Species Status Assessment of Bushy Whitlow-Wort (*Paronychia congesta* Correll)

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Throughout this document, the first uses of scientific and technical terms are underscored with dashed lines; these terms are defined in the glossary in Appendix A.

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EXECUTIVE SUMMARY

This report summarizes the results of a species status assessment (SSA) of bushy whitlow-wort, *Paronychia congesta*. The Texas botanist Donovan Correll first collected bushy whitlow-wort in 1963, and in 1966 he described it as a new species, *Paronychia congesta*, in the Carnation Family (Caryophyllaceae); botanists continue to recognize it as a valid, unique species. This perennial herbaceous plant has only been found in a very small area of northwestern Jim Hogg County in south Texas. Although Villaseñor (2016, p. 695) included bushy whitlow-wort as an endemic, native species of the flora of Coahuila, Mexico, we have found no evidence of this species' occurrence outside of Jim Hogg County, Texas.

We, the U.S. Fish and Wildlife Service, recognized the species as a candidate for listing under the Endangered Species Act in 1975 (40 FR 27824) and 1985 (50 FR 39526). It was removed twice from the candidate list, in 1980 (45 FR 82480) and 2006 (71 FR 53756), due to insufficient information about its biological vulnerability and threats. In 2007, Forest Guardians submitted a petition to list 475 southwestern species, including bushy whitlow-wort, under the ESA (Forest Guardians 2007, entire). In 2009, in response to this petition, the Service published a 90-day finding that the petitioned action may be warranted (74 FR 66866). Therefore, we initiated review of the status of the species to determine if the petitioned action was warranted.

The objective of this analysis is to assess the species' current viability and trends and project its future viability under a range of scenarios. This SSA Report is a summary of the information assembled and reviewed by the Service and incorporates the best available scientific and commercial data. We evaluated the species' current representation, resiliency, and redundancy and projected those variables into the future. This report documents the results of the status review for bushy whitlow-wort and will serve as the biological basis of the Service's listing determination.

The Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (TXNDD) maintains geographic and population data of bushy whitlow-wort and other plant and animal species of conservation concern in Texas. This data is organized by standard geographical units for populations and habitats called "Element Occurrences" (EOs). Only two small EOs of bushy whitlow-wort have been found. The two EOs cover a total area of 19.5 hectares (48.1 acres), and are only 2.1 kilometers (1.3 miles) apart. There are only 12 documented observations of the two EOs from 1963 through 2020. The maximum numbers of individuals observed at the two EOs are about 2,000, at EO 1 in 1987, and 1,904, at EO2 in 1994. At other times, surveyors recorded from 0 to 633 individuals. This variation may have been due, in part, to the withering of the diminutive plant's stems during drought, making them undetectable; at most, the tufted mounds of foliage stand less than 25 centimeters (10 inches) tall. Different methods and intensities of surveys may also explain the variation in observed population sizes.

The very few recorded observations of bushy whitlow-wort have yielded little information about its life history. The species flowers from spring to late summer, in response to rainfall, and produces tiny, one-seeded fruits. We know nothing about the pollinators, pollination biology, seed dispersal, seed dormancy, seed germination, rates of recruitment, mortality, demographic trends, reproductive age, or lifespan. However, the woody rootstocks reveal that the species is clearly perennial, and possibly long-lived. Therefore, if recruitment of bushy whitlow-wort is low or sporadic, this may be compensated by long average lifespans.

The two documented populations of bushy whitlow-wort occupy nearly barren, exposed, sloping outcrops of calcareous rock and/or indurated caliche along the boundary of the Goliad and Catahoula geological formations, known locally as the Bordas Escarpment. The species is likely to be a geo-endemic that is uniquely adapted to the soil or geological features that occur there. Some observers describe the unique substrates of occupied sites as calcareous tuff, which occurs in discrete sites along the Goliad/Catahoula boundary. We developed a potential habitat model based on the distribution of the geological, soil, and slope features of occupied sites to predict where else the species may occur. This model indicates that a range of thousands to tens of thousands of hectares of potential habitat exist in south Texas; the largest clusters of potential habitat are in Webb, Jim Hogg, Zapata, and Starr counties. Based on available botanical surveys, we estimate that less than 1 percent of this potential habitat has been surveyed by botanists qualified to identify the species.

We provisionally estimate that viable populations have at least 1,500 individuals of reproductive age and provisionally estimate that the species' viability requires an intermediate value of 10 or more resilient populations that are distributed over the species' known range. We provisionally adopt the NatureServe default minimum separation distance of 1.0 km (0.6 mi) to delineate populations.

Bushy whitlow-wort currently has low population redundancy, as there are only two known populations. The demographic and genetic consequences of small population sizes are potential threats of unknown immediacy, severity, and extent. Oil and gas exploration and development are potentially severe threats of unknown immediacy, severity, and extent. Wind energy development is a currently severe threat throughout the species' range. Urban and residential development and cattle grazing are not significant threats to the species. Climate changes will likely affect bushy whitlow-wort in complex ways, but we cannot currently project the net effect of positive and negative interactions. Essentially all of the species' known populations, as well as undocumented populations that may exist in potential habitats, occur on privately owned lands. Landowners are not obligated to allow rare plant surveys on their lands. Consequently, there is limited information regarding the species' current distribution, abundance, and status throughout the range of its potential habitats. There are no known specific efforts to conserve the species or its habitats.

We rank the current conditions of the two documented bushy whitlow-wort EOs as moderately resilient. However, species surveys have been conducted only on a very small fraction of the potential habitats where bushy whitlow-wort can be reasonably expected to occur. Consequently, our analysis of the species' current condition may underestimate its viability. If the species exists only at the two known populations, its status is highly vulnerable to threats that affect one or both populations. It is also possible that an unknown number of resilient populations may remain undiscovered in south Texas and Coahuila, Mexico, and that the species' redundancy, representation, and overall viability are more secure than we now know.

Nevertheless, our assessments of species statuses must be based on the best available information. Since bushy whitlow-wort has only two known populations, we must conclude that it has extremely low redundancy. The populations have, at best, moderate resilience, and the degree of representation remains unknown. In synthesis, even under the most optimistic circumstances, bushy whitlow-wort is a narrow endemic with very specific habitat requirements. We project how the future viability of bushy whitlow-wort may be influenced by a range of plausible scenarios. We chose a future time frame of 2050 to 2074 to coincide with the time frame we used for climate change projections and evaluated the attributes of population sizes, demographic trends, the number and geographic distribution of populations, population genetics, habitat loss from energy development, and the potential effects of climate changes. The degree of uncertainty regarding the species' current status is magnified in future projections; we are currently unable to project if it is likely that the species will maintain multiple, if any, resilient populations to contribute to the species' viability 50 years from now.

Conservation actions that may prevent a decline in the species' status include: Outreach, technical support, and assistance to private landowners interested in the species' conservation; surveys of potential habitats in south Texas and Coahuila, Mexico; and collection and propagation of seeds to establish ex-situ populations and reintroduction into secure habitats.

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CHAPTER 1. INTRODUCTION AND ANALYTICAL FRAMEWORK

Bushy whitlow-wort is a perennial herbaceous plant in the Carnation Family (Caryophyllaceae) that has only been found in a very small area of northwestern Jim Hogg County in south Texas. On July 1, 1975, the Smithsonian Institution included it in a list of over 3,000 plant species recommended as candidates for protection under the Endangered Species Act (ESA; 40 FR 27824). On December 15, 1980, we, the U.S. Fish and Wildlife Service (USFWS) classified it as a taxon that had proven to be more abundant or widespread than was previously believed, or not subject to any identifiable threat, and removed it from the candidate list (45 FR 82480). We again recognized it as a candidate for listing on September 27, 1985 (50 FR 39526), where it remained for 21 years. The Center for Biological Diversity *et al*. (2004) submitted a petition to protect bushy whitlow-wort and 224 other taxa that had remained candidates for many years. On September 12, 2006, we again removed it from the candidate list, due to the insufficient information on biological vulnerability and threats to support listing under the ESA (71 FR 53756). On June 18, 2007, Forest Guardians (now called Wild Earth Guardians) submitted a new petition to list bushy whitlow-wort and 474 additional taxa under the ESA. On December 16, 2009, in response to this petition, we determined that listing as threatened or endangered may be warranted (74 FR 66866).

USFWS uses a Species Status Assessment (SSA) Framework (USFWS 2016; Smith *et al*. 2018) to review the best available scientific information about the life history and ecology of a species, assess its current species viability and trends, and project its future viability under a range of scenarios. The SSA does not convey policy decisions, but compiles the information and analyses that support many ESA actions, including candidate conservation, listing, recovery planning, Section 7 consultations, permitting, five-year reviews, and reclassification.

USFWS defines species viability as the ability to sustain populations in the wild over time (USFWS 2016, p. 21). The assessment of viability is derived from an analysis of the species' requirements in terms of its resilience, redundancy, and representation.

- Resilience refers to the ability of species and populations to endure random environmental and demographic variations (Shaffer and Stein 2000, pp. 308-310). Resilient populations are better able to recover from losses caused by variations in rainfall or wildfire frequency (environmental stochasticity) and fluctuations in recruitment (demographic stochasticity). The metrics of resilience include the sizes and growth rates of populations (USFWS 2016, p. 21).

- Redundancy refers to the ability of a species to endure catastrophic events (Shaffer and Stein 2000, pp. 308-310). Catastrophic events are rare occurrences, usually of finite duration, that cause severe impacts to one or more populations. Examples include tropical storms, floods, prolonged drought, and unusually intense wildfire. The metrics of redundancy are the number of populations and their geographic distribution and connectivity.

- Representation refers to the ability of a species to adapt to novel changes in its biological and physical environment (USFWS 2016, p. 21). Representation is the genetic and ecological diversity, both within and among populations, necessary to conserve long-term adaptive capability (Shaffer and Stein 2000, pp. 307-308).

CHAPTER 2. SPECIES INFORMATION

In this chapter, we provide biological information about bushy whitlow-wort, including its taxonomic history, morphological description, known and projected range and distribution, and known life history.

2.1. Species description

The following species description has been adapted from Correll 1966, p. 307; Correll and Johnston 1979, pp. 628–629; Damude and Poole 1990, pp. 3–4; Hartman *et al*. 2005b, p. 36; Poole *et al*. 2007, pp. 332–333; and Strong and Williamson 2015, p. 123:

Bushy whitlow-wort is a perennial herbaceous plant of the Carnation Family (Caryophyllaceae). Correll (1966) described *Paronychia congesta* as a new species, based on specimens collected about 1.6 kilometers (km) (1.0 miles (mi)) south of Thompsonville in northwest Jim Hogg County, Texas. (Thompsonville is now a dispersed rural community (Garza 2020); the former town site is uninhabited). Individuals have multiple stems, from 6 to 24 centimeters (cm) (2.4 to 9.4 inches (in)) tall, radiating from a perennial caudex (woody rootstock) (see cover photograph and Figure 1.b). The narrow, stemless, sharply-pointed leaves are arranged in opposing pairs, often appressed to the stems; leaves and bracts are crowded and overlapping at the bases of stems and primary branches. Each leaf is 4 to 7 millimeters (mm) (0.2 to 0.3 in) long and 0.5 mm (0.02 in) wide; stipules are long, thin, silvery, membranaceous, hairless, and about as long as the leaves. The stems, leaves, and sepals are covered with dense, short, spreading hairs. Dense clusters of 7 to 28 tiny flowers are arranged in blueish-green cymes at the tips of stems (Figure 1.a). Bisexual flowers are subtended by bracts, lack petals, and have 5 petal-like calyx lobes that are lemon-yellow on the inner side and fade from green to reddish-brown on the outer side. Calyx lobes are 2.5 to 3.1 mm (0.10 to 0.12 in) long and are longer than bracts; each lobe has a hooded tip from which emerges a stiff, short awn 0.5 to 0.7 mm (0.02 to 0.3 in) long. Each flower has 2 to 5 stamens and a single pistil with two styles united nearly to the stigmas. Fertilized flowers can produce a bladder-like fruit, called a utricle, with a single ovoid seed 0.8 to 0.9 mm (0.03 to 0.04 in) long. The distinguishing characteristics are summarized in Table 1.

Table 1. Characteristic features that distinguish bushy whitlow-wort from other species of *Paronychia*.

Feature	**Description**
Sepal color:	Lemon-yellow.
Epidermal ornamentation:	Dense, short hairs on most parts of the plant.
Leaf arrangement:	Numerous, congested, overlapping leaves and bracts at the bases of stems and primary branches.
Floral morphology:	Calyx lobes longer than bracts; short, erect awns at tips of lobes.

In the field, bushy whitlow-wort can be mistaken for other species that are similar in appearance, such as slimleaf heliotrope (*Heliotropium torreyi*) and an unidentified bluet (*Houstonia*) species (Damude and Poole 1990, p. 5; Strong 2020 p.1). Consequently, effective surveys require thorough knowledge of the local flora, and reported occurrences should be documented with photographs and voucher specimens deposited in a herbarium.

2.2. Taxonomic classification and phylogenetics

There are about 110 species of *Paronychia*, of which 26 occur in North America (Hartman *et al*. 2005a, p. 30). Turner (1983a) reviewed the taxonomic status of the Texas species of *Paronychia*. He observed that *P. congesta* was most similar to *P. jamesii*, a more common species that is widely distributed from west Texas and Arizona to Nebraska and Wyoming; he concluded that they are distinct taxa, based on the geographic separation of their ranges (p. 10) and the more congested inflorescences, gradually tapered calyx lobes, and non-divergent awns of the former species (p. 18). Another very rare endemic *Paronychia*, *P. maccartii*, occurs in Webb County just 16 km (10 miles) west of the *P. congesta* type location. However, these species are not closely related and are easily distinguished in the field (see Table 1); furthermore, *P. maccartii* inhabits loose, sandy soils, while *P. congesta* is found on calcareous rock outcrops (Turner 1983b, p. 3). A phylogenetic study based on a relatively small sample of 21 taxa within the tribe *Paronychieae* indicated that the genus *Paronychia*, as currently circumscribed, may be polyphyletic (Oxelman *et al*. 2002, p. 231). Nevertheless, *P. congesta* continues to be recognized as a unique, valid species (Hartman *et al*. 2005b, p. 36; Natural Resources Conservation Service 2020a; Tropicos 2020).

2.3. Life history: Phenology, reproduction, demographic trends, and life span

Phenology and reproduction

Bushy whitlow-wort has been observed in flower from April through June and August; flowering appears to be stimulated by recent rainfall (Turner 1983b, p. 6; Damude and Poole 1990, p. 17; Poole *et al*. 2007, p. 333). Pollinators have not been observed, and the pollination biology and breeding system remain unknown (Damude and Poole 1990, p.18). *Paronychia pulvinata* (mentioned below) is effectively pollinated by an ant species, *Formica neorufibarbis gelida* (Puterbaugh 1998, p. 42); given the minute size of bushy whitlow-wort flowers, ants may also be important as pollinators or seed dispersers. Damude and Poole (1990, p. 16) observed immature and mature seeds on June 8, 1987. Due to the small size of individuals, the small population sizes, relatively few flowers, and the single-seeded fruit, seed production is evidently very limited. Seed dispersal, seed dormancy, and the longevity of seed viability are also unknown, and the species has not been propagated. Turner (1983b, p. 6) speculated that the species may reproduce vegetatively by rhizomes, but this has not been confirmed.

Demographic trends and life span

Botanists have observed the known populations of bushy whitlow-wort on relatively few occasions, and we have found no data on rates of recruitment, mortality, or demographic trends. Although the species flowers and sets seed, seed germination and juvenile individuals have not been observed. However, for many plant species of south Texas, most recruitment occurs in rare pulses during years when rainfall is far above average. This may be an adaptation to the wide annual variation in regional precipitation. Hence, the failure to observe recruitment in bushy whitlow-wort is not surprising, considering the lack of studies that specifically tracked recruitment.

It has not been possible to determine the reproductive age or life spans of individuals. However, since individuals have woody rootstocks up to 1.25 cm (0.5 in) in width, the species is clearly perennial, and individuals may persist for many years (Damude and Poole 1990, pp. 15–16). Forbis and Doak (2004, pp. 1149–1150) found that *Paronychia pulvinata*, a species of xeric alpine rock outcrops in Colorado, has high survival rates and extremely low fecundity; they estimated that at least 1 percent of individuals live up to 324 years. Like bushy whitlow-wort, *P. pulvinata* is a low-growing, caespitose perennial with herbaceous branches emerging from a woody caudex. Therefore, it is possible that the low or sporadic recruitment of bushy whitlow-wort is compensated by long average lifespans.

