborations of federal and state conservation agencies, environmental consultants, non-profit organizations, and private landowners to conserve cactus populations in Texas, USA Establishing good working relationships with landowners is essential for these conservation efforts.

*Zusammenfassung*: *Echinocereus fitchii* subsp. *albertii* is a federally and state endangered cactus endemic to Texas that occurs exclusively on private lands. *Sclerocactus brevihamatus* subsp. *tobuschii* is a federally threatened and state endangered cactus occurring on private lands, as well as protected lands in Texas. Although listed under both federal and state laws, these laws give very limited protections to listed plants on private land. Nevertheless, section 7 of the Endangered Species Act requires federal agencies to ensure that their actions do not harm listed species. This paper provides case studies demonstrating how section 7 consultations lead to collaborations of federal and state conservation agencies, environmental consultants, non-profit organizations, and private landowners to conserve cactus populations in Texas, USA Establishing good working relationships with landowners is essential for these conservation efforts.

**Keywords**: Blace lace cactus, *Echinocereus fitchii* subsp. *albertii*, Tobusch fishhook cactus, *Sclerocactus brevihamatus* subsp. *tobuschii*, private land, pipeline, section 7

## Introduction

In the United States, species at risk of extinction may be protected by the federal Endangered Species Act (ESA; U.S. Congress, 2003) as well as the laws of the individual states and territories. However, federal and Texas laws provide very limited protections for listed plants on private land. Consequently, effective conservation strategies for endangered plants in the United States rely on collaboration, promotion, and outreach – as well as a dash of regulation. Here we illustrate collaborative conservation of *Echinocereus fitchii* subsp. *albertii* and *Sclerocactus brevihamatus* subsp. *tobuschii* through three case studies.

The United States ESA was enacted in 1973 and

| Term | Definition |
|---|---|
| Endangered species | In danger of extinction throughout all or a significant portion of its range; does not include insects determined to be pest species. |
| Threatened species | Likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. |
| Species | Includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species or vertebrate fish or wildlife which interbreeds when mature. |
| Take | To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. |

**Table 1.** Selected terms defined under Section 3 of the ESA.

| Section | Summary of provisions |
|---|---|
| 4 | Determination of endangered and threatened species. Establishment of endangered and threatened species lists; designation of critical habitats; procedures to petition for addition or removal of a species from the endangered species list; five-year reviews; regulations to protect threatened species; recovery plans; monitoring of delisted species. |
| 6 | Cooperation with the states. Consultation with states on acquisition and management of land for listed species conservation; cooperative agreements and financial assistance to assist states for listed species conservation. |
| 7 | Interagency cooperation. Requires federal agencies to conserve listed species and consult with USFWS and NMFS to ensure that actions they authorize, fund, or carried out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat of such species. |
| 9 (2) | Prohibitions with respect to endangered plant species: Import and export to/from the United States; remove, possess, damage or destroy from areas under federal jurisdiction, or in knowing violation of state laws, including trespass; transport or offer for sale through interstate or international commerce; violate regulations in Section 4 (d) for threatened plant species. |

**Table 2.** Summary of the provisions of sections of the ESA relevant to this article.

has been amended ten times up to 2003. The ESA is administered by the United States Fish and Wildlife Service (USFWS) and, in the case of marine and anadromous species, the National Oceanic and Atmospheric Administration Fisheries (National Marine Fisheries Service). Section 2(b) of the ESA establishes its purposes: to conserve endangered and threatened species and the ecosystems they depend on, and to accomplish the objectives of international treaties and conventions for endangered species conservation. Tables 1 and 2 list several terms defined in the Act and the provisions of sections (respectively) that are relevant to this discussion. Due to the precendent of English Common Law, the ESA confers different protections for plants and animals (U.S. Forest Service, 2021). Section 9(a)(1) prohibits the take of listed animals from public and private lands; section 9(a)(2) prohibits the removal, possession, damage, or destruction of endangered plants only from federal lands, or in knowing violation of state laws, including trespass; thus, the law does not protect listed plants on private lands unless an action violates state law. Threatened plants may be protected through specific regulations established at the time they are listed. The ESA lists 938 plant species as threatened or endangered within the United States, including twenty-four endangered plants and eight threatened plants in the State

| Species | Common Name | Federal Status | State Status |
|---|---|---|---|
| *Echinocereus fitchii* subsp. *albertii* (*E. reichenbachii* subsp. *albertii)* | Black lace cactus | Endangered (as *Echinocereus reichenbachii* var. *albertii*) | Endangered |
| *Coryphantha ramillosa* subsp. *ramillosa* | Bunched cory cactus | Threatened (as *Coryphantha ramillosa*) | Threatened |
| *E. chisoensis* subsp. *chisoensis* | Chisos hedgehog cactus | Threatened (as *Echinocereus chisoensis* var. *chisoensis)* | Threatened |
| *E. davisii* | Davis' green pitaya | Endangered (as *Echinocereus viridiflorus* var. *davisii*) | Endangered |
| *Sclerocactus mariposensis* | Lloyd's mariposa cactus | Threatened | Threatened |
| *Escobaria minima* | Nellie's cory cactus | Endangered | Endangered |
| *Escobaria sneedii* subsp. *sneedii* | Sneed's pincushion cactus | Endangered (as *Coryphantha sneedii* var. *sneedii*) | Endangered |
| *Astrophytum asterias* | Star cactus | Endangered | Endangered |
| *S.brevihamatus* subsp. *tobuschii* | Tobusch fishhook cactus | Threatened | Endangered |

**Table 3.** Cactus species listed in Texas with federal and state status indicated.

of Texas (USFWS, 2021a); nine listed species in Texas are cacti (Table 3).