2.4. Habitats and ecology

Surface geology

The two documented populations of bushy whitlow-wort occupy exposed slopes of calcareous rock and/or indurated caliche along the boundary of the Goliad geological formation and the Catahoula and Frio Clay (undivided) geological formation (Turner 1983b, p. 5; Damude and Poole 1990, pp. 9, 10, 12; Poole *et al*. 2007, p. 333; see Figures 2 and 3). "Caliche" is a word of Spanish origin that generally refers to soils or minerals of whitish appearance. However, the term has a specific geological meaning, referring to soil strata of calcium carbonate that precipitated as water evaporated from the soil. In contrast, limestone consists of calcium carbonate deposits that formed in ocean sediments. Caliche strata often form in arid regions; those of the Goliad formation formed in an arc parallel to the present Gulf of Mexico during the early Pliocene geological epoch (about 5 to 6 million years ago (mya); Baskin and Hulbert 2008, pp. 93, 96–97).

This geological transition zone from the Goliad to Catahoula formations is known locally as the Bordas Escarpment. In the vicinity of the bushy whitlow-wort populations, elevations drop about 46 meters (m) (151 feet (ft)) from northeast to southwest; these slopes occur along the uppermost reaches of the Arroyo Veleño watershed, a seasonal watercourse that flows into the Rio Grande at Zapata, Texas. The Goliad formation, of Miocene to early Pliocene age (23.0 to about 5 mya), contains deposits of clay, sandstone, marl, caliche, limestone, and conglomerate. The older Catahoula formation is of Oligocene age (33.9 to 23 mya); it contains deposits of clay, mudstone, volcanic tuff, volcanic conglomerate, sandstone, and sand, with some gypsum and calcareous concretions. In some places, outcrops of Goliad caliche overlie deep beds of Catahoula tuff. These tuff deposits are often calichified (Galloway *et al*. 1977, p. 37). Strong and Marr (2014, cited in TXNDD 2017) described the area of EO 2 as "a volcanic tuff/limestone hill". In synthesis, bushy whitlow-wort is likely to be a geo-endemic species that is restricted to exposed outcrops of Goliad formation caliche or calcareous rock; alternatively, it may be even more highly restricted to exposed calcareous tuff that occurs in specific places along the Goliad-

Catahoula boundary (as shown in Figure 1.c); calcareous tuff is exposed in an unknown proportion of the red-tinted "estimated potential habitat" shown in figure 4).

Soils

The Natural Resources Conservation Service (NRCS) classifies soils in the vicinity of the known bushy whitlow-wort populations as Zapata soils (Soil Conservation Service 1974, p. 17; NRCS 2020; see diagram in Figure 2).The representative Zapata soil profile consists of grayish-brown fine sandy loam 0 to 5 cm (0 to 2 in) deep; brown sandy clay loam 5 to 20 cm (2 to 8 in) deep; and indurated, laminar, pinkish-white caliche below 20 cm (8 in). The occupied sites are also very near or overlay areas of Cuevitas-Randado Association soils. A representative profile has brown and reddish-brown fine sandy loam from 2.5 to 23 cm (1 to 9 in) in depth, and indurated, laminar, white caliche below 23 cm (9 in); clearly, Zapata and Cuevitas soils are very similar. Although the immediate area of occupied sites has very little soil, such areas of exposed rock are included within these soil map unit polygons.

Plant community

Damude and Poole (1990, pp. 12, 13) described the associated plant community as an open shrubland with the tallest plants reaching 1.2 to 1.8 m (4 to 6 ft) in height. However, within this shrubland community, bushy whitlow-wort occurs primarily in nearly barren openings on exposed limestone, caliche, or calcareous tuff (see Figure 1.c), where the nearly white rocks reflect and intensify sunlight. Table 2 lists associated plant species reported at occupied sites.

Table 2. Plant species associated with bushy whitlow-wort habitats (Turner 1983b, p. 9; Damude and Poole 1990, p. 14; Strong and Williamson 2015, p. 131).

Family	**Genus**	**Species[1]**	**Common Name[1]**	**Habit**
Asparagaceae	*Yucca*	*treculeana*	Spanish dagger	Tree, Shrub
Asteraceae	*Gochnatia*	*hypoleuca*	Chomonque	Shrub
Asteraceae	*Liatris*	*punctata*	Dotted blazing star	Herb
Asteraceae	*Tetraneuris*	*linearifolia*	Fine-leaf four-nerved daisy	Herb
Asteraceae	*Tetraneuris*	*scaposa*	Four-nerved daisy	Herb
Asteraceae	*Thelesperma*	*filifolium*	Stiff greenthread	Herb
Asteraceae	*Thymophylla*	*pentachaeta*	Five needle dogweed	Herb
Asteraceae	*Wedelia*	*texana*	Orange Zexmenia	Sub-shrub
Asteraceae	*Zinnia*	*acerosa*	Desert Zinnia	Herb
Boraginaceae	*Heliotropium*	*greggii*	Fragrant heliotrope	Herb
Boraginaceae	*Heliotropium*	*torreyii*	Narrow leaf heliotrope	Herb
Cactaceae	*Echinocereus*	*fitchii* ssp. *fitchii*	Fitch's rainbow cactus	Small succulent
Cactaceae	*Opuntia*	*leptocaulis*	Tasajillo	Shrub
Cactaceae	*Opuntia*	*lindheimeri*	Nopal, prickly pear	Shrub
Capparaceae	*Koeberlinia*	*spinosa*	Junco, allthorn	Shrub

Family	**Genus**	**Species**[1]	**Common Name**[1]	**Habit**
Ebenaceae	*Diospyros*	*texana*	Chapote, Texas persimmon	Tree, shrub
Ephedraceae	*Ephedra*	*antisiphillitica*	Joint fir	Shrub
Euphorbiaceae	*Bernardia*	*myricifolia*	Oreja de ratón	Shrub
Euphorbiaceae	*Chamaesyce*	*sp.*	Spurge	Herb
Euphorbiaceae	*Croton*	*sp.*	Croton	Herb
Euphorbiaceae	*Jatropha*	*dioica*	Sangre de drago, leatherstem	Herb
Fabaceae	*Acacia*	*berlandieri*	Guajillo	Shrub
Fabaceae	*Acacia*	*rigidula*	Blackbrush	Shrub
Fabaceae	*Calliandra*	*conferta*	Feather duster	Sub-shrub
Fabaceae	*Dalea*	*frutescens*	Black Dalea	Sub-shrub
Fabaceae	*Desmanthus*	*velutinus*	Velvet bundleflower	Herb
Fabaceae	*Eysenhardtia*	*texana*	Kidneywood	Shrub
Fabaceae	*Parkinsonia*	*texana* v. *texana*	Texas palo verde	Tree, Shrub
Fabaceae	*Prosopis*	*glandulosa*	Honey mesquite	Tree, Shrub
Fabaceae	*Sophora*	*secundiflora*	Texas mountain laurel	Shrub, tree
Krameriaceae	*Krameria*	*ramosissima*	Calderona, rattany	Sub-shrub
Loasaceae	*Cevallia*	*sinuata*	Stinging Cevallia	Herb
Oleaceae	*Forestiera*	*angustifolia*	Elbow-bush	Shrub
Poaceae	*Aristida*	*purpurea*	Purple three-awn	Herb
Polemoniaceae	*Giliastrum*	*acerosum*	Blue bowls	Herb
Polygalaceae	*Polygala*	*lindheimeri*	Shrubby milkwort	Herb
Rhamnaceae	*Karwinskia*	*humboldtiana*	Coyotillo	Shrub
Rhamnaceae	*Ziziphus*	*obtusifolia*	Clepe, lotebush	Shrub
Rubiaceae	*Stenaria*	*nigricans*	Prairie bluets	Herb
Sapotaceae	*Sideroxylon*	*celastrinum*	Coma	Shrub
Scrophulariaceae	*Leucophyllum*	*frutescens*	Cenizo	Shrub
Solanaceae	*Lycium*	*sp.*	Wolfberry	Shrub
Verbenaceae	*Tetraclea*	*coulteri*	Coulter’s wrinklefruit	Herb
Zygophyllaceae	*Guaiacum*	*angustifolium*	Guayacán	Shrub

1. Taxonomy updated to conform mostly to PLANTS database (Natural Resources Conservation Service 2020). Common names from Richardson and King 2011.

Climate

Bushy whitlow-wort occurs in the semi-arid, subtropical climate of the Tamaulipan shrublands of south Texas. The average annual precipitation is 60.4 cm (23.8 in), with the greatest amounts from May to July and September to October (NCDC 2020; see Table 3). The average daily maximum temperature exceeds 35° C (95° F) from June through August, and the average frost free period is from February 8 to December 11 (307 days) (Texas Almanac 2020).

Table 3. Monthly precipitation and temperature averages for Hebbronville, Texas, 1981–2010 (NCDC 2020).

Month	Average Precipitation		Average Temperature		Average Daily Maximum Temperature		Average Daily Minimum Temperature	
	cm	in	°C	°F	°C	°F	°C	°F
Jan	3.18	1.25	13.4	56.2	19.8	67.6	7.1	44.8
Feb	3.68	1.45	15.6	60.1	22.2	72	9.0	48.2
Mar	3.02	1.19	19.1	66.4	25.7	78.3	12.5	54.5
Apr	3.71	1.46	23.0	73.4	29.6	85.3	16.4	61.5
May	7.87	3.1	26.6	79.9	32.7	90.8	20.6	69
Jun	6.53	2.57	29.1	84.3	35.3	95.5	22.9	73.2
Jul	6.78	2.67	29.6	85.3	35.9	96.7	23.3	73.9
Aug	4.29	1.69	29.8	85.6	36.5	97.7	23.1	73.6
Sep	8.38	3.3	27.3	81.1	33.4	92.2	21.1	69.9
Oct	5.99	2.36	23.4	74.1	29.9	85.9	16.8	62.3
Nov	3.43	1.35	18.5	65.3	25.1	77.1	12.0	53.6
Dec	3.56	1.4	13.8	56.9	20.2	68.3	7.5	45.5
TOTALS	60.43	23.79						

2.5. Populations, Element Occurrences, and geographic distribution

USFWS assesses a species' viability based on the resiliency, redundancy, and representation of its populations (described in Section 1). Simply stated, populations are groups of interbreeding organisms of a particular taxon. Measurements of population size, number, and distribution require the delineation of populations. Populations are delineated by barriers to gene flow between individuals. For terrestrial plants, the barriers to gene flow are distances greater than the ranges of pollination and seed dispersal, as well as reproductive isolation due to differing phenologies, pollinators, or genetic incompatibilities. Thus, a comprehensive understanding of plant populations derives from data on the habitat requirements, phenology, pollination systems, pollinators, the longevity of pollen viability, seed dispersal mechanisms, the longevity of seed viability, breeding systems, and population genetics.

The Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (TXNDD) maintains geographic and population data of plant and animal species of conservation concern in Texas. This data is contributed and used by many entities involved in conservation, including TPWD and other state agencies, federal agencies, academic researchers, environmental consultants, non-profit conservation organizations, and private individuals. Data for each species is organized by standard geographical units for populations and habitats called "Element Occurrences" (EOs), which are defined as "areas of land and/or water in which a species or natural community is, or was, present" (NatureServe 2002, p. 1). EOs are displayed as points, lines, and polygons buffered by their estimated geographic precision. The reported populations occur or occurred within, but not necessarily throughout, the buffered EO points, lines, and polygons (see Figure 3). The recommended minimum separation distances between EOs is 1 km (0.6 mi) for gaps of unsuitable habitat or unoccupied suitable habitat (NatureServe 2002, p. 26).

Table 4 summarizes data from the most recent update of bushy whitlow-wort EOs (TXNDD 2017).

For bushy whitlow-wort and other plant species of conservation concern, we use the EO standard as the unit of analysis for two reasons. First, the use of a single standard benefits coordination among all the partners concerned with the conservation and management of a species. Additionally, the comprehensive understanding of populations described above requires many scientific investigations spanning many years. Furthermore, since about 95% of Texas is privately owned, access to conduct population studies may not be granted. EOs are practical approximations of populations, based on the best available scientific information, that allow us to make timely decisions and conduct conservation actions now. Throughout this document, EO refers specifically to the occurrences compiled by the TXNDD, as shown in Table 4 and Figure 3; we use the term "population" in the more general sense, including occurrences that have not been documented, as well as discussions about the requirements of populations.

Table 4. Bushy whitlow-wort Element Occurrence records and population sizes.

EO No.[1]	EO ID[1]	County	Site Name	Observations		
				Date	Numbers Observed	Citation
1	1611	Jim Hogg	Thompsonville South; type locality	1963	Unknown	Correll 1966
				1983	4	Turner 1983b
				1987	± 2000	Poole 1987
				1988	Unknown	Damude and Poole 1990
2	7761	Jim Hogg	Thompsonville Breaks	1987	± 100	Damude and Poole 1990
				1988	Unknown	Damude and Poole 1990
				1990	Unknown	Damude and Poole 1990
				1991	1057	Poole and Janssen 1994
				1993	122	Poole and Janssen 1994
				1994	1904	Poole and Janssen 1994
				2014	0	TXNDD 2017
Unknown[2]	Unknown[2]	Jim Hogg	1.8-acre portion of EO 1 or EO 2	2014	633	Strong and Williamson 2015

1. Element Occurrence Number and Element Occurrence Identity from TXNDD 2017.
2. Landowner granted access for survey, but requested that the location not be publicized.

Damude and Poole (1990) and Strong and Williamson (2015) refer to EO 1 as the "five-acre site", and EO 2 as the "15-acre site". These EOs, as mapped by TXNDD, occupy 3.1 hectares (ha) (7.7 acres (ac)) and 18.0 ha (44.4 ac), respectively; however, EO 2 is bisected by highway FM 649, which converted about 1.6 ha (4.0 ac) of habitat to pavement and graded right-of-way. Therefore, the total area of these EOs is about 19.5 ha (48.1 ac). The two EOs are separated by 2.05 km (1.27 mi).

The few reported population sizes of both EOs vary widely. This may be due to different observers surveying different areas of the same population (Damude and Poole 1990, p. 16), particularly since the earlier censuses were conducted before Global Positioning Systems (GPS) were widely available. It is also possible that living, dormant bushy whitlow-wort plants are undetectable during periods of extended drought. Although the woody rootstock is perennial, the herbaceous stems and foliage may die back to ground level and wither away; this is a common pattern observed in perennial herbaceous plants of the Tamaulipan shrublands ecosystem. In 2014, Strong and Marr (TXNDD 2017) observed no individuals at EO 2 during a survey of the public right-of-way (ROW) of FM 649. However, this ROW had recently been graded and was partially colonized by buffelgrass (*Pennisetum ciliare*), an introduced invasive forage grass; bushy whitlow-wort may have been eradicated from the ROW by disturbance and buffelgrass competition. In July of 2014, one landowner granted these surveyors access to a portion of one of the EOs, but requested that the location not be disclosed (Strong and Williamson 2015, p. 131).

Villaseñor (2016, p. 695) lists *Paronychia congesta* Correll as an endemic, native species of the flora of Coahuila, Mexico. However, this source does not reference a herbarium voucher or other documentation. We have found no evidence of any herbarium specimens or other documentation of this species collected outside of Jim Hogg County, Texas, including a database search of 19 herbaria that have large collections of Mexican plant species (CONABIO 2020). It is plausible that bushy whitlow-wort might occur in northern Tamaulipas, Nuevo León, or Coahuila, where there are similar habitats and climate within a few hundred kilometers of the Jim Hogg County populations. Nevertheless, the currently available data does not justify extending the species' known range into Coahuila.

2.6. Estimate of potential habitat

It is possible that the two documented populations of bushy whitlow-wort really are the only places in the world this species inhabits. It might have evolved right where it is and remained there ever since, or might once have been more abundant, and more recently died back to its current locations. It is also possible that the species occurs in other undocumented locations. Most of Jim Hogg and surrounding counties are sparsely populated. The traditional regional land use, livestock ranching, requires large tracts of land, due to the low and highly variable rainfall; typical private ranches in this area are about 1,875 ha (4,635 ac) in size (Montalvo *et al*. 2020, p. 31). Very few published rare plant surveys have been conducted on private lands in this region, and the public lands that can be surveyed are almost entirely limited to the few highway ROWs. Therefore, if additional populations of bushy whitlow-wort do exist, it is highly unlikely that they would have been documented.

The existence of the only known populations of bushy whitlow-wort on exposed outcrops along the Bordas Escarpment, where the Goliad and Catahoula/Frio Clay formations meet, strongly suggests a hypothesis that the species is a geo-endemic that is uniquely adapted to some soil or geological features that occur there. We used the ArcGIS software to determine what geographic features are found at the known bushy whitlow-wort habitats (Figure 3), and to develop a potential habitat model based on the distribution of those features to predict where else the species may occur. These features, or geographic layers, are:

- We used a shapefile of Texas surface geology, described by Stoeser *et al*. (2005). As discussed in Section 2.4, the bushy whitlow-wort EOs overlie the boundaries of the Miocene Goliad formation and the Oligocene Catahoula and Frio Clay (undivided) formations. We created a geographic layer (shapefile) from both of these formations.
- We downloaded county soil survey shapefiles from the Web Soil Survey (NRCS 2020b) for Jim Hogg and other south Texas counties. Note that different county soil surveys often use different names for soils with the same or very similar descriptions, so we selected soil map units from each county that matched the descriptions of the Zapata and Cuevitas-Randado Association soils of Jim Hogg County (as described in Section 2.4). Table 5 lists the soil map units selected from each county for this potential habitat model.

Table 5. Soil map units selected for bushy whitlow-wort potential habitat model.

County	Soil map unit names
Jim Hogg	Zapata soils; Cuevitas-Randado association.
Webb	Cuevitas-Randado complex, gently undulating; Jiménez-Quemado complex, undulating; Zapata rock outcrop complex, gently undulating.
Zapata	Cuevitas-Randado complex, 0–3% slope; Jiménez-Quemado complex, 1–8% slope; Zapata-rock outcrop complex, 1–8% slope.
Duval	Piedras and Cuevitas soils, 1–5% slope.
Jim Wells	Olmos association, undulating.
Starr	Jiménez-Quemado association; Zapata soils.
Hidalgo	Jiménez-Quemado complex, 1–8% slope; Randado-Cuevitas complex, 0–3% slope.

- Sloping surfaces can be useful indicators of geo-endemic plants because the rock strata where such plants occur are often exposed along slopes, rather than buried beneath deep soil horizons. We obtained Digital Elevation Models (DEMs; USGS 2020a) and used the slope tool in the ArcGIS Spatial Analyst extension to determine the percent slope of occupied portions of the bushy whitlow-wort EOs; these areas had slopes ≥ 8 percent. We then created a geographic layer of all areas with 8 percent or greater slope in the 7 counties listed above.

We used the ArcGIS Intersect tool to map the areas in 7 south Texas counties where all three of the geographic layers described above overlap (Figure 4). This model could be improved if this species had been documented at more sites, or if the model could be tested throughout its geographic range. The model could also be improved by using additional geographic layers that either positively or negatively explain the species' distribution, such as a data layer that specifically delineates areas of exposed calcareous tuff; however, we are not aware of any other available geographic data layers that explain the distribution of bushy whitlow-wort. The resulting polygons, displayed in red in Figure 4, represent this estimate of potential bushy whitlow-wort habitat. We emphasize that this model is based on only two population sites, and has not been ground-truthed. It is a hypothesis based on the available data on the species habitat and distribution.

In Duval, Jim Wells, and Hidalgo counties, the model identified relatively small, isolated polygons. In Webb, Zapata, Jim Hogg, and Starr counties, the model identified larger clusters of potential habitat. However, this difference in polygon size may be due, in part, to differences in the way the NRCS soil map units were mapped in each county. In general, plant species are more likely to colonize and persist where there are larger areas of contiguous habitat. The table in Figure 4 summarizes statistics about these potential habitat areas in each county. Although we do not know what the minimum habitat size is for bushy whitlow-wort, the table groups the polygons into three size ranges to aid comparisons between counties: ≥ 0.1 ha, ≥ 1.0 ha, and ≥ 10 ha (0.25 ac, 2.47 ac, and 24.7 ac). This method identified a total of 136,736 polygons covering 41,670 ha (102,966 ac). From these totals, more than 71,000 polygons ≥ 0.1 ha, totaling 38,950 ha (96,245 ac) of potential habitats; over 9,000 polygons ≥ 1.0 ha, totaling 18,828 ha (46,524 ac); and 76 polygons ≥ 10 ha, totaling 1,893 ha (4,678 ac).

As discussed in Section 2.4, some observers described the known bushy whitlow-wort habitats as caliche or calcareous rock, while others describe this more specifically as calcareous tuff. Caliche outcrops are relatively abundant in south Texas. However, extensive plant surveys have been conducted where caliche outcrops occur on tracts of Lower Rio Grande Valley National Wildlife Refuge (LRGV NWR) in southern Starr and southwestern Hidalgo counties; bushy whitlow-wort has never been reported there.

The calcification of volcanic tuff deposits is a phenomenon that occurs sporadically along the boundary of the Goliad and Catahoula formations. If bushy whitlow-wort is more specifically restricted to outcrops of calcareous tuff, its potential habitats would be only a portion of the estimated potential habitat shown in Figure 4. Outcrops of calcareous tuff may occur where the red potential habitat polygons border the light gray Catahoula formation, as shown in Figure 4, but we are unaware of any available geographic data layers that delineate exposed calcareous tuff.

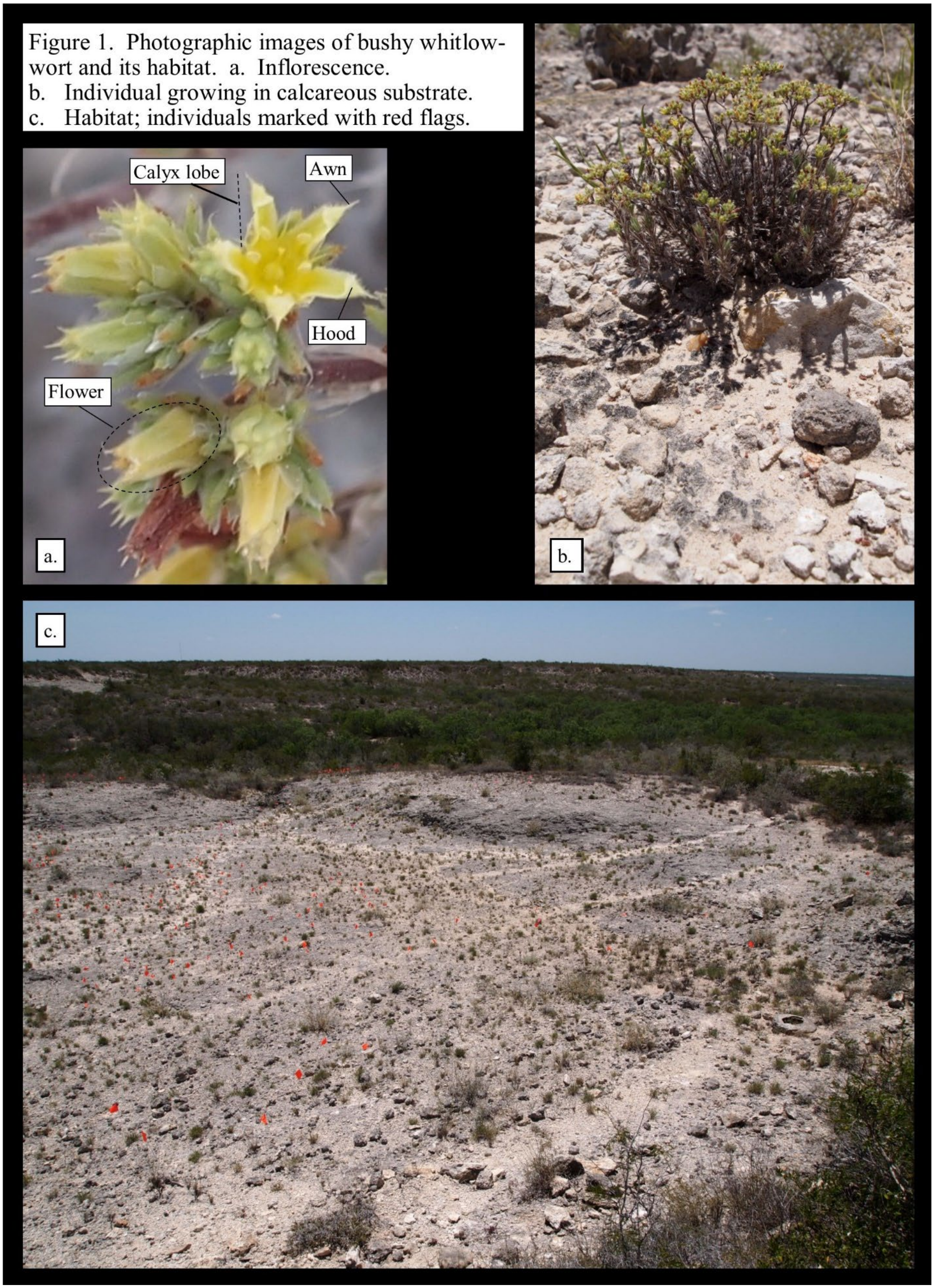
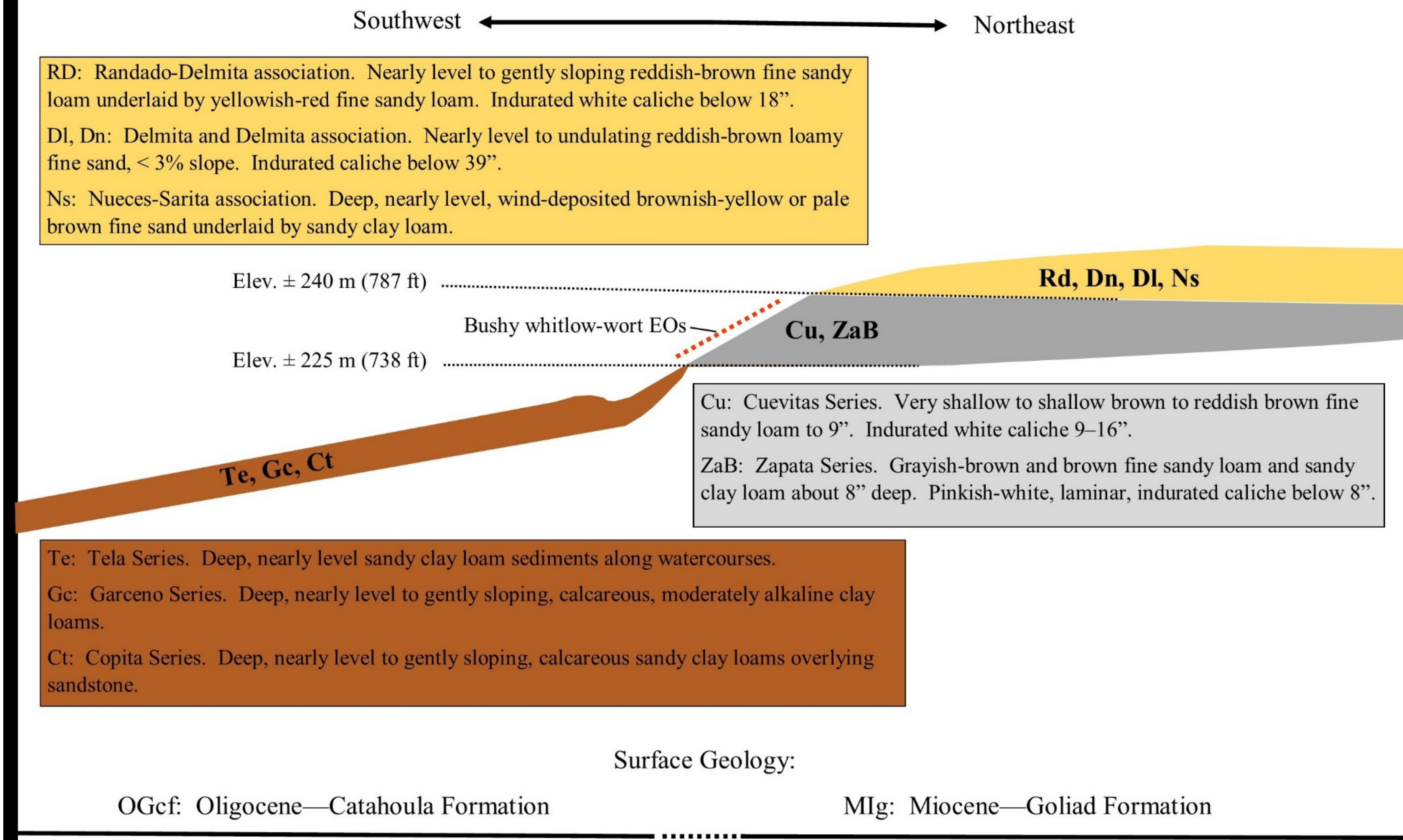


Figure 1. Photographic images of bushy whitlow-wort and its habitat. a. Inflorescence.
b. Individual growing in calcareous substrate.
c. Habitat; individuals marked with red flags.

Figure 2. Diagram of soil map units and surface geology of known bushy whitlow-wort populations (SCS and TAES 1974, USGS 2020a).

Note: Vertical scale is much greater than horizontal scale.



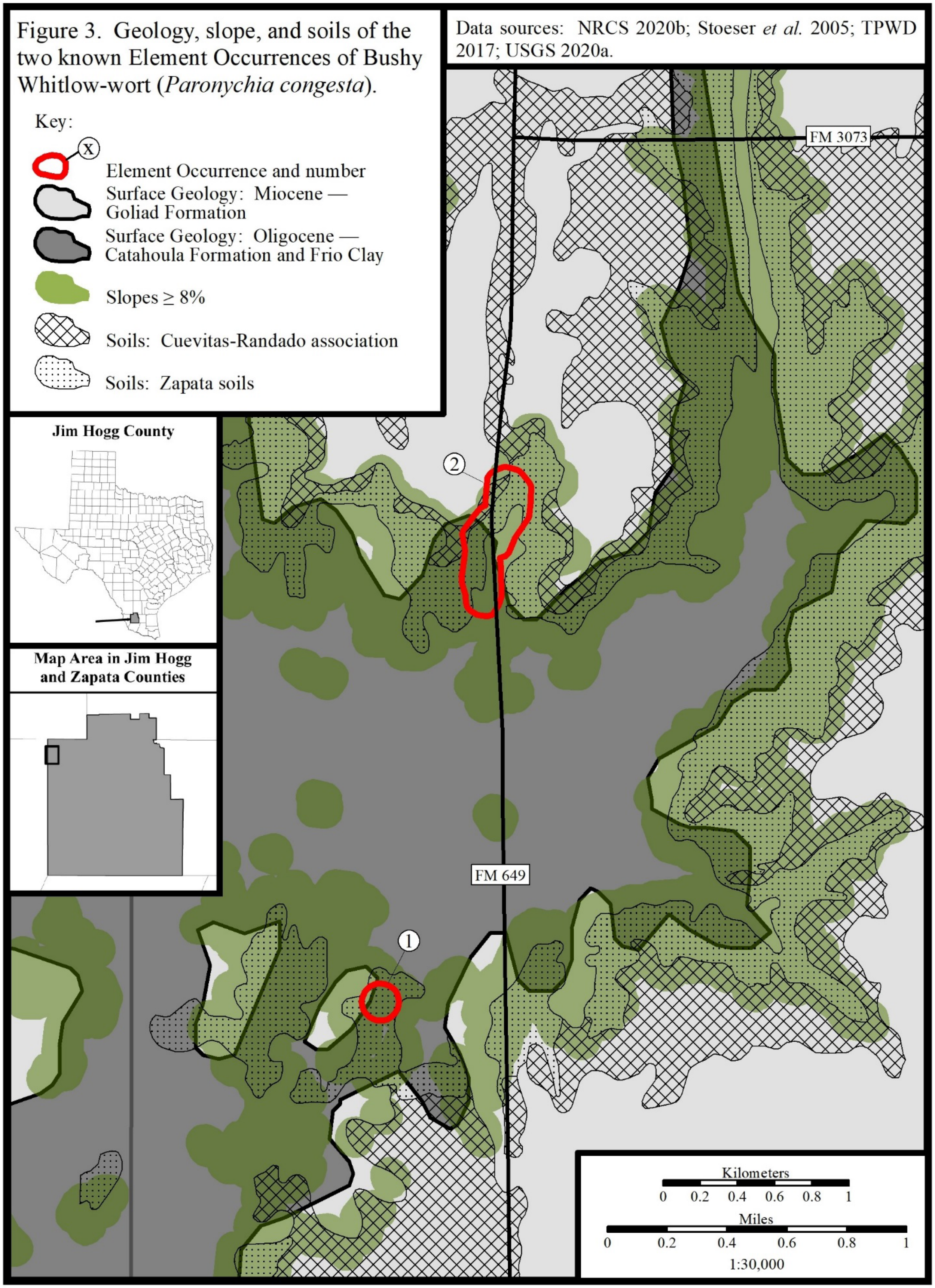
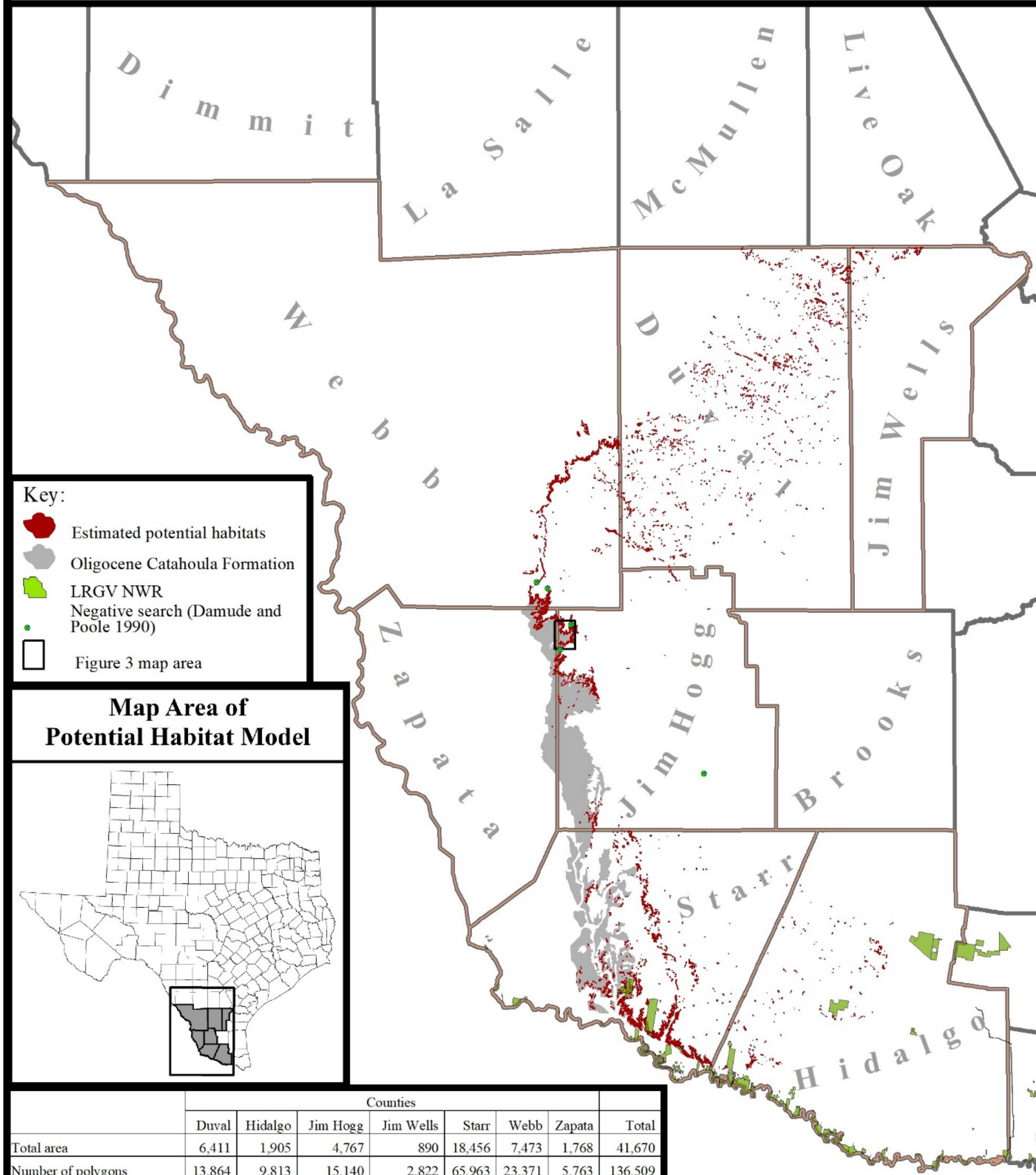