The State of Texas enacted protections for endangered and threatened plants on 1 September 1981 (Chapter 88 of the Texas Parks and Wildlife Code). Texas Parks and Wildlife Department (TPWD) administers the law, which defines endangered and threatened plants in the same terms as the federal ESA and adds federally listed plants to the state list. However, TPWD may also add plant species that are not federally listed. For example, on 30 March 2020, TPWD added seven threatened plant species to the state list, so in addition to the twenty-four plants that are also federally endangered, Texas lists fifteen threatened plants (TPWD, 2020). The Texas law allows qualified individuals to obtain permits to take state-listed plants from public lands for propagation, education or scientific studies. The law prohibits the sale, take or possession for commercial sale, or transportation of state-listed plants from public lands, but allows the commercial sale of listed plants taken from private lands through permit.

Thus, state and federal laws do not restrict landowners' uses of their lands, nor do the laws confer authority to conservation agencies to access private lands to survey or monitor listed plants without landowner permission. Section 30.05 of the Texas Penal Code establishes that accessing private property without the owner's consent is a criminal trespassing offence subject to fines and imprisonment (TPWD, 2021). Although Texas is a large state, encompassing 68,075,247ha, over 95% is privately owned (Ramirez, 2018) and only 1.9% is federally owned (Congressional Research Service, 2020). Consequently, we know very little about the distribution and abundance of rare plants in Texas; some protected plants may in fact be more secure than we know. These facts underscore the need to establish good working relationships and build trust with private landowners – a tall order in a state where landowners traditionally disdain government interference.This may be compounded by misinterpretations of endangered species laws, leading to fears that the government will tell landowners what they can and cannot do if endangered plants are discovered on their property.