Figure 3. Geology, slope, and soils of the two known Element Occurrences of Bushy Whitlow-wort (*Paronychia congesta*).

Figure 4. Estimate of bushy whitlow-wort (*Paronychia congesta*) potential habitats.
Data sources: NRCS 2020b; Stoeser *et al.* 2005; TPWD 2017; USGS 2020a.



	Counties							
	Duval	Hidalgo	Jim Hogg	Jim Wells	Starr	Webb	Zapata	Total
Total area	6,411	1,905	4,767	890	18,456	7,473	1,768	41,670
Number of polygons	13,864	9,813	15,140	2,822	65,963	23,371	5,763	136,509
Area of polygons ≥ 10 ha	11	10	575	35	265	769	212	1,893
No. of polygons ≥ 10 ha	1	1	13	2	16	30	13	76
Area of polygons ≥ 1 ha	3,861	669	2,326	406	7,343	3,460	756	18,828
No. of polygons ≥ 1 ha	1,881	343	953	213	3,920	1,472	302	9,077
Area of polygons ≥ 0.1 ha	6,185	1,671	4,467	833	17,123	7,015	1,650	38,950
No. of polygons ≥ 0.1 ha	8,466	3,845	7,897	1,508	33,904	12,495	3,082	71,146

CHAPTER 3. SUMMARY OF INDIVIDUAL, POPULATION, AND SPECIES REQUIREMENTS

This summary is based on the supporting information described in Section 2.

3.1. Individual requirements

Our knowledge of the requirements of bushy whitlow-wort individuals is limited because the species has been observed on very few occasions and in only two places. We know the species is adapted to the hot, semi-arid, subtropical climate of south Texas. Individuals occur on nearly barren rocky outcrops within the Tamaulipan shrublands. Individuals flower as early as April or as late as August in response to rainfall; the timing and amount of rainfall are likely to be important, but we have no data to quantify these requirements.

We do not know what the breeding system is, nor how the flowers are pollinated. We do not know how seeds are dispersed, whether they have dormancy mechanisms, how long seeds may remain viable in the soil, or what stimulates germination; in fact, neither seed germination and juvenile plants—recruitment—nor mortality have been observed. We have no data on the reproductive age or average lifespans of individuals, although the woody rootstocks are evidence that individuals are perennial. Thus, we cannot determine the requirements of individuals related to reproduction and survival.

Individuals have only been found on outcrops of caliche or calcareous rocks that are exposed along slopes of the Bordas Escarpment in south Texas; since the species has not been found elsewhere, it appears to require this type of substrate. This requirement may be more specifically restricted to outcrops of calichified volcanic tuff that is exposed in discrete locations along the boundary of the Goliad and Catahoula geological formations. The occupied sites occur in areas classified as Zapata soils and Cuevitas-Randado association; these soil types, or soils with very similar descriptions, occur in at least 6 other south Texas counties.

3.2. Population requirements

Populations of bushy whitlow-wort must be large enough to have a high probability of surviving a prescribed period of time. For example, Mace and Lande (1991, p. 151) propose that species or populations be classified as vulnerable when the probability of persisting 100 years is less than 90 percent. This metric of population resilience is called minimum viable population (MVP).

Table 6 is an adaptation of a method for estimating plant MVPs published in Pavlik (1996, p. 137). Species with traits that all fall under column A would have MVPs of about 50 individuals. Those with traits that all ascribe to column C would have MVPs around 2,500 individuals. We added an intermediate column (B) to Pavlik's table that assigns an MVP of 1,275 for species with intermediate traits. The bold letters in the table indicate values, if known, for bushy whitlow-wort. The species is perennial and occurs in old-growth (climax successional) vegetation; these two factors require fewer individuals. The breeding system, production of ramets (such as rhizomes), individual survivorship, and the longevity of seed viability are all unknown; these four factors are removed from the estimate. Due to the small size of individuals, relatively few flowers per individual, single-seeded fruits, and infrequent germination, the species has very low fecundity. The species is also herbaceous, and environmental variation is high, due to wide variation in annual rainfall. Hence, three factors require more individuals. Therefore, our estimate of MVP is the weighted average of these factors:

$$\frac{(2 \times 50) + (3 \times 2{,}500)}{5} = 1{,}520 \text{ (or about 1,500 individuals).}$$

Table 6. Minimum viable population guidelines applied to bushy whitlow-wort (adapted from Pavlik 1996, p. 137).

Factor	**A. MVP of 50 individuals for species with these traits.**	**B. Intermediate MVP of 1,275 individuals for species with intermediate or unknown traits.**	**C. MVP of 2,500 individuals for species with these traits.**
Longevity	**Perennial**		Annual
Breeding System	Selfing	**Unknown**	Outcrossing
Growth Form	Woody		**Herbaceous**
Fecundity	High		**Low**
Ramet Production	Common	**Unknown**	Rare or None
Survivorship	High	**Unknown**	Low
Longevity of Seed Viability	Long	**Unknown**	Short
Environmental Variation	Low		**High**
Successional Status	**Climax**		Seral or Ruderal

This estimate of MVP is based only on numbers of mature individuals (those that have flowered at least once or are judged capable of flowering) because juveniles that die before they reproduce do not contribute to the effective population size or future genetic diversity. Consequently, population censuses should be conducted during the peak of flowering and fruiting (following occurrences of significant rainfall from April through August).

Resilient populations must also have stable or increasing demographic trends over time. This means that recruitment of new individuals is at least as great as mortality. Viable populations must also have sufficient numbers of individuals that are not too closely related or too widely dispersed for effective pollination, outcrossing, and seed production.

Determination of population sizes and numbers requires a method for delineating populations. However, we currently have no data to estimate the extent of gene flow for bushy whitlow-wort through pollination and seed dispersal. As discussed in Section 2.5, the TXNDD uses NatureServe's Plant EO Specifications Decision Tree to evaluate the separation distance between plant observations when delineating populations (EOs). The minimum separation distance is 1 km. However, separation distances may be larger and may vary depending on habitat and geographic distribution. We also adopt his provisional separation distance 1 km for bushy whitlow-wort.

Populations must have enough genetic diversity to be able to adapt and survive when threatened by new pathogens, competitors, or changing environmental conditions. Furthermore, inbreeding increases within populations that lack genetic diversity; if the species is susceptible to inbreeding depression, this would lead to a loss of individual fitness, reduced reproductive output, higher mortality, and population decline. If the breeding system requires outcrossing, seed production and recruitment would decline within populations that lack genetic diversity.

3.3. Species requirements

We assessed the requirements of bushy whitlow-wort in terms of its resilience, redundancy, and representation (Shaffer and Stein 2000, pp. 307-310).

Resilience, discussed in Section 3.2, refers to population sizes and demographic trends; larger populations, and populations with positive long-term demographic trends, are more likely to endure than small or declining populations. We provisionally estimate that viable populations have at least 1,500 individuals of reproductive age.

Redundancy indicates the number of populations and their distribution over the species' range. Species that have more populations distributed over a broader geographic range have a greater chance of surviving catastrophic events. Greater redundancy increases the probability that at least some populations will survive catastrophic events, such as extended drought. There is no established minimum viable number of populations. The criterion of redundancy for endangered plant recovery typically ranges from 5 to 20 populations; species that form stable, long-lived populations can be secure with fewer populations, and species with unstable, short-lived populations require greater redundancy. Since the lifespans of bushy whitlow-wort individuals and the demographic trends of its populations are unknown, we provisionally estimate that the species requires an intermediate value of 10 or more resilient populations. These populations should be distributed across the species' range, as indicated by the potential habitat model discussed in this report, or by improved models as they become available.

Representation refers to the breadth of genetic diversity and environmental adaptation necessary to conserve long-term adaptive capability. Viable species typically possess both intra- and inter-population genetic diversity; inter-population differentiation reflects adaptation to a range of ecological factors, and increases the likelihood that at least some portion of a species will be able to adapt to changing climates and other future threats.

CHAPTER 4. FACTORS THAT AFFECT THE SURVIVAL OF BUSHY WHITLOW-WORT

The following list describes factors that either positively or negatively affect the continued survival of bushy whitlow-wort.

4.1. Threats

Land use changes

We are not aware of any current land use changes within the two known occupied habitats of bushy whitlow-wort since they were first discovered in 1963 and 1987; however, see the discussion of potential wind energy development below. These privately owned properties have been used for livestock grazing for many years. We have no information on the species' palatability to cattle. However, due to its small stature, it offers very little nutritional reward to cattle, particularly when larger palatable plants are relatively abundant. Cattle are not attracted to the barren rock outcrops where the species occurs, so the impact of trampling should be negligible. In any case, the species has persisted in its current locations despite decades of grazing. We conclude that cattle grazing is not a significant threat to the species' survival. The very shallow Zapata and Cuevitas-Randado association soils of occupied populations are underlaid by indurated caliche along steep slopes; since they are not suitable for row crops or other agricultural uses, we do not anticipate habitat losses due to a change in agricultural use.

One of the two EOs was bisected by highway FM 649 in 1954; we estimate that the highway construction and ROW destroyed about 1.63 ha (4.03 ac) of habitat. We are not aware of planned highway construction that would affect the occupied habitats. Due to the low population density in rural Jim Hogg County and the distance to population centers, currently there are no projected habitat losses to urban and residential development.

The occupied habitats and potential habitats, like much of South Texas, occur within areas of extensive oil and gas exploration and extraction during the 20th century. Each oil and natural gas well drilling operation involves clearing an area of approximately one to several ha in size (about 2 to 5 ac), where the operation of heavy equipment compacts the soil for a period of months to more than a year. Gravel roads are also cleared to allow the access of trucks and equipment to each well site, and pipelines may be installed to transport the product. Oil and gas well development causes long-term impacts to the natural landscape, including the loss of native vegetative cover and soil compaction, and may include contamination of sites with petroleum or chemical wastes used in drilling operations. In addition, the proliferation of roads accelerates the spread of invasive plants, such as buffelgrass. Figure 5 is an aerial photograph of an area of intensive energy development in northern Zapata County, about 21 km (13 mi) west of the bushy whitlow-wort populations. The rectangular, white well-drilling pads and access roads have consumed a substantial portion of the landscape. However, the production of petroleum in Jim Hogg County has declined from about 29,000 barrels (bbl) per month in the mid-1990s to 1,600 bbl in October, 2020, and natural gas production has declined similarly since the mid-2000s (ShaleXP 2021). Petroleum and natural gas production has declined in the same pattern in the vicinity of Thompsonville, where the two known EOs of bushy whitlow-wort occur (Texas-drilling.com). The occupied and potential habitats are also about 30–50 km (18.6–31.0 mi) southeast of the Eagle Ford shale area of oil and natural gas production (Figure 6). New well production within the Eagle Ford shale increased rapidly after 2008, then declined due to the drop in petroleum prices in 2015 (Wikipedia 2020a). Nevertheless, large reserves of oil and natural gas remain in the Eagle Ford shale. We assume that fluctuation in petroleum markets may once again lead to new well production in the Eagle Ford shale area, and perhaps also in the vicinity of bushy whitlow-wort habitats, although we cannot project the likelihood if or when this will occur. Petroleum and gas development in the Eagle Ford shale is not likely to have a direct effect on bushy whitlow-wort habitats, since they are physically separated, but renewed development of petroleum reserves that may underlie these habitats could cause their destruction and degradation. In summary, the development of new oil and gas wells and infrastructure is a threat to the known populations of bushy whitlow-wort of low immediacy and unknown likelihood but potentially large severity and extent.