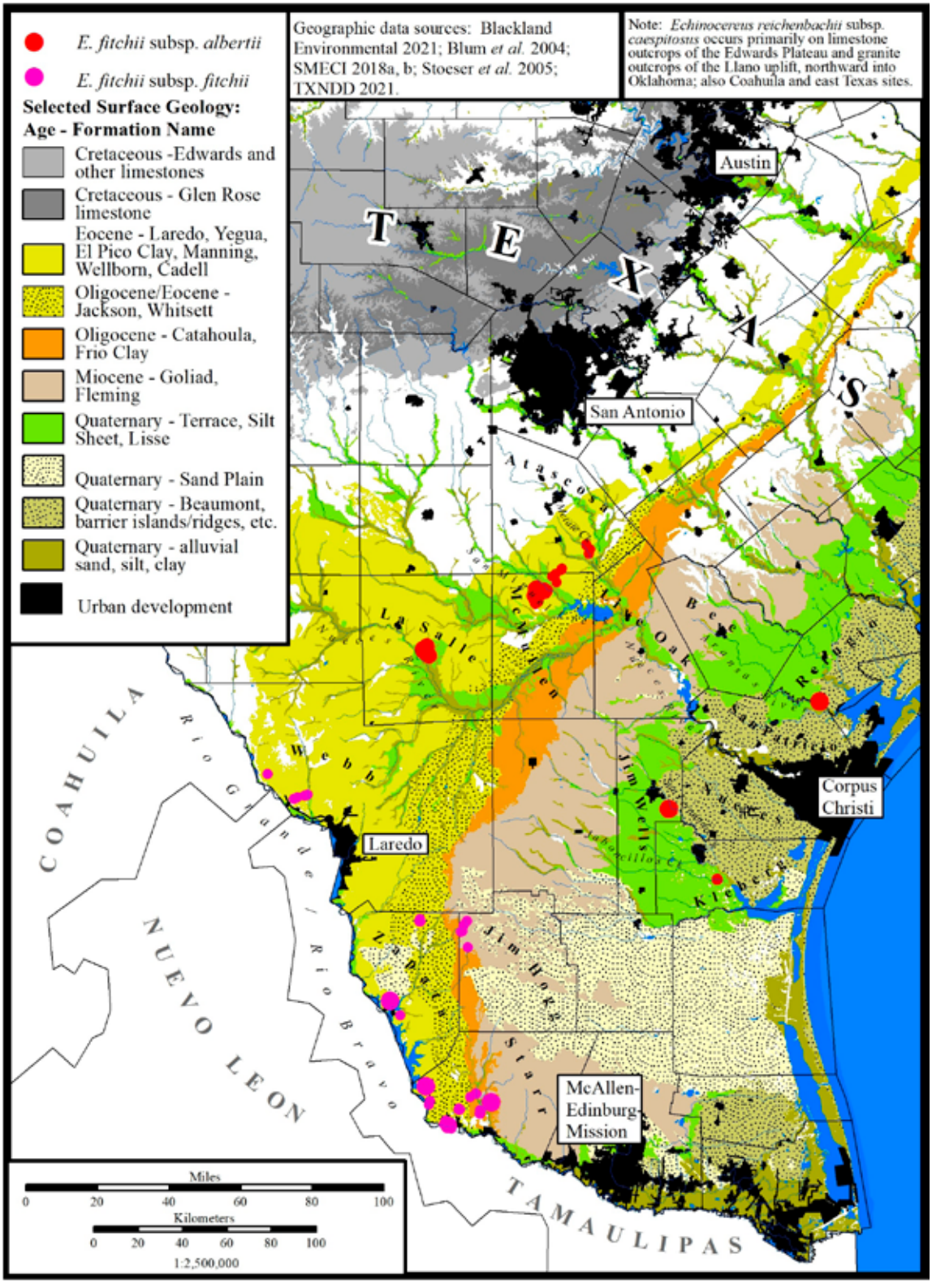


**Figure 1**. Distribution of *Echinocereus fitchii* subsp. *albertii* and *fitchii* in South Texas showing geology and watercourses. Map by Chris Best, USFWS.

Landowners tend to be more receptive to working with non-governmental conservation organizations and university researchers. In our experience, most Texas landowners are conservation minded; they take pride in good stewardship of the land and its natural heritage, including endangered plants. For example, for several decades the landowner of an *Echinocereus fitchii* subsp. *albertii* (herein referred to as subsp. *albertii*) population site in Refugio County has graciously allowed researchers to access the site to study this population. In 2016 we discovered that cattle had trampled and uprooted a number of subsp. *albertii* plants. A new ranch manager, not yet familiar with this cactus, had spread hay at the population site; this attracted cattle to the sparsely vegetated area, which they normally avoid. The situation was conveyed to the landowner, who then instructed the manager to avoid placing hay near the subsp. *albertii* population. Thanks to the working relationship between our research team and the landowner, cattle's impact on the health of the population was ameliorated.

Compared with the limited prohibitions in section 9, section 7 of the ESA can indeed protect listed plants on public as well as private land – but there is a catch: it is only triggered when a development project with federal involvement (nexus) may affect the plant. Section 7 requires federal agencies to consult with USFWS to ensure that actions they authorise, fund, or carry out will not 'jeopardize the continued existence' of a listed species or damage its habitat. Federally funded highway construction, compliance with the Clean Water Act, and Environmental Protection Agency regulations are all examples of a federal nexus. Jeopardy is more than the loss of finite numbers of individual listed plants, which is in fact allowed; it means actions that 'reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species' (USFWS, 2021b). This can include the incremental affects that each of many projects may have. Through consultation, projects may be modified to avoid, minimise, or mitigate impacts to listed species. Where listed plants are concerned, project proponents may agree to voluntary 'conservation measures' to prevent a species' incremental decline toward extinction. The case studies presented here arose through section 7 consultation.

**Case Study 1**

*Echinocereus fitchii* subsp. *albertii* (commonly referred to in the United States as 'black lace cactus', describing its often dark, sometimes interlocking spines) is an endemic cactus subspecies that has been documented in six south Texas counties (Figure 1). This subspecies was listed as endangered (as *E. reichenbachii* var. *albertii*) under both the federal ESA (Federal Register, 1979a) and by the State of Texas on 18 May 1987.

San Miguel Electric Cooperative, Inc. (SMECI) operates on approximately 15,505ha of land, most of which is leased from private landowners for current and future coal surface mining operations in Atascosa and McMullen Counties, Texas. Prior to mining, the leased lands are used primarily for livestock grazing, oil and gas production and recreational hunting. As such, SMECI's activities require coordination with private landowners and a variety of regulatory agencies. In the United States, coal surface mining is regulated by the Office of Surface Mining Reclamation and Enforcement, which establishes the federal nexus for section 7 consultation with USFWS. Federal authority in surface mining is delegated to corresponding state agencies, which in this case is the Railroad Commission of Texas (RCT). In 2014, during preliminary surveys of a new SMECI mining permit, USFWS Biologist Frank Weaver discovered a population of subsp. *albertii*. SMECI engaged with members of academia, TPWD and private landowners to minimise impacts, and contracted Blackland Environmental LLC (Blackland) to develop and implement voluntary conservation measures to prevent jeopardy to subsp. *albertii*.

Texas mining regulations require baseline surveys for vegetation, fish and wildlife resources and the development of protection plans for certain species and/or their habitats. From 2015-2021, Blackland has performed several surveys to map the extent of subsp. *albertii* on lands leased for but not yet disturbed by mining activities, totaling approximately 6,072ha. As a result, Blackland has developed improved survey methodologies, and SMECI has gained a better understanding of the distribution of subsp. *albertii* in the area.