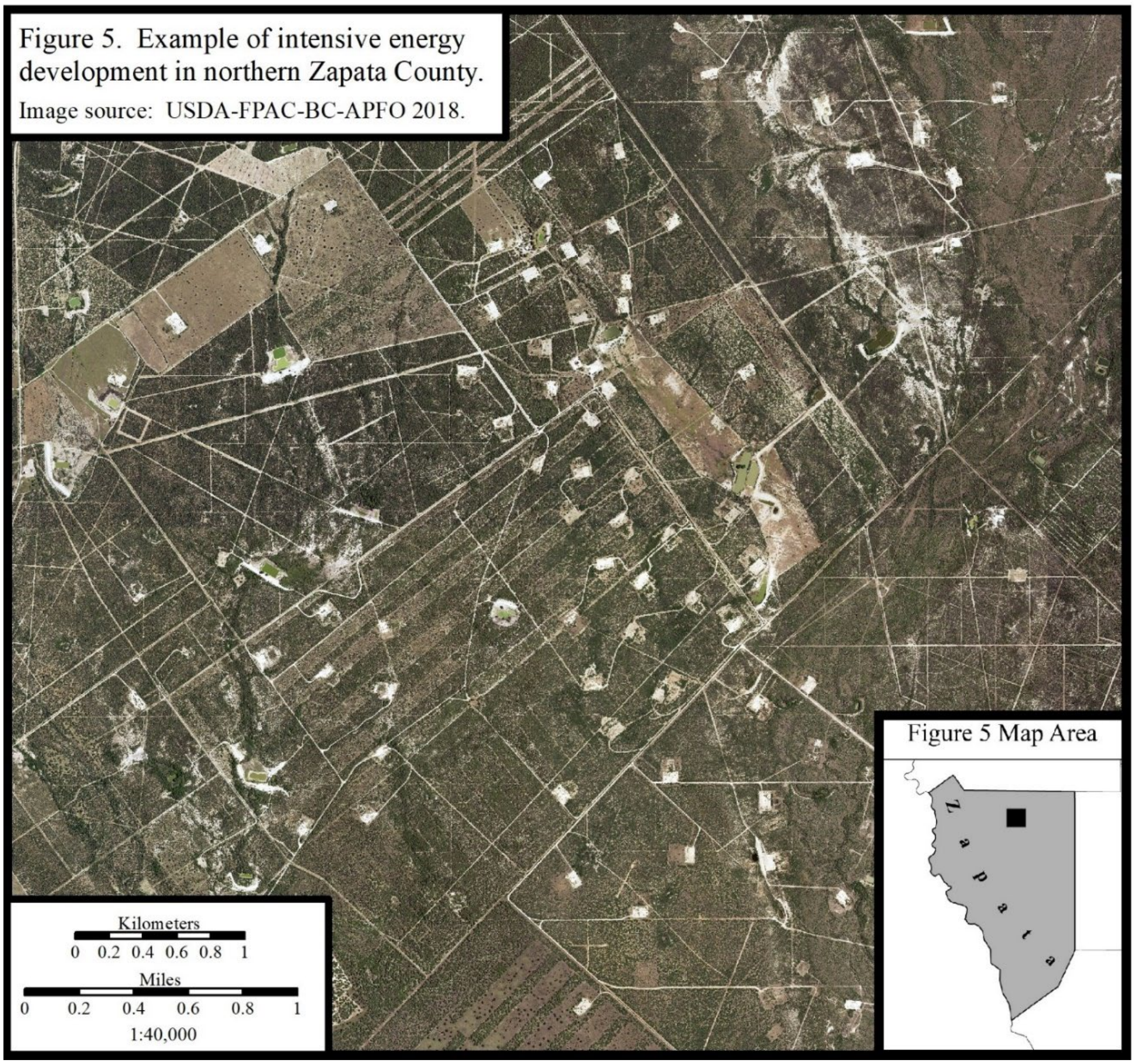
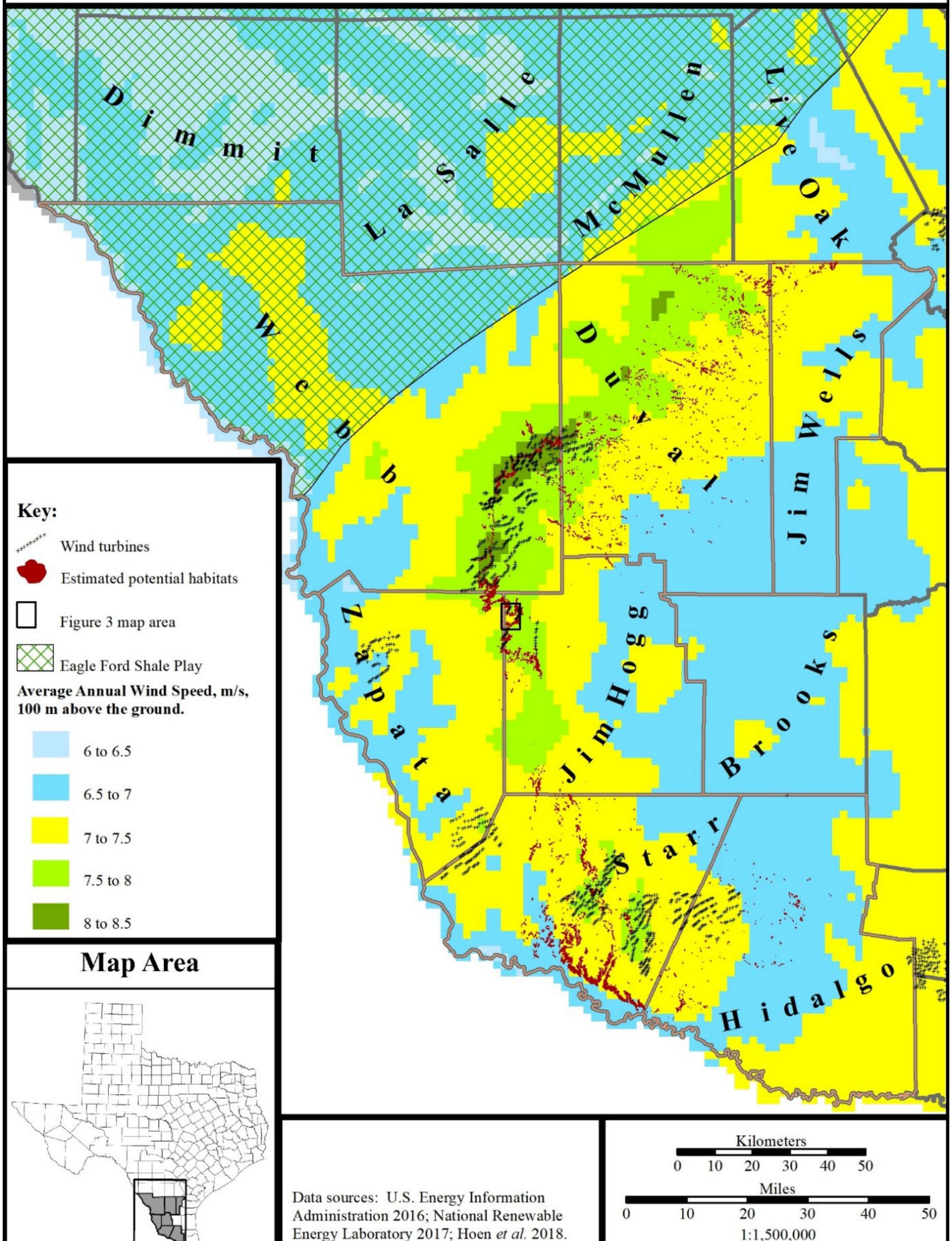


Figure 5. Example of intensive energy development in northern Zapata County.
Image source: USDA-FPAC-BC-APFO 2018.

Texas leads the U.S. in wind electric power generation (Wikipedia 2020b). Wind power generation continues to grow in south Texas, including major new proposed wind farms in Jim

Hogg and Zapata counties (Contreras 2019; Bordas Renewable Energy 2020; Corso 2020). Wind farm development entails land clearing for arrays of wind turbines, access roads, and power lines that is roughly equivalent to the impacts of oil field development. The potential for wind energy development is greater in areas of greater average wind speed. Data from the National Renewable Energy Laboratory (2017; Figure 6) reveal that the occupied and potential habitats of bushy whitlow-wort are closely aligned with areas of the highest average wind speed in South Texas, indicating that they have high potential for wind energy development. Since 2010, large numbers of wind turbines have been constructed near and within areas we identify as potential habitats for bushy whitlow-wort, and new construction continues at a very rapid pace (Figure 7). Twenty-one turbines are located from 0.8 to 4.2 km (0.5 to 2.6 mi) from the known EOs of bushy whitlow-wort, and about 20 new turbines have been proposed, but not yet permitted, within this immediate area (Figure 8). We conclude that development of new wind farms is an immediate threat to the known populations of bushy whitlow-wort and its potential habitats of large severity and extent.

Figure 6. Potential development areas for the Eagle Ford shale and wind energy in South Texas.



Data sources: U.S. Energy Information Administration 2016; National Renewable Energy Laboratory 2017; Hoen *et al.* 2018.

Figure 7. Wind turbine completion dates in South Texas, 2010–2021.

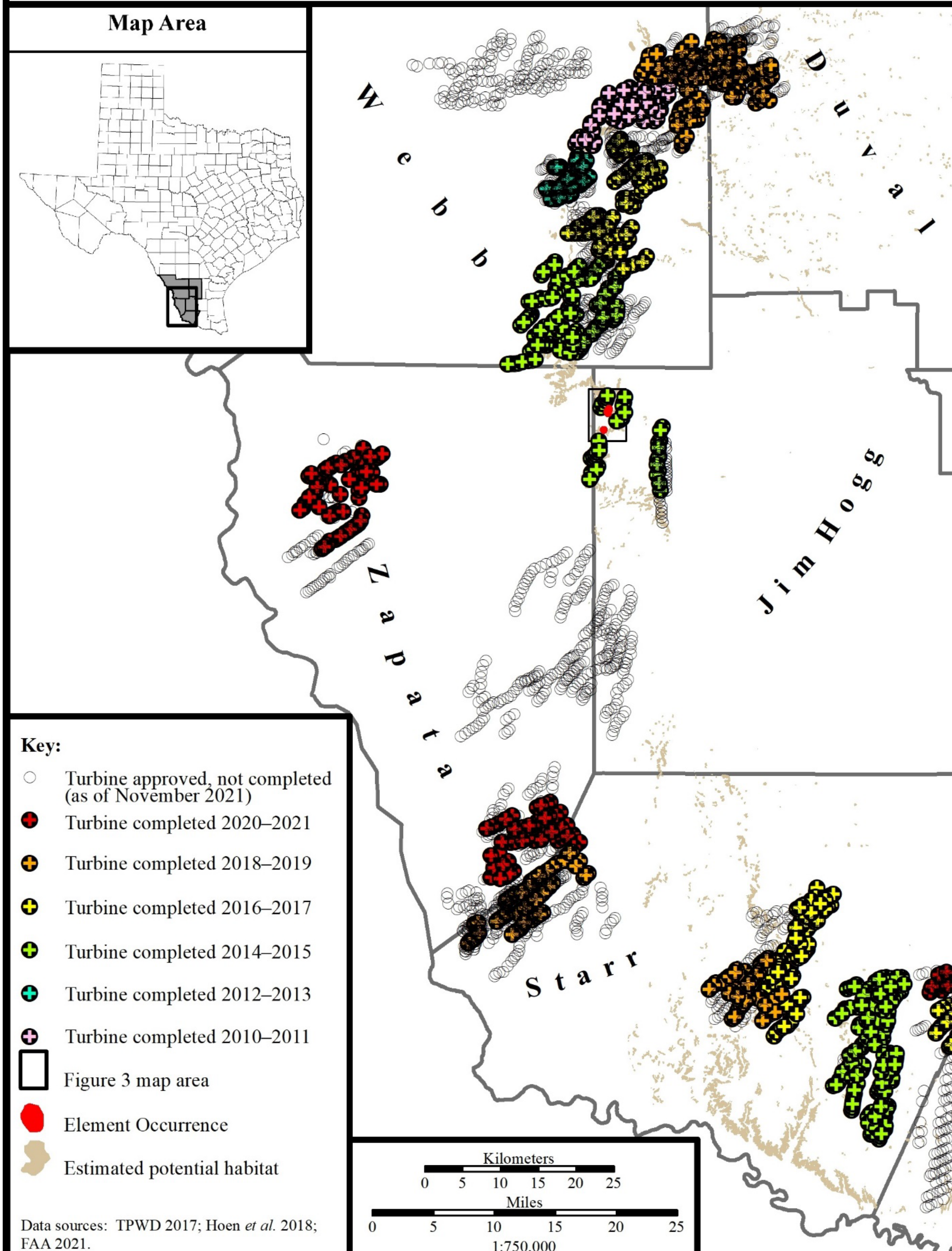
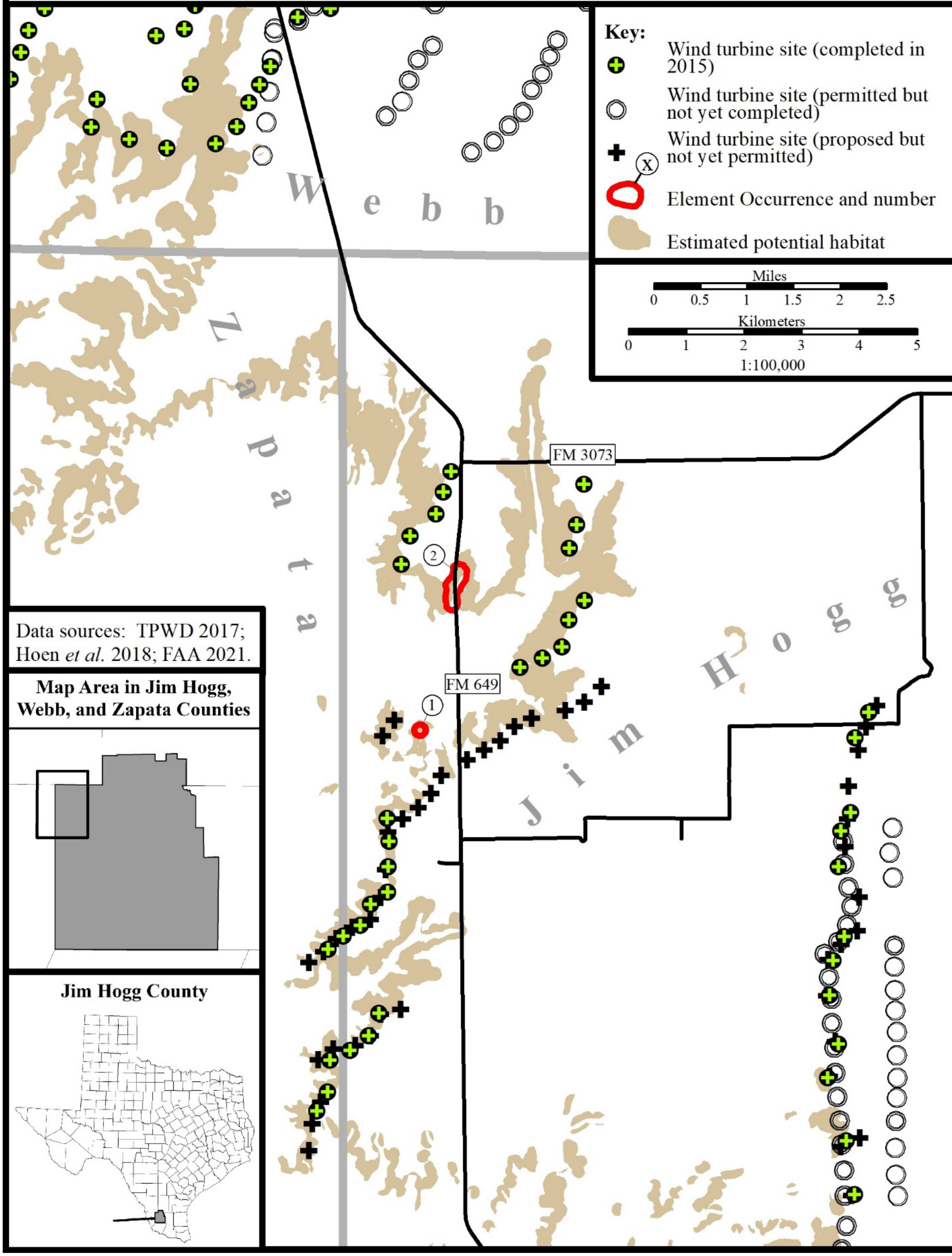


Figure 8. Proximity of existing and proposed wind turbine sites to the two known Element Occurrences and estimated potential habitat of bushy whitlow-wort (*Paronychia congesta*).



Few known populations

Only two EOs of bushy whitlow-wort have been documented, with a combined area of 19.5 ha (48.1 ac). The populations are separated by only 2.1 km (1.3 mi). A single event, such as prolonged drought, or a single development project could easily destroy a large portion of the species' known remaining resources. The close proximity of the two EOs increases this vulnerability. We conclude that the small number of bushy whitlow-wort populations (lack of redundancy) is a current, severe threat to the species.

Demographic consequences of small population sizes

Small, isolated populations are more vulnerable to catastrophic losses caused by random fluctuations in recruitment (demographic stochasticity) or variations in rainfall or other environmental factors (environmental stochasticity) (USFWS 2016, p. 20). In addition to population size, it is likely that population density also influences population viability, since reproduction requires genetically compatible individuals to be clustered within the forage ranges of the species' pollinators. Surveyors have reported a population size of up to about 2,000 individuals, on single occasions, for each of the two known EOs of bushy whitlow-wort. Compared to the estimated MVP of 1,500 individuals, this might suggest that these populations are relatively resilient. However, on other occasions, surveyors found as few as 4 and 100 individuals at the two EOs. We do not know if these lower numbers represent actual population fluctuations, or if the surveyors were unable to detect live, dormant individuals. Due to the infrequency of censuses, we cannot assess current population sizes or trends. We conclude that the demographic consequences of small population sizes present a potential threat of unknown immediacy, severity, and extent.

Genetic consequences of small population sizes.

Small, reproductively isolated populations are susceptible to the loss of genetic diversity, to genetic drift, and to inbreeding (Barrett and Kohn 1991, pp. 3−30).