Prior to conducting onsite surveys for subsp. *albertii*, Blackland performed desktop reviews to delineate potential habitats. This species' habitat has been historically described as 'openings in mesquite brush occurring along streams of the coastal plain' (USFWS, 1987) and saline fine sandy loam within several hundred meters of watercourses, in the coastal grassland – Rio Grande plain scrub ecotone, that is occasionally flooded (Emmett, 1989). Accordingly, sites initially delineated as potential habitats were

**Figure 2**. Subsp. *albertii* and soils typical of the gravelly hilltop site. Photograph Jeremiah McKinney.


**Figure 3**. subsp. *albertii* near the top of the gravelly hill photo. Photograph Jeremiah McKinney.

**Figure 4**. Overview of conditions observed at the rocky gravel pit site. Photo Jeremiah McKinney.

**Figure 5**. The rocky gravel pit site provides a suitable environment for subsp. *albertii*. Photograph Jeremiah McKinney.

grassland habitats or openings within wooded areas on saline soils within 305m of watercourses. This conservative method of habitat mapping led to the discovery of numerous subsp. *albertii* populations and subpopulations from the spring of 2015 to the spring of 2019. However, two populations were discovered in the autumn and winter of 2019 in different habitat types. One occurred at a hilltop blackbrush (*Acacia rigidula*) shrubland site with gravelly soils approximately 2,000m from a watercourse (Figures 2-3). The other site is a rocky hilltop described by the United States Geological Survey (USGS) 7.5-minute topographic map as a gravel pit (Figures 4–5). Habitat conditions at those sites appeared more consistent with those described for *E. fitchii* subsp. *fitchii* as 'gravelly sandstone-derived upland soils, often with high gypsum (calcium sulfate) levels' (USFWS, 2019), yet the plant morphology appeared consistent with those previously identified in the area as subsp. *albertii*. Further analysis of the subsp. *albertii* populations documented by Blackland revealed that stunted woody plant growth was the most consistent factor across all sites. Shrubs may be stunted by micro-habitat conditions that limit soil moisture availability, such as landscape position, soil texture, shallow soils overlying impermeable substrates or soil chemistry, discussed below.

Accordingly, Blackland revised the habitat modeling approach in 2020 and 2021 through a detailed review of current and historical aerial photography. This method identified grasslands and wooded sites with open to moderately open canopy spacing as potential habitat, regardless of soil type or proximity to watercourses. As a result,

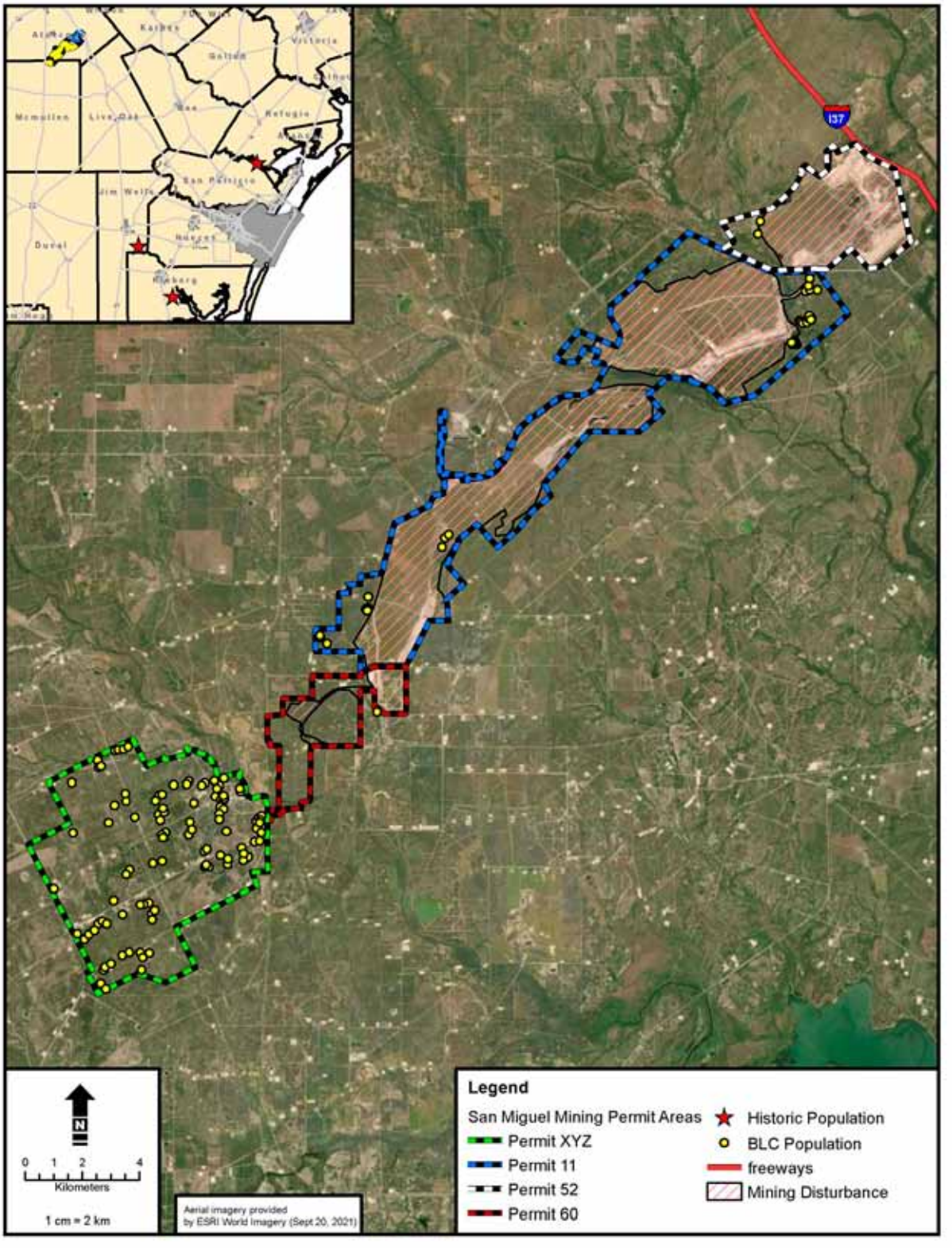


**Figure 6**. subsp. *albertii* documented by the SMECI in Atascosa and McMullen Counties from 2014 to 2021. Author Jeremiah McKinney.

**Figure 7**. subsp. *albertii* flowering in Atascosa Co. at 68m April 2019. Photograph Peter Berresford.

**Figure 8**. subsp. *albertii* flowering in McMullen Co. at 87m April 2019. Photograph Peter Berresford.

**Figure 9**. Shade provided by grasses for subsp. *albertii*. Photograph Jeremiah McKinney.

**Figure 10**. subsp. *albertii* flowering amongst grasses, herbaceous flowering plants and low-growing shrubs. Photograph Jeremiah McKinney.

**Figure 11**. subsp. *albertii* predominantly observed among grasses and herbaceous flowering plants at the base of *E. enneacanthus* subsp. *intermedius* and decid-uous low-growing shrubs. Photograph Jeremiah McKinney.

**Figure 12**. A view of the saline shrubland of subsp. *albertii* BL-7 during autumn. Photograph Jeremiah McKinney.

**Figure 13**. Flags mark the position of subsp. *albertii* BL-7 in the saline shrubland. Photograph Jeremiah McKinney.

**Figure 15**. Impact of feral pigs on subsp. *albertii*. Photograph Jeremiah McKinney.


**Figure 14**. A sizeable hole excavated by feral pigs under a plant of subsp. *albertii*. Photograph Jeremiah McKinney.

**Figure 16**. The dry site conditions observed in June 2020. Photograph Jeremiah McKinney.

surveys in 2020 and 2021 documented additional subsp. *albertii* populations within areas that were previously excluded from consideration. Figure 6 shows the subsp. *albertii* populations and subpopulations documented by Blackland for SMECI from 2014 to 2021. In Atascosa County, plants were documented from elevations of approximately 70–120m and in McMullen County between 85–125m elevation.

RCT and USFWS recommended that subsp. *albertii* surveys should be done during the flowering season, when the vibrant, distinctive blooms would increase detectability (Figure 7). Accordingly, from 2015 to 2018 the SMECI surveys were conducted exclusively during the flowering season. However, these surveys revealed that flowering was often localised due to irregular rainfall distribution. Flowering duration also varied from year to year, based on rainfall frequency; plants flowered for multiple days in wet years to a single day in dry years. As such, the timing of surveys was difficult to predict and often required multiple trips throughout the flowering season (Figure 8). To best monitor daily flowering activity in remote areas, Blackland utilised Covert Code Black cellular scouting cameras. This technology allowed tracking of bud development and flowering activity on a daily basis.

Blackland also observed greater detectability of subsp. *albertii* during the winter months at sites that had a history of cattle grazing. At these sites, subsp. *albertii* was predominantly observed among grasses and herbaceous flowering plants that were protected from grazing at the base of larger cacti and deciduous low-growing shrubs (Figures 9–11). As such, even when subsp. *albertii* was

flowering, the plants were very difficult to detect among dense low growing shrubs and subshrubs, such as goldbush (*Isocoma coronopifolia*). These observations may be attributed to 'protection from trampling by livestock or from other natural threats' (USFWS, 1987). Accordingly, SMECI used winter surveys for sites of active and historical grazing to increase subsp. *albertii* detection. Although no quantitative data were collected to compare winter and spring survey efficacies, Blackland found that it was easier to locate small populations and subpopulations during the winter than during the subsequent flowering season. Based on these findings and those noted at a subpopulation of the Jim Wells County population (USFWS, 1987), surveys for subsp. *albertii* may be improved through an understanding of the current and past land uses, such as prolonged grazing.