The loss of genetic diversity may reduce the ability of a species or population to resist pathogens and parasites, to adapt to changing environmental conditions, or to colonize new habitats. Conversely, populations that pass through a genetic bottleneck may subsequently benefit through the elimination of harmful alleles. Nevertheless, the net result of the loss of genetic diversity is likely to be a loss of fitness and lower chance of survival of populations and of the species.

Genetic drift is the random change in the frequencies of alleles in a population over time. Genetic drift is caused by random differences in founder populations and the random loss of rare alleles in small, isolated populations. Genetic drift may have a neutral effect on fitness, but most commonly has a negative effect, especially among out-crossing species; this is due to the expression of deleterious recessive alleles that have become homozygous. It is also a cause of the loss of genetic diversity in small populations.

Inbreeding depression is the loss of fitness among progeny arising from sexual reproduction between closely related individuals. The probability of sexual reproduction between closely related individuals increases in small, isolated populations. However, plant species differ greatly in response to inbreeding; currently, we do not know if inbreeding of bushy whitlow-wort leads to inbreeding depression.

The known populations of bushy whitlow-wort are relatively small, and there may have been no recent gene flow between them. They may already suffer from genetic bottlenecks, genetic drift, inbreeding, and loss of allelic diversity. However, the population genetics of this species has never been investigated. We conclude that the genetic consequences of small population sizes present a potential threat of unknown immediacy, severity, or extent.

Climate changes

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013, p. 23) projects the following changes by the end of the 21st century, relative to the 1986 to 2005 averages:

- It is virtually certain that most land areas will experience warmer and/or fewer cold days and nights;
- it is virtually certain that most land areas will experience warmer and/or more frequent hot days and nights;
- it is very likely that the frequency and/or duration of warm spells and heat waves will increase in most land areas;
- it is very likely that the frequency, intensity, and/or amount of heavy precipitation events will increase in mid-latitude land masses; and
- it is likely that the intensity and/or duration of droughts will increase on a regional to global scale.

Similarly, the U.S. Global Climate Research Program (USGCRP) Fourth National Climate Assessment (USGCRP 2017) reports that average annual temperatures from 1986—2016 have increased in the Southern Great Plains (including the range of bushy whitlow-wort) by 0.42° C (0.76° F), compared to the 1901—1960 baseline (USGCRP 2017, Chapter 6, Table 6.1). Average annual temperatures in the Southern Great Plains are projected to increase by 2.65° to 4.69° C (4.78° to 8.44° F), under moderate and high emission scenarios, respectively, by the late 21st century (USGCRP 2017 Chapter 6, Table 6.4). By the end of the 21st century, under the highest emissions scenario, precipitation in Jim Hogg and surrounding counties is projected to decrease from 10 to 20 percent during the winter and spring; summer and fall precipitation changes in this region are projected to be smaller than natural variations (USGCRP 2017 Chapter 7, pp. 15–16 and Figure 7.5). However, the frequency of heavy precipitation events in the Southern Great Plains has increased from 1901 to 2016 and 1948 to 2016 (USGCRP 2017 Chapter 7 pp. 5–9 and Figures 7.2–7.4) and is projected to continue to increase under moderate and high emission scenarios (USGCRP 2017 Chapter 7 pp. 18–24 and Figures 7.6–7.8).

The magnitude of projected changes varies widely, depending on which scenario of future greenhouse gas emissions is used. These scenarios are called Representative Concentration Pathways (RCPs). Under the best-case scenario of RCP2.6, the combined emissions of carbon dioxide, methane, and nitrous oxide, expressed as the carbon dioxide equivalent, will stabilize at

475 parts per million (ppm) by the year 2100. This figure rises to 630, 800, and 1,313 ppm under the RCP4.5, RCP6.0, and RCP8.5 scenarios, respectively (IPCC 2013, p.22).

To evaluate how the climate of bushy whitlow-wort habitats may change, we used the National Climate Change Viewer (U.S. Geological Survey 2020b) to compare past and projected future climate conditions for Jim Hogg County, Texas. The baseline for comparison was the observed mean values from 1981 through 2010, and 30 climate models were used to project future conditions for 2050 through 2074. We selected the climate parameters of annual mean maximum temperature, annual mean precipitation, and annual evaporative deficit. We used both the RCP4.5 and RCP8.5 scenarios to provide a range of projected values. The results are summarized in Table 7 and in Figures 8, 9, and 10. To interpret these results, it is important to consider the means as well as the dispersion of the 30 climate models (Table 7); wide dispersion indicates greater uncertainty. The historic baseline annual mean maximum temperature is 29.4° C (84.9° F). This will increase by 1.9° to 2.9° C (3.4° to 5.2° F) under RCP4.5 and RCP8.5, respectively, by 2050–2074. The model means for RCP4.5 and RCP8.5 project little change in annual mean precipitation (-0.3 to -1.2 millimeters per month (mm/mo)) (-0.01 to -0.05 inches per month (in/mo), respectively), by 2050–2074. However, these models do not simulate well the projected patterns of regional precipitation (IPCC 2013, p. 11). Hence, the projection reflects a lack of precision, rather than a likelihood that there will be little change in precipitation. On the other hand, the models more consistently project an increase in evaporative deficit. Evaporative deficit, defined as the difference between actual and potential evapotranspiration (U.S. Geological Survey 2014, p. 11), may be a better indicator of plant stress than precipitation alone, since it takes temperature into account. The baseline evaporative deficit for Jim Hogg County is 72.7 mm/mo (2.86 in/mo). By 2050–2074, evaporative deficit will increase by 8.2 to 12.9 mm/mo (0.32 to 0.51 in/mo) under RCP4.5 and RCP8.5, respectively. Hence, these models project that plant growth and survival in Jim Hogg County will become more moisture-limited, although the degree of change depends on the RCP model. Under the RCP8.5 scenario, the projected changes in temperatures and evaporative deficit are greater, as one would expect.

Table 7. Means and dispersion of projected changes of 30 climate projection models for Jim Hogg County, Texas: 2050 to 2074 compared to 1981 to 2010 (U.S. Geological Survey 2020b).

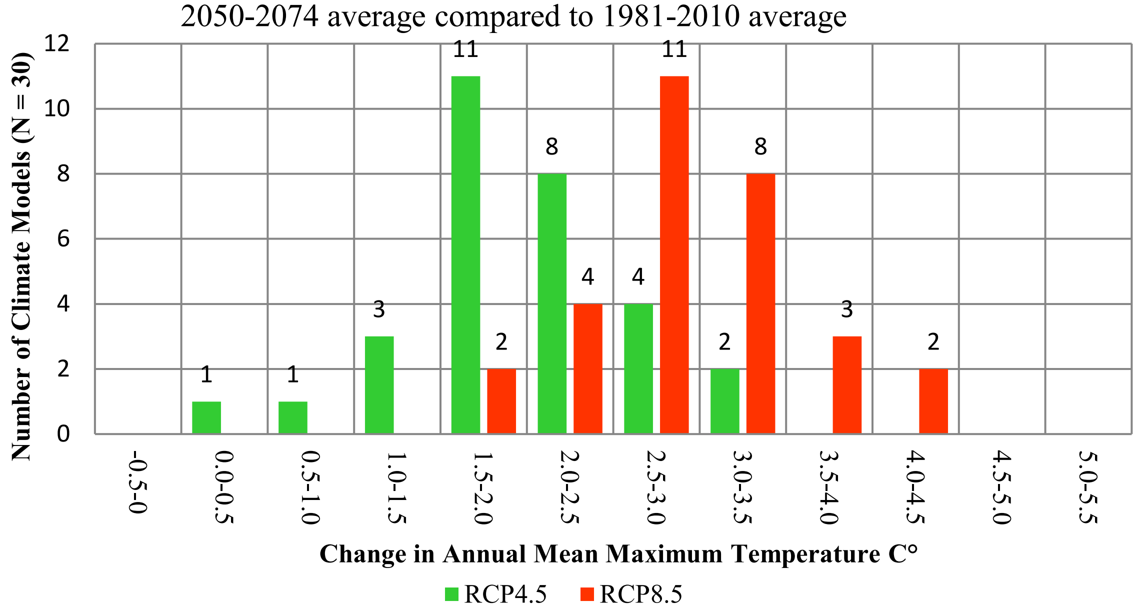
Climate Parameter	RCP	Projected changes 2050–2074, means of 30 models	Ranges of individual models
Annual Mean Maximum Temperature. 1981–2010 baseline: 29.4° C (84.9° F)	4.5	+1.9° C (+3.4° F)	0.3° to +3.4° C (0.5° to 6.1° F)
	8.5	+2.9° C (+5.2° F)	+1.7° to +4.3° C (3.1° to 7.7° F)
Annual Mean Precipitation. 1981–2010 baseline: 45.8 mm/mo (1.8 in/mo)	4.5	-0.3 mm/mo (-0.01 in/mo)	-12.5 to +8.7 mm/mo (-0.49 to +0.34 in/mo)
	8.5	-1.2 mm/mo (-0.05 in/mo)	-12.8 to +13.8 mm/mo (-0.50 to +0.54 in/mo)
Annual Mean Evaporative Deficit. 1981–2010 baseline:	4.5	8.2 mm/mo (0.32 in/mo)	-3.9 to +20.1 mm/mo (-0.15 to +0.79 in/mo)
	8.5	12.9 mm/mo (0.51 in/mo)	+0.7 to +27.4 mm/mo (+0.03 to +1.08 in/mo)

Climate Parameter	RCP	Projected changes 2050–2074, means of 30 models	Ranges of individual models
72.7 mm/mo (2.86 in/mo)			

Nevertheless, we do not know how bushy whitlow-wort responded to prior climate changes, nor can we determine how these projected climate changes, forecast by the range of models and emissions scenarios, will affect the interactions of bushy whitlow-wort with its habitat and associated plant and animal community. Higher temperatures and increasing evaporative deficit could reduce the species' growth, reproduction, and survival. Alternatively, these changes could increase the areas of nearly barren, exposed outcrops, thus increasing the amount of available habitat. Warmer winters might extend the growing season to the species' benefit. Climate changes might affect bushy whitlow-wort differently from species it competes with, such as the introduced, invasive buffelgrass. Thus, although it is likely that the projected climate changes will affect the survival of bushy whitlow-wort in infinitely complex ways, we cannot confidently project what the net result of beneficial and detrimental effects will be. Therefore, climate changes present potential threats of low immediacy and unknown severity and extent.

Figure 9. Projected Changes in Annual Mean Maximum Temperature (C°), Jim Hogg Co., TX

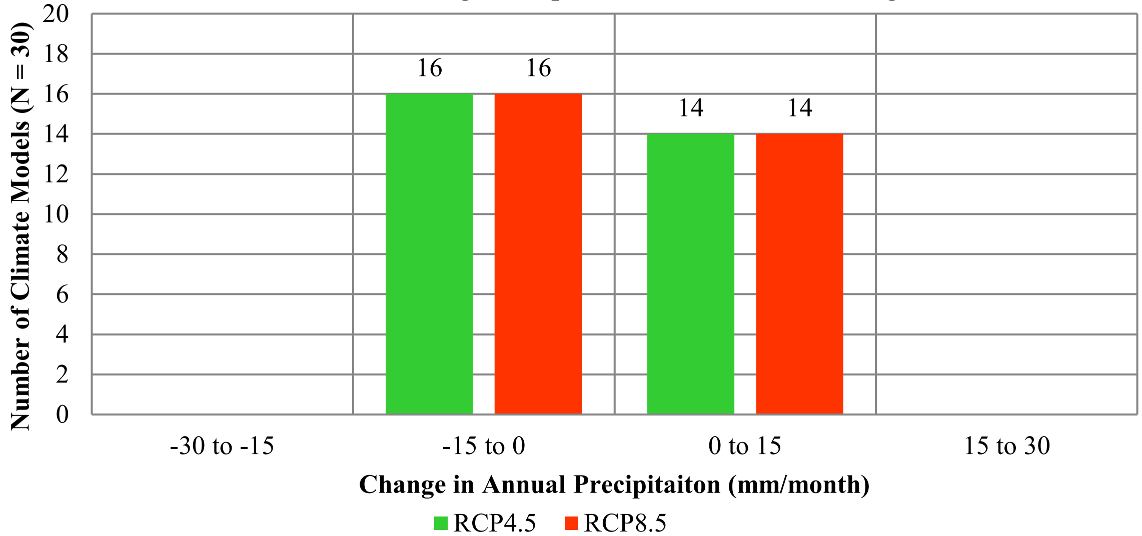
2050-2074 average compared to 1981-2010 average



RCP4.5 Mean: 1.9°; Range 0.3° to 3.4°
RCP8.5 Mean: 2.9°; Range 1.7° to 4.3°

Figure 10. Projected Changes in Annual Mean Precipitation (mm/month), Jim Hogg Co., TX

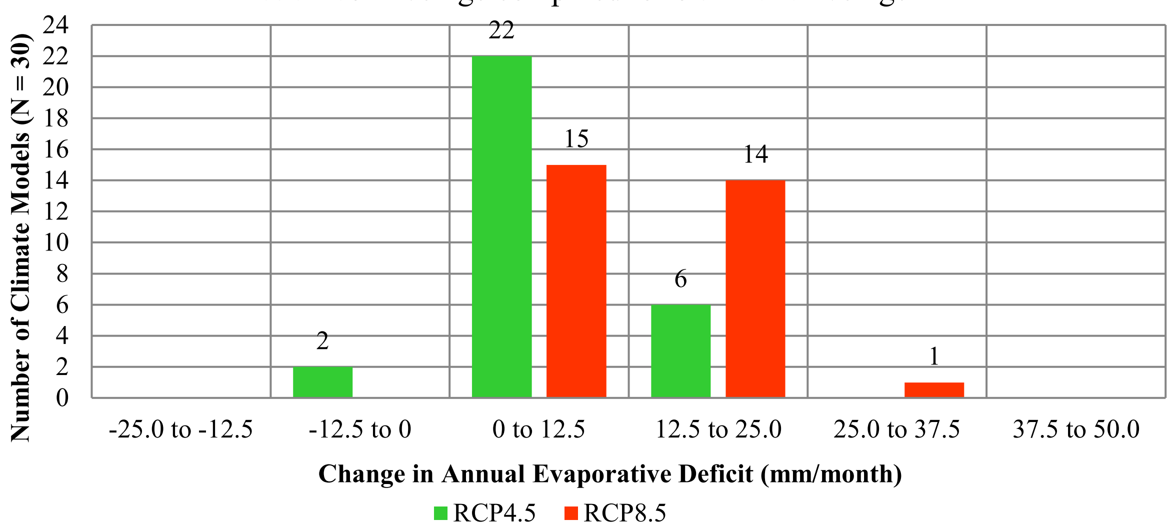
2050–2074 average compared to 1981–2010 average



RCP4.5 Mean: -0.3 mm/month; Range: -12.5 to +8.7 mm/month
RCP8.5 Mean: -1.2 mm/month; Range: -12.8 to +13.8 mm/month

Figure 11. Projected Changes in Annual Evaporative Deficit (mm/month), Jim Hogg Co., TX

2050-2074 average compared to 1981-2010 average



RCP4.5 Mean: 8.2 mm/month; Range: -3.9 to +20.1 mm/month
RCP8.5 Mean: 12.9 mm/month; Range: 0.7 to +27.4 mm/month

4.2. Challenges

Private land ownership

The two known EOs occur almost entirely on privately owned land (a small portion of EO 2 is publicly-owned ROW of FM 649). Private ownership does not itself constitute a threat; the species has persisted on private rangeland and appears to be compatible with livestock grazing. Many south Texas landowners actively support wildlife habitat conservation and appreciate the region's natural beauty. However, Janssen (2006, p. 35) spoke to two of the three landowners of the two EOs. These landowners no longer allowed surveys on their lands and expressed opposition to the ESA. Janssen was unable to locate the third landowner. Strong and Williamson (2015, p. 131) were granted permission to survey one of the sites, but not to reveal the location. Landowner support for conservation, but opposition to federal and state protections for endangered species, is common in this region; landowner perceptions of government over-reach are not without historic precedent, such as the federal expropriation of land for Falcon Reservoir during the 1950s. Consequently, landowners are reluctant to grant permission to federal and state conservation agencies to survey their lands for species of conservation concern. In section 2.6 we describe a potential habitat model to predict where else this species might occur. If those potential habitats could be surveyed, it is possible, perhaps likely, that more populations would be discovered. If we possessed more complete documentation of the status of bushy whitlow-wort, it may prove to be more viable than we now know. Another rare, endemic South Texas plant, Johnston's Frankenia (*Frankenia johnstonii*), was listed as endangered in 1984 (49 FR 31418). At that time it was known from only 6 privately owned ranches in Starr and Zapata counties, Texas, and Nuevo León, México. Over the next 30 years, a number of large populations were discovered, extending the species' known range to Webb County and Tamaulipas, México; based on this evidence of its more secure status, we removed Johnston's Frankenia from the endangered species list in 2016 (81 FR 1322). Hence, this status assessment of a species that occurs almost entirely on inaccessible private land is a challenging conundrum.