*Observations from Transplanting & Monitoring*

To minimize impacts to subsp. *albertii* at the San Miguel Permit 60 mine area, in 2016 and 2017 SMECI transplanted forty-one individuals that were within the mine footprint to an adjacent offsite population identified as BL-7. This process was facilitated through a partnership with SMECI, Blackland, and the landowner. The BL-7 population, mapped in 2015, occupied approximately 0.5ha adjacent to La Jarita Creek, and had an estimated 1,800–2,000 subsp. *albertii* plants. The vegetation community of BL-7 is a saline shrubland. Visual indicators of salinity include a gray to white soil surface color and a variety of halophytic plants (Figures 12–13). Annual monitoring of translocated subsp. *albertii* was conducted from November 2016–April 2021.

From 2016–2018, transplant survival was high, with a few plants uprooted by *Sus scofa* (wild boar) (Figures 14–15), trampled by livestock, and in one case, utilised for nest material by *Neotoma micropus* (southern plains wood rats). On 20 April 2019, approximately 73% of the transplanted subsp. *albertii* were observed in excellent or good condition. However, due to a severe drought that significantly impacted the overall plant community of the site, only approximately 17% remained in June 2020. A detailed inspection of the site documented a vast reduction in the number of shallow-rooted plants, including resident subsp. *albertii* and other cacti, herbaceous plants, grasses and small shrubs (Figure 16). These conditions were noted, but less evident, in the surrounding habitats where soils appeared less saline. Following this die-off, RCT requested a census of the BL-7 subsp. *albertii* population to document the impacts of the drought and possible parasite activity. This census detected no obvious signs of parasites, but documented a 27-35% reduction in the subsp. *albertii* population. The 2020 census used a whole-field count method which differs from the 2015 method which used a combined count of individual plants in open areas and visual estimates in dense brush. SMECI also performed a census of BL-7 in April 2021 to document the effects of a freeze, from 14–17 February 2021, when temperatures were at or below freezing for four consecutive days (NOAA, 2021). The April 2021 census documented a total of 1,098 plants, representing a reduction of 16.2% from the December census. Survey methods were identical for both the December 2020 and April 2021 surveys; therefore, comparisons of the data are reliable.

**Figure 17**. Pipeline right of way in Edwards Co., Texas passing close to subsp. *tobuschii.* photograph Chris Best, USFWS.

Based on these observations, site protections and added consideration for transplant site selection would likely enhance subsp. *albertii* transplant survival. Sites selected for transplanting may benefit from fencing to exclude livestock and wild boar. Similarly, the trapping and removal of southern plains woodrat may also increase survivability. It may also be beneficial to avoid transplanting subsp. *albertii* into sites with hypersaline soils. Although subsp. *albertii* 'is thought to be adapted to saline soils' (USFWS, 2009), the mortality observed at BL-7 implies that the chemical properties of hypersaline soils may exacerbate drought conditions to unsuitable levels for subsp. *albertii*.

**Figure 18**. subsp. *tobuschii* in bud, Bandera Co., Texas. This endemic cactus begins flowering when the diameter reaches 2cm – at about nine years old. Photograph Chris Best, USFWS.

**Figure 19**. Two flowering subsp. *tobuschii* in Bandera Co., Texas estimated to be around fifty years old. Photograph Chris Best, USFWS.

**Case Study 2**

Beginning in about 2011, a frenzy of oil and gas pipelines, spawn of the petroleum fracking boom, has spread from the Permian Basin in west Texas to refineries along the Gulf of Mexico, up to 800km away. Texas law gives pipeline developers the right of eminent domain, allowing them to condemn whatever private property they need for pipeline construction (RCT, 2021). Pipeline easements are typically about sixty metres in width. During construction, everything in the pipeline's swath – trees, soil, and the underlying rock – is bulldozed and ground into rubble. Many of the new pipelines invoked section 7 through the nexus of the Clean Water Act. Pipelines that crossed the Edwards Plateau, in west-central Texas, potentially affected the endangered *Dendroica chrysoparia* (golden-cheeked warbler) and *Sclerocactus brevihamatus* subsp. *tobuschii* (Tobusch fishhook cactus) (Figure 17). When this subspecies was federally listed as endangered (as *Ancistrocactus tobuschii*; Federal Register 1979b), only 200 individuals were known to exist.

Because the ESA provides stronger protection for listed animals than for listed plants, to avoid critical habitats of the warbler, pipelines veered across the rocky upland habitats of the cactus. Pipeline developers usually contract environmental consultants to guide them through the regulatory procedures, including section 7 of the ESA. The consultants brought in scores of sharp-eyed plant surveyors to search for the cryptic *S. brevihamatus* subsp. *tobuschii* (herein referred to as subsp. *tobuschii*) within the rights-of-way prior to construction. Along one seventy-eight kilometre stretch, 311 subsp. *tobuschii* were detected (Figure 18–19). Those that were within the right-of-way but outside the construction footprint were demarcated with temporary fencing to avoid damage during construction. About half of the cacti lay in the path of destruction. These were carefully excavated and taken to Lady Bird Johnson Wildflower Centre in Austin, Texas, which was contracted to care for the plants as their root systems regenerated in containers of soil medium derived from their native soil. While at the Wildflower Centre nursery, the plants flowered and produced seed that have been seed-banked for future scientific studies and reintroduction, and researchers published an article on the species' reproductive biology (Clary, Landel, Watson & Mecredy, 2018). The salvaged subsp. *tobuschii* were subsequently donated to a researcher at San Angelo State University in Texas, who will investigate the survival and growth of these plants in secure reintroduction sites.

The subsp. *tobuschii* surveys conducted along proposed pipelines, as well as new powerlines and highway improvements, yielded troves of data about the subspecies' distribution on otherwise inaccessible private land. This supported an estimate of the total population of nearly half a million subsp. *tobuschii* distributed over two million hectares (USFWS, 2017). On this basis, USFWS reclassified the subspecies' status from endangered to threatened under the Endangered Species Act (ESA) (Federal Register, 2018). This case study provides an encouraging example of the collaborative work of state and federal agengies, non-profit organisations, environmental consultants, scientists and private landowners leading to successful conservation efforts.

Pipeline construction continues to impact the threatened cactus, but fortunately conservation

**Figure 20**. Reintroduction of salvaged subsp. *tobuschii* at Marshall White Ranch, Edwards Co., Texas, 21 October 2020. Left to right – Hagen Patterson, Governance Affairs Coordinator for White Water Midstream Pipeline, Jeff Mundy, Beth and Marshall White and Gary Mowad. Photograph Chris Best, USFWS.

**Figure 21**. Plant of subsp. *albertii* from Golondrina population. Photograph Chris Best, USFWS.

**Figure 22**. Details of spines of subsp. *albertii* from Golondrina poulation. Photograph Chris Best, USFWS.

**Figure 23**. Habitat at La Golondrina; more than twenty subsp. *albertii* present in scene. Photograph Chris Best, USFWS.

**Figure 24**. A fourteen-month old seedlings of subsp. *albertii* from seed collected at La Golondrina; note central spines on juvenile. Photograph Chris Best, USFWS.

efforts continue as well. Gary Mowad of GMEC Consulting has worked on a dozen pipeline consultations in the last few years. He represents the developers on some pipelines, and in other cases he works with landowners who want to minimise the environmental impacts of pipelines to their lands. In 2020, Mowad arranged for subsp. *tobuschii* salvaged from a pipeline to be nursed at San Antonio Botanical Garden (San Antonio, Texas) through the blazing summer heat, and he needed to find a suitable reintroduction site where the plants could be transplanted once the weather cooled. Marshall White, a conservation-minded Edwards County landowner, agreed to take the salvaged subsp. *tobuschii*, which were successfully transplanted in October of that year (Figure 20). On 25 September 2021, Mowad visited the site and found that 100% of the transplanted indiviudals had survived.

**Case Study 3**

In 1995, René Barrientos acquired La Golondrina Ranch, 3,723 hectares of beaten-down, marginal range and cropland in La Salle County, about midway between San Antonio and Laredo, Texas. Nine years later, TPWD honored Barrientos with its 2004 Lone Star Land Steward Award for his successful restoration of native vegetation and wildlife habitat at La Golondrina (Oko, 2004). In April 2020, Ranch Manager Asa Wilson discovered a population of subsp. *albertii* on the ranch (Figures 21-22).

The landowner, Barrientos, was delighted – but also deeply concerned. What worried Barrientos was the proliferation of pipelines, a concern shared by thousands of other Texas landowners. One recent pipeline had already spanned La Golondrina, and now a competing pipeline was planned adjacent to the first one. It would pass right through the newly-discovered population of subsp. *albertii*. Jeff Mundy, an environmental lawyer representing Barrientos in negotitations with the pipeline at La Golondrina Ranch, asked Gary Mowad of GMEC Consulting for assistance when subsp. *albertii* was discovered in that pipeline's cross-hairs. Fortuitously, Mundy also represented Marshall White, the Edwards County landowner who agreed to take the salvaged subsp. *tobuschii*, discussed in case study 2.

Mowad invited us to visit La Golondrina in

**Figure 25**. Flowering subsp. *albertii* at La Golondrina in early April 2021. Photograph René Barrientos.

June 2020 to see the subsp. *albertii* population. We confirmed that Wilson got the identification right. This new population greatly increases the known range of subsp. *albertii*. The habitat at this site is typical of most *albertii* habitats (Figure 23). The population occupies gravelly, alkaline, saline Maverick clay (Soil Conservation Service, 1994) on a lower terrace of a tributary of the Nueces River; large gypsum nodules occur within the soil profile; elevation ranges from 105–118m. It is sparsely vegetated with halophytic plants and stunted Tamaulipan shrub species, including *Sporobolus pyramidatus* (whorled dropseed), *Prosopis reptans* (dwarf screwbean), *Varilla texana* (saladillo), *Pappophorum vaginatum* (whiplash pappus-grass), *Cylindropuntia leptocaulis* (tasajillo), *Opuntia engelmannii* subsp. *lindheimeri* (nopal), *Acacia rigidula* (blackbrush acacia), *Echinocereus pentalophus* subsp. *procumbens* (alichoche cactus) also occur at this site, and *Thelocactus setispinus* (twisted rib cactus), *Amoreuxia wrightii* (Wright's yellow-show) and *Jatropha cathartica* (jicamilla) occur nearby. Barrientos and Wilson have found more subsp. *albertii* in other moderately saline sites dominated by *Hilaria belangeri* (curly-mesquite grass).