4.3. Conservation

We are not aware of any specific efforts to conserve populations or habitats of bushy whitlow-wort. The species has never been propagated, nor have seeds been collected for long-term storage in a seed bank.

<u>Summary of factors affecting the survival of bushy whitlow-wort</u>.

- Bushy whitlow-wort is currently severely limited throughout its range by the small number of its populations.
- The demographic and genetic consequences of small population sizes reduces resiliency of existing populations.
- Energy development from oil and gas exploration and development is a potentially severe threat of low immediacy throughout the species' range.
- Wind energy development is a current, potentially severe threat throughout the species' range.

- Urban and residential developments are not current or projected future threats to the species.
- Cattle grazing is not a significant threat to the species' survival. It is unlikely that the occupied habitats would be converted to other agricultural uses in the future.
- Climate changes could affect bushy whitlow-wort in complex ways, but we cannot currently project the net effect of positive and negative interactions.
- Essentially all of the species' known populations, as well as undocumented populations that may exist in potential habitats, occur on privately owned lands. Landowners are not obligated to allow rare plant surveys on their lands, and may be reluctant to do so. Consequently, we have insufficient knowledge of the species' actual distribution, abundance, and status throughout the range of its potential habitats.
- We are unaware of any efforts to conserve the species or its habitats.

Table 8. Summary of threats to bushy whitlow-wort.

Threats	Immediacy	Severity	Extent
Habitat loss from oil and gas development	Low	Potentially high	Potentially large
Habitat loss from wind energy development	Current	Potentially high	Potentially large
Lack of redundancy	Current, ongoing	High	Throughout range
Demographic and genetic consequences of small population sizes	Unknown	Unknown	Unknown
Climate changes	Low	Unknown	Unknown

CHAPTER 5. CURRENT CONDITIONS AND ASSESSMENT OF CURRENT SPECIES VIABILITY OF BUSHY WHITLOW-WORT

5.1. Current conditions

We ranked the current conditions of extant bushy whitlow-wort EOs as high, medium, or low based on a subjective assessment of the criteria listed in Table 9. If the habitats or areas of occurrence of a previously documented EO had been completely altered by soil disturbance, construction, or conversion to non-native vegetation, it would be considered extirpated. However, we acknowledge that dormant, viable seeds could persist for an unknown length of time in sites considered extirpated, if the soils remain intact.

Table 9. Ranking criteria for both bushy whitlow-wort Element Occurrences.

Criteria	High	Medium	Low
Number of mature individuals	≥ 1,500	From 750 to 1,500	From 1 to 750
Demographic trends	Net recruitment ≥ net mortality over 10-year period	Net recruitment = net mortality over 10-year period	Net recruitment < net mortality over 10-year period
Habitat condition	Undisturbed soil/geological profile; intact native vegetation	Prior moderate soil/geological disturbance; invasive plant cover < 20%	Recent or extensive soil/geological disturbance; invasive plant cover > 20%
Landowner support for the species conservation	Enthusiastic support	Intermediate	Indifferent or opposed.
Protection from development	Occupied habitat is permanently, legally protected	Occupied habitat is voluntarily or temporarily protected	Occupied habitat has no protection from development
Access for surveys, monitoring, and census	Population sites may be accessed at least annually	Population sites may be accessed at least 1 to several times per decade	Access is denied, infrequent, or logistically difficult
Ability to conduct management actions	Highly likely	Possible, but uncertain	Not possible

The two EOs of bushy whitlow-wort have essentially the same rankings. Surveyors estimated about 2,000 individuals at EO 1 in 1987 and extrapolated 1,904 individuals at EO 2 in 1994. The only recent census, in 2014, detected 633 individuals in a portion of one EO. Although we do not know the current size of either population, since the habitats are intact, it is likely that both exceed the MVP level of 1,500 individuals. We have no information on demographic trends. Habitats have been moderately disturbed in the past by gravel roads and petroleum infrastructure (EO 1) and a highway ROW (EO 2), but are otherwise intact. We cannot assess the current landowners' support for the species' conservation, although one landowner granted access for a survey. Neither EO is protected from development. We do not know if either site requires management; for example, if buffelgrass invades the habitat, we would recommend treatments to reduce its cover. However, we do not know if such management actions could be conducted at these EOs. In synthesis, we rank the current conditions of the two documented EOs as medium (moderately resilient).

5.2. Assessment of the current species viability of bushy whitlow-wort

In Section 1, we stated that we base assessments of species viability on an evaluation of resiliency, redundancy, and representation. Bushy whitlow-wort has two known populations with a combined area of 19.5 ha (48.1 ac). With only two moderately resilient populations occupying such a small area, the species is extremely vulnerable to both natural and man-made impacts. Since the two EOs are only 2.1 km (1.3 mi) apart, this vulnerability is exacerbated by their close proximity.

We estimate that the amount of potentially suitable habitats ranges from thousands to tens of thousands of hectares, mainly in Webb, Jim Hogg, Zapata, and Starr counties. Most of this land consists of large privately owned ranches that may be reluctant to grant access for rare plant surveys, and there are few public roads or other publicly owned lands. Qualified botanists have only surveyed a very small fraction of this potential habitat—probably less than 1 percent. Vegetation surveys that do not specifically search for bushy whitlow-wort are likely to overlook it, due to its small size and minute flowers. It is possible that bushy whitlow-wort occurs in more places, but we have neither positive nor negative surveys upon which to determine the actual number and distribution of its populations (redundancy). Furthermore, we have no information on the breadth of its genetic and ecological diversity (representation). If, indeed, the species exists only at the two known populations, its status is highly vulnerable to threats that affect one or both populations. At the opposite extreme of possible statuses, many resilient populations may remain undiscovered along the Goliad-Catahoula geological boundary, and the species may also occur in similar habitats in Coahuila, Mexico. Additional resilient populations would increase the species' redundancy and representation, and therefore its overall viability.

Nevertheless, our assessments of species statuses must be based on the best available information. Since bushy whitlow-wort has only two known populations, we must conclude that it has extremely low redundancy. The populations have, at best, moderate resilience, and the degree of representation remains unknown. In synthesis, even under the most optimistic circumstances, bushy whitlow-wort is a narrow endemic with very specific habitat requirements; we conclude that the species has low viability.

CHAPTER 6. PROJECTIONS OF FUTURE VIABILITY OF BUSHY WHITLOW-WORT

In this chapter we project how the future viability of bushy whitlow-wort may be influenced by a range of scenarios. We chose a future time frame of 2050 to 2074 to coincide with the time frame we used for climate change projections (discussed in section 4). The "improvement" scenario represents improvements over current conditions. The "current trends continue" scenario represents conditions if current trends continue. The "declining" scenario represents deteriorating conditions. We describe, below, 7 relevant attributes of each scenario: Population size and demographic trends, number and geographic distribution of populations, population genetics, habitat loss from energy development, and the potential effects of climate changes. These projections of varying scenarios should not be interpreted as mutually exclusive. The attributes of the scenarios will interact independently, and future viability will likely result from a combination of scenarios. For example, the number and geographic distribution of populations could be better than expected by 2050, but climate changes and habitat loss from energy development could have more severe impacts than expected (or vice-versa). The degree of uncertainty regarding the species' current status is magnified in future projections; we are currently unable to project if it is likely that the species will maintain multiple, if any, resilient populations to contribute to the species' viability 50 years from now.

6.1 Scenario 1. Improvement

Resiliency

a. The known populations have 1,500 or more mature individuals (the MVP threshold).

b. Demographic trends of known populations are stable or increasing (net recruitment equals or exceeds mortality over a span of 10 years).

Redundancy

c. Number of populations: Qualified botanists receive permission to survey a large number of the highest-potential habitats throughout the species' range. Both the presence and absence of bushy whitlow-wort populations in these habitats contributes to improved understanding of the species' ecology, management, abundance, and geographical range. Ten or more extant populations are discovered and documented.

d. Geographic distribution of populations. Documented populations are distributed throughout the range of potential habitats.

Representation

e. Populations have healthy levels of heterozygosity, and there is ample intra- and inter-population genetic variation.

Threats

f. Habitat loss from energy development: Prior to disturbance, species surveys are conducted in proposed energy development projects, including oil and gas wells, wind power farms, and associated access roads, power lines, and pipelines. Project sites are chosen to avoid disturbance to bushy whitlow-wort populations and potential habitats, and there are no effects on populations or adverse modifications of habitats.

g. Climate changes: The effects of climate changes on bushy whitlow-wort and its habitats are relatively moderate, and are well-tolerated by the species.

6.2 Scenario 2. Current trends continue

Resiliency

a. The known populations remain extant, but the population sizes are unknown.

b. Demographic trends of known populations are unknown.

Redundancy

c. Number of populations: Qualified botanists are unable to access or survey a representative sample of the high potential habitats. The presence and absence of bushy whitlow-wort populations in these habitats remains unknown. Nothing new is learned about the species' ecology, management, and true geographical range. No new populations are discovered.

d. Geographic distribution of populations. The true abundance and distribution of bushy whitlow-wort remain unknown.

Representation

e. Population genetics and genomics are not investigated.

Threats

f. Habitat loss from energy development: Energy development projects, including oil and gas wells, wind power farms, and associated access roads, power lines, and pipelines, are conducted without regard to the potential adverse effects to bushy whitlow-wort and its habitats. The effects of these projects on bushy whitlow-wort populations and habitats remain unknown.

g. Climate changes: The long-term effects of climate changes on bushy whitlow-wort and its habitats remain unknown.

6.3 Scenario 3. Deterioration

Resiliency

a. The size of known populations declines to less than 750 mature individuals (50% of the MVP threshold).

b. Demographic trends of known populations are decreasing (mortality exceeds net recruitment over a span of 10 years).

Redundancy

c. Number of populations: Qualified botanists are unable to access or survey any potential habitats. The presence and absence of bushy whitlow-wort populations in these habitats remains unknown. Nothing new is learned about the species' ecology, management, and true geographical range. No new populations are discovered; the true abundance and distribution of bushy whitlow-wort remain unknown; and the two documented populations decline or are extirpated.

d. Geographic distribution of populations. The geographic range of bushy whitlow-wort is restricted to the two documented sites.

Representation

e. Populations have low levels of heterozygosity and incur a loss of fitness from inbreeding depression; intra- and inter-population genetic variation are low.

Threats

f. Habitat loss from energy development: Energy development projects, including oil and gas wells, wind power farms, and associated access roads, power lines, and pipelines, incur extensive adverse effects to the known bushy whitlow-wort EOs and habitats.

g. Climate changes: The effects of climate changes on bushy whitlow-wort and its habitats contribute to the species' loss of viability.

Table 10. Summary of bushy whitlow-wort viability under a range of scenarios.

Attributes	**Scenarios**		
	Improvement	**Current Trends Continue**	**Declining**
Redundancy			
a. Number of populations.	≥ 2 populations.	2 populations.	< 2 populations.
b. Geographic distribution of populations.	Populations documented throughout range of potential habitats.	Distribution remains unknown.	Species is restricted to the 2 currently known sites.
Resiliency			
c. Population size.	≥ 1,500 mature individuals	From 750 to < 1,500 mature individuals	From 1 to < 750 mature individuals.
d. Demographic trends.	Net recruitment ≥ net mortality over 10-year period.	Unknown.	Net recruitment < net mortality over 10-year period.
Representation			
e. Population genetics.	Relatively high levels of heterozygosity and intra- and inter-population genetic variation.	Population genetics and genomics remain unknown.	Low levels of heterozygosity and loss of fitness from inbreeding depression; intra- and inter-population genetic variation are low.
Threats			
f. Impacts of energy development (petroleum, natural gas, and wind farms)	Energy development projects have no effects on populations or adverse modifications of habitats.	The effects of energy development projects on bushy whitlow-wort populations and habitats remain unknown.	Energy development projects incur extensive adverse effects to the known bushy whitlow-wort EOs and its habitats.
g. Climate changes.	Climate changes are relatively moderate, and are well-tolerated by the species.	Long-term effects of climate changes on the species remain unknown.	Climate changes contribute to the species' loss of viability.

6.4 Summary of Species Viability

This assessment describes the viability of bushy whitlow-wort in terms of resiliency, redundancy, and representation by using the best scientific and commercial information available. We used these parameters to describe current and potential future conditions regarding the species' viability. To address the uncertainty associated with potential future threats and how they will affect the species' resource needs, we assessed potential future conditions using three plausible scenarios. These scenarios were based on the primary threats and positive influences on the species across its range.

We ranked the current conditions of the two documented bushy whitlow-wort EOs as moderately resilient. However, species surveys have been conducted only on a very small fraction of the potential habitats where bushy whitlow-wort can be reasonably expected to occur. Consequently, our analysis of the species' current condition may underestimate its viability. If the species exists only at the two known populations, its status is highly vulnerable to threats that affect one or both populations. It is also possible that an unknown number of resilient populations may remain undiscovered in south Texas and Coahuila, Mexico, and that the species' redundancy, representation, and overall viability are more secure than we now know.

Nevertheless, our assessments of species statuses must be based on the best available information. Since bushy whitlow-wort has only two known populations, we must conclude that it has extremely low redundancy. The populations have, at best, moderate resilience, and the degree of representation remains unknown.

In synthesis, even under the most optimistic circumstances, bushy whitlow-wort is a narrow endemic with very specific habitat requirements. We projected how the future viability of bushy whitlow-wort may be influenced by a range of plausible scenarios. We chose a future time frame of 2050 to 2074 to coincide with the time frame we used for climate change projections and evaluated the attributes of population sizes, demographic trends, the number and geographic distribution of populations, population genetics, habitat loss from energy development, and the potential effects of climate changes. The degree of uncertainty regarding the species' current status is magnified in future projections; we are currently unable to project if it is likely that the species will maintain multiple, if any, resilient populations to contribute to the species' viability 50 years from now.

CHAPTER 7. RECOMMENDED CONSERVATION ACTIONS.

- Conduct landowner outreach, in collaboration with academic researchers, TPWD biologists, Texas AgriLife extensionists, and NRCS district conservationists, to promote conservation and awareness of bushy whitlow-wort and to answer questions from the public.
- Search for new populations on public land and seek landowner permission to conduct surveys on private lands, focusing on areas identified as potential habitats.
- Promote and support surveys for populations in potential habitats in the Mexican states of Tamaulipas, Nuevo León, and Coahuila.
- Provide technical guidance and material support to private landowners who voluntarily wish to conserve the species on their land.
- Investigate the species' pollination biology, life history, ecology, and habitat requirements.
- Investigate the extent of genetic diversity within and among the species' known populations; this effort should be initiated after thorough surveys have provided a more complete understanding of the species' distribution.
- Collect seeds from extant populations for seed bank storage and propagation, in accordance with USFWS policy on controlled propagation of endangered species (FR 65: 56916). Prioritize seed collection from populations that are declining or cannot be protected and managed appropriately. Propagate plants from the representative genetic ecotypes (genotypes that are specifically adapted to distinct ecological areas) and produce seed ex-situ for experimental and reintroduction efforts (to prevent excessive collection from wild sources and depletion of the soil seed reserve at extant populations).
- Conduct pilot reintroductions in sites with unoccupied potential habitats to determine effective methods of population reintroduction and augmentation.
- Conduct larger-scale reintroductions, based on results of pilot reintroductions, in sites with unoccupied potential habitats that can be protected through conservation agreements, conservation easements, or other arrangements.

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ADDITIONAL INFORMATION

9.1. Photograph credits.

Cover: Jackie M. Poole, TPWD (retired).
Figures 1.a, 1.b, and 1.c: Anna Strong, TPWD.

9.2. Scientific units.

Scientific Terms	Symbols
Acre	ac
Celsius degrees	C°
Centimeter	cm
Fahrenheit degrees	F°
Feet	ft
Hectare	ha
Inches	in
Kilometers	km
Meters	m
Mile	mi
Millimeter	mm
Million years ago	mya
Parts per million	ppm

9.3. Acronyms used.

Acronyms			
EO	Element Occurrence	RCP	Representative Concentration Pathways
ESA	Endangered Species Act	ROW	Right of Way
FR	Federal Register	SSA	Species Status Assessment
GPS	Global Positioning System	TPWD	Texas Parks and Wildlife Department
IPCC	Intergovernmental Panel on Climate Change	TXNDD	Texas Natural Diversity Database
MVP	Minimum Viable Population	USFWS	U.S. Fish and Wildlife Service
NCDC	National Climate Data Center	USGCRP	U.S. Global Climate Research Program.
NRCS	Natural Resource Conservation Service	USGS	U.S. Geological Survey

APPENDIX A. GLOSSARY OF SCIENTIFIC AND TECHNICAL TERMS.