Through propagation, we often gain insights about a species' natural history that would be difficult to learn from wild populations. Spring 2020 had been dry in south Texas, and we observed no evidence of developing fruit on subsp. *albertii* at this site. We examined six dessicated fruits that had persisted from a previous year, from which we recovered 198 seeds. We planted the seeds in a pot of natural soil medium with bottom watering on 7 July 2020, kept outside (in Austin, Texas) in the shade. Twenty-seven seeds germinated by 23 July, after which the pot was left in full sun and watered about once a week. No additional seeds germinated during the following year, suggesting that seeds either lose viability within a year or two, or else go into long dormancy. Four individuals failed to establish. Marauding ants carried off ten, and a sudden thunderstorm in August washed away five. Eight remained alive in summer 2021. On 26 July 2021 the seedlings were planted in individual 10cm pots in a medium of equal proportions of pea gravel, crushed limestone, and decomposed leaf mold, to which were added some soil and roots excavated from the base of several *Echinocereus reichenbachii* subsp. *caespitosus* (lace cacti) to inoculate them with mycorrhizal fungi that associate with roots of these taxa (Figure 24). One small *Bouteloua trifida* (red grama) plant was planted in each of the 10cm pots. *Bouteloua trifida* is a diminutive native bunch grass; some local native plant growers believe that the presence of native grasses in the wild may benefit the establishment of cacti and other native plants. After thirty-one days, the average height had increased 35%, to 26mm, and the number of tubercles per rib had increased 40%, to 7.9. These plants will be returned to La Golondrina in October 2021. In the meantime, subsp. *albertii* at La Golondrina flowered in early April 2021 (Figure 25).

Through their negotiations, Barrientos, Mundy, and Mowad convinced the pipeline developer to pay for a subsp. *albertii* survey along their right-of-way, reduce the width of the right-of-way and pay to salvage individual plants of subsp. *albertii* found on the right-of-way and transplant them into secure habitats elswhere at La Golondrina. Barrientos has removed all livestock from that portion of his ranch, and told us, 'No domestic animals, horses, cows, etcetera will ever be allowed to graze this special habitat, as their hooves cause irreparable damage to black lace cactus.'

## Discussion

Species in peril of extinction and loss of biodiversity are global problems governed by different rules and regulations depending on the distributional range of a given species. Although in the United States specific federal and state agencies are charged with protecting listed species, in reality protection also depends on collaboration with the citizens on whose land species live.

In Texas and other private lands states of the United States, research and conservation of rare plants is hindered by the limited access to private lands. Section 7 of the ESA, when invoked through federal agency actions and authorities, creates unique opportunities for endangered plant research and conservation on private land. This often involves a complex collaboration of parties, but the keystone entities are the landowners, and in many cases the survival of a species rests on the shoulders of landowners.

Private landowners in partnership with state and federal agencies, scientists and other entities can make meaningful contributions to the conservation of listed species. As the case study of *S. brevihamatus* subsp. *tobuschii* demonstrated, access to private lands can tremendously increase our understanding of the status of species and their abundance. Additionally, Section 7 consultations for a lignite mine and an oil pipeline led to discoveries of new populations of subsp. *albertii* that greatly expanded this subspecies' known range. Figure 1 overlays the known geographic locations of subsp. *albertii* on the surface geological formations and watersheds of south Texas, with the cactus growing on gypseous, saline soils derived from Quaternary terrace deposits. All three case studies discussed here show transplantation of plants is a viable means to salvage plants in the path of destruction, thus allowing for industry to progress without necessitating annihilation of rare species.

Private landowners in Texas (and elsewhere) use land for different purposes, and those purposes have changed over time. A century ago, livestock grazing for some landowners was an extractive land use: the vegetation was a resource to be consumed until depleted before moving on. Others who have remained in ranching could only do so through the science and practice of rangeland management, a discipline that combines experience, observation, intuition, and adaptation. Good rangeland management is all about conservation, and conservation of natural resources is at the core of traditional ranches. Yet the 'DNA' of traditional private landowners is also in opposition to government over-reach; perhaps this is why their forebears migrated to the rugged frontier in the first place. Although many traditional Texas landowners were not highly receptive to endangered species laws during the early decades, attitudes are changing. The presence of rare species confers a unique value to a property that is worth protecting. Furthermore, the power of corporate pipeline developers to seize land has led some landowners to ponder which is the greater threat: too much regulation, or too little. Finally, we cannot help but wonder whether the protections of subsp. *albertii* under the ESA might warrant reduction – as with *S. brevihamatus* subsp. *tobuschii* – if landowner concerns over regulation were overcome, and its distribution and abundance were more completely known.

## Disclaimer

'he findings and conclusions in this article are those of the authors and do not necessarily represent the views of the United States Fish and Wildlife Service.

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