Term	Definition
Allele	Alternate forms of a gene.
Awn	A bristle or hairlike prolongation of a structure, such as the nerves of a bract of a grass spikelet (Shaw 2012, p. 1045).
Bract	A reduced leaf subtending a flower, usually associated with an inflorescence (Correll and Johnston 1979, p. 1747).
Breeding System	The ability of a plant species to reproduce via outcrossing, self-fertilization, apomixis, or a combination (Wikipedia 2015).
Caespitose	Growing in clusters or tufts.
Calcareous	Containing relatively high levels of calcium carbonate or other calcium compounds.
Caliche	As used here, a soil stratum that formed through precipitation of calcium carbonate and other minerals from the soil solution.
Calyx	The external whorl of a flower (Correll and Johnston 1979, p. 1747); the sepals, collectively.
Candidate	A species for which U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or tyhreate3ned, but for which preparation and publication of a proposal is precluded by higher priority listing actions (76 FR 66370).
Caudex	(Pl. caudices). The woody base of an otherwise herbaceous perennial (Correll and Johnston 1996).
Conglomerate	A course grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter…conglomerate is the consolidated equivalent of gravel (Natural Resources Conservation Service and Texas AgriLife Research 2011, p. 189).
Cyme	A determinate flower cluster in which the first flower is terminal on the main axis, the next flower(s) terminal on axes arising from the axils of bracts subtending the first flower, and so on; often flat-topped or convex (Correll and Johnston 1979, p. 1749).
Demography	Scientific study of populations.
Digital Elevation Model	Digital model or 3D representation of a terrain's surface — commonly for a planet (including Earth), moon, or asteroid — created from terrain elevation data (Wikipedia 2015).
Effective population size	The size of an idealized population in which individuals contribute equally to the gamete pool and have the same variation in allele frequencies and levels of inbreeding as the observed population (Barrett and Kohn 1991).
Element Occurrence	An area of land and/or water in which a species or natural community is, or was, present (NatureServe 2002).

Term	Definition
Evaporative deficit	The difference between actual and potential evapotranspiration (USGS 2014, p. 11).
Evapotranspiration	The combined loss of water vapor from an ecosystem by evaporation and transpiration from plants.
Gene flow	The transfer of alleles or genes from one population to another (Wikipedia 2013).
Genetic bottleneck	An event that greatly restricts an organism's genetic diversity.
Genetic drift	A change in allele frequencies within a population over time.
Geo-endemic	Endemic to a specific geological formation.
Habitat	Ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism (Wikipedia 2013).
Herbaceous	Plant tissues, such as leaves and stems, that are not lignified and typically last for a single season or year; as opposed to woody plants and tissues.
Homozygous	A diploid (or polyploid) organism possessing the same allele at a specific gene locus on homologous chromosomes.
Inbreeding	Sexual reproduction between closely related individuals.
Inbreeding depression	The reduction of fitness caused by mating between relatives (Edmands 2007, p. 464).
Minimum viable population	The fewest individuals required for a specified probability of survival over a specified period of time (Pavlik 1996; Mace and Lande 1991); see Population Viability Analysis.
Miocene	The geological epoch that extends from about 23.03 to 5.333 million years ago (Wikipedia 2020).
Oligocene	The geological epoch that extends from about 33.9 million to 23 million years ago (Wikipedia 2020).
Outcross	In plants, sexual fertilization involving the union of gametes from different individuals.
Phenology	Seasonal pattern of plant growth, development, and reproduction.
Phylogeny	The study of evolutionary relatedness among various groups of organisms (e.g., species, populations), which is discovered through molecular sequencing data and morphological data matrices (Wikipedia 2013).
Pistil	The ovule-bearing portion of a flower, consisting of stigma and ovary, usually with a style between (Correll and Johnston 1979, p. 1758).
Polyphyly	A group of organisms whose last common ancestor is not a member of the group (Wikipedia 2009).
Population	Collection of inter-breeding organisms of a particular species (Wikipedia 2013).
Ramet	An individual, genetically identical plant reproduced as a clone of the parent plant.
Recruitment	Addition of new individuals to a population.
Redundancy	The number of populations or sites necessary to endure catastrophic losses (Shaffer and Stein 2000, pp. 308-310).

Term	Definition
Representation	The genetic diversity necessary to conserve long-term adaptive capability (Shaffer and Stein 2000, pp. 307-308).
Resilience	The size of populations necessary to endure random environmental variation (Shaffer and Stein 2000, pp. 308-310).
Rhizome	Horizontal stems that grow under the surface of the ground.
Section 7	The section of the Endangered Species Act of 1973, as amended, outlining procedures for interagency cooperation to conserve Federally listed species and designated critical habitats (USFWS and NMFS 1998, p. xviii).
Sepal	A leaf or segment of the calyx (Correll and Johnston 1979).
Shapefile	A digital geospatial vector data storage format developed by Esri. (Wikipedia 2015).
Shrubland	Vegetation composed of shrubs (many-stemmed woody plants, generally less than 6 m tall) (NatureServe 2010).
Species viability	A species' ability to sustain populations in the wild beyond the end of a specified time period, assessed in terms of its resilience, redundancy, and representation (USFWS 2015).
Stamen	Male reproductive structure of the flower, consisting of a filament and anther: the androecium (Anderson 2001).
Stigma	The receptive part of the pistil on which the pollen germinates. (Correll and Johnston 1979).
Stipule	One of the pair of usually leafy appendages found at the base of the petiole in many plants (Correll and Johnston 1979).
Style	A narrowed, often elongate portion of a pistil between the stigma and ovary (Correll and Johnston 1979).
Subtropical	Climatic region intermediate between tropical and temperate, where freezing temperatures occur infrequently and are of limited duration and intensity.
Succession	Ecological succession is the change in composition and structure of an ecological community over time.
Tamaulipan shrubland	The semi-arid, subtropical ecological region of northeast Mexico and south Texas characterized by shrub vegetation.
Taxon	(Plural, taxa). A natural group of organisms at any rank in the taxonomic hierarchy (Anderson 2001).
Taxonomy	Scientific classification of living organisms.
Tuff	A type of rock formed by consolidation of volcanic ash (Wikipedia 2018).
Utricle	A small, bladdery, one-seeded fruit (Correll and Johnston 1979, p. 1764).

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APPENDIX B. DESCRIPTIONS OF SOIL MAP UNITS SELECTED FOR THE ESTIMATE OF BUSHY WHITLOW-WORT POTENTIAL HABITAT.

1. Jim Hogg County (Soil Conservation Service 1974, pp. 8, 15, 17).

Zapata Series.

The Zapata series consists of very shallow, gently sloping soils. These soils formed in loamy materials that overlie thick beds of indurated caliche. In a representative profile, the surface layer is grayish-brown and brown fine sandy loam and sandy clay loam about 8 inches thick. The underlying material is pinkish-white caliche that is laminar and indurated. These soils are well drained. They are moderately permeable and have a low available water capacity.

Zapata soils, gently sloping. Map Unit Symbol: ZaB.

These soils are in irregular to elongated areas that are dominantly less than 100 acres in size but range from 10 to about 300 acres in size. Slopes range from 1 to 5 percent. Mapped with these soils are caliche outcrops along slope breaks and areas of nearly level Cuevitas and Randado soils. These included soils make up about 25 percent of the acreage, but they are not in all mapped areas of these Zapata soils.

Cuevitas Series.

The Cuevitas series consists of very shallow to shallow, nearly level to gently sloping soils. These soils formed in loamy material. In a representative profile, the surface layer is fine sandy loam. It is brown in the upper 1 inch and reddish brown in the other 8 inches. The underlying material is indurated white caliche that is about 7 inches thick. Below this, the thick beds of caliche are weakly cemented. These soils are well drained and moderately permeable. They have a low available water capacity.

Randado Series. The Randado series consists of very shallow to shallow, nearly level to gently sloping and gently undulating soils. These soils formed in loamy material. In a representative profile, the surface layer is reddish brown and about 8 inches thick. The next lower layer is yellowish-red fine sandy loam, about 8 inches thick. The underlying material is cemented caliche. These soils are well drained and moderately permeable. They have low available water capacity.

Cuevitas-Randado association. Soil Map Symbol: Cu.

This mapping unit is made up of nearly level to gently sloping and gently undulating soils in irregular to oblong areas that are mostly more than 100 acres in size. Slopes range from 0 to 3 percent, but are dominantly about 1 percent. About 55 percent of this mapping unit is Cuevitas soils, 35 percent is Randado soils, and 10 percent is Delmita and Zapata soils and a few spots of rock outcrops. Randado soils are on the more level parts of the landscape. The Cuevitas and

Randado soils in this association have the same profile as that described as representative for each of the series.

2. Webb County (Soil Conservation Service 1985, pp. 23–24, 29–30, 43–44).

<u>Cuevitas-Randado complex, gently undulating</u>. Map Unit Symbol: CRB.

These very shallow and shallow soils are on broad, slightly convex plains and on the summits and side slopes of low hills. The areas are irregular in shape and range from 20 acres to several thousand acres in size. Slopes range from 0 to 3 percent.

Typically, the surface layer of the Cuevitas soil is neutral fine sandy loam about 9 inches thick. It is brown in the upper 2 inches and reddish brown in the lower part. Below that, strongly cemented caliche extends to a depth of 16 inches. The next layer to a depth of 60 inches is weakly cemented caliche. The Cuevitas soil is well drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The rooting zone is very shallow. Water erosion and soil blowing are moderate hazards if this soil is left bare of vegetation.

Typically, the surface layer of the Randado soil is neutral fine sandy loam about 10 inches thick. It is reddish brown in the upper 3 inches and red in the lower part. The subsoil, from 10 to 16 inches, is red, neutral sandy clay loam. Below that, strongly cemented caliche extends to a depth of 22 inches. The next layer to a depth of 60 inches is weakly cemented caliche. The Randado soil is well drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The rooting zone is shallow. Water erosion and soil blowing are moderate hazards if this soil is left bare of vegetation.

This complex is 45 to 65 percent Cuevitas soil and similar soils, 30 to 40 percent Randado soil and similar soils, and 0 to 25 percent contrasting soils and scattered areas of rock outcrop. A soil that is similar to the Cuevitas soil has a thinner surface layer than that of the Cuevitas soil. The Zapata soil is similar to both the Cuevitas and the Randado soil but has more carbonates. The contrasting soils are Delmita and Tela soils. The percentages were determined by use of sampling transects across areas of the map unit. These soils are used mostly as rangeland and as habitat for wildlife. They are also important sources of caliche for construction material. Forage yields for cattle are low. Normally, brush grows more heavily on these soils than on nearby soils. The brush provides cover for a wide variety of wildlife, but because they are shallow the soils do not provide an abundance of food plants, other than browse, suitable for wildlife. The carrying capacity of the soils for deer, javelina, and quail is generally not so high as that of the more productive surrounding soils. The soils making up this complex are not suited to use as dryland cropland. The very shallow to shallow rooting zone, the very low available water capacity, the erratic distribution of rainfall, and the hazards of water erosion and soil blowing are the main limitations. These soils are poorly suited to most urban and recreation uses. The main limitation is shallowness to a cemented pan. The soils are in the Shallow Sandy Loam range site.

Jimenez-Quemado complex, undulating. Map Unit Symbol: JQD.

These shallow to very shallow soils are on the summit and side slopes of hills and ridges. Areas are irregular to elongated in shape and range from 20 acres to several thousand acres in size. Slopes range from 1 to 8 percent. The Jimenez soil is mainly on side slopes of hills and ridges, and the Quemado soil is mainly on the summit of hills and ridges. The areas of these soils are so intricately mixed that mapping them separately was not practical at the scale used in mapping.

Typically, the surface layer of the Jimenez soil is very gravelly sandy clay loam about 13 inches thick. The upper 9 inches is dark brown, and the lower 4 inches is brown. Below that, strongly cemented caliche extends to a depth of 25 inches. The next layer is very gravelly, weakly cemented caliche to a depth of 60 inches. The soil is calcareous and moderately alkaline throughout. The Jimenez soil is well drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The rooting zone is shallow to very shallow. The water erosion hazard is moderate, and the soil blowing hazard is slight if this soil is bare of vegetation.

Typically, the surface layer of the Quemado soil is neutral, reddish brown, very gravelly sandy loam about 6 inches thick. The subsoil, which extends to a depth of 12 inches, is neutral, reddish brown, very gravelly sandy clay loam. The underlying layer, which extends to a depth of 14 inches, is strongly cemented caliche. The next layer is very gravelly, weakly cemented caliche to a depth of 60 inches. The Quemado soil is well drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The rooting zone is shallow. The hazard of water erosion is moderate, and the hazard of soil blowing is slight if this soil is bare of vegetation.

This soil complex is 40 to 55 percent Jimenez soil and similar soils, 30 to 50 percent Quemado soil and similar soils, and 0 to 30 percent contrasting soils and scattered areas of rock outcrop. One soil that is similar to the Jimenez soil has a lighter colored surface layer. A soil that is similar to the Quemado soil has hard caliche at 20 to 30 inches. The contrasting soils are Aguilares, Catarina, Copita, Maverick, Nido, and Palafox soils. The percentages were determined by use of sampling transects across areas of the map unit. The soils are used mostly as rangeland and as habitat for wildlife. They are also an important source of caliche and gravel for use as construction materials. Forage yields for cattle are low. Under normal conditions, heavier brush grows on these soils than on nearby soils. Although the brush provides cover for a wide variety of wildlife species, these shallow, gravelly soils do not produce an abundance of food plants palatable to wildlife. Only browse is readily available. As a result, the carrying capacity of these soils for deer, javelina, and quail is lower than that of the more productive surrounding soils. These soils are not suited to use as cropland. The high gravel content, very low available water capacity, and very shallow to shallow rooting zone are the main limitations. These soils are poorly suited to most urban and recreation uses. The very shallow to shallow depth to a cemented pan and the high content of gravel are the main limitations. Jimenez and Quemado soils are in the Gravelly Ridge range site.

Zapata-Rock outcrop complex, gently undulating. Map Unit Symbol: ZAC.

This complex consists of very shallow, gently sloping Zapata soil and areas of Rock outcrop. The Zapata soil is on summits and side slopes of low hills. The areas are rounded or irregular in shape and range from 20 to 250 acres in size. Slopes range from 1 to 5 percent. Typically, the surface layer of the Zapata soil is brown, calcareous, moderately alkaline gravelly sandy loam about 7 inches thick. The underlying layer, which extends to a depth of 10 inches, is fractured, indurated cache. Below that, to a depth of 60 inches, there is pale brown, strongly cemented caliche that becomes less cemented with depth. The Zapata soil is well drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The rooting zone is very shallow. Water erosion is a moderate hazard and soil blowing a slight hazard if this soil is left bare of vegetation.

The Rock outcrop in this map unit consists of exposed, indurated or strongly cemented caliche.

This soil complex is 75 to 85 percent Zapata soil and similar soils, 10 to 20 percent Rock outcrop, and 0 to 15 percent contrasting soils. The similar soils include the Cuevitas soil, which has reddish colors and no lime in the surface layer, and a soil that has a darker surface layer than that of the Zapata soil. Another soil is similar to the Zapata soil but has hard caliche at a depth between 10 and 20 inches. Another similar soil is more than 35 percent, by volume, gravel. The contrasting soils are Copita, Nido, Randado, Tela, and Verick soils. The percentages were determined by use of sampling transects across areas of the map unit. The Zapata soil is used mostly as rangeland and as habitat for wildlife. It is an important source of caliche and gravel for use as construction material. Forage yields for cattle are low. Brush grows more heavily on this soil than on nearby soils. The brush provides cover for a wide variety of wildlife, but because the soil is shallow and gravelly it does not produce an abundance of wildlife food plants other than browse. The carrying capacity of this soil for deer, javelina, and quail is not so high as that of the more productive surrounding soils. This soil is not suited to use as cropland. The very shallow rooting zone, the very low available water capacity, the hazard of water erosion, and the rock outcrops are the main limitations. The Zapata soil is poorly suited to most urban uses. The shallowness to a cemented pan, the rock outcrop, and corrosivity to uncoated steel are the main limitations. This soil is poorly suited to most recreation uses. The shallowness to a cemented pan and the gravelly surface texture are the main limitations. The Zapata soil is in the Shallow Ridge range site.

3. Zapata County (Natural Resources Conservation Service 2011, pp. 26–28, 37–39, 70–71).

Cuevitas-Randado complex, 0 to 3 percent slopes. Map Unit Symbol: CRB.

Setting.
Major land resource area: MLRA 83C—Central Rio Grande Plain.
Composition.
Cuevitas and similar soils: 55 percent. Randado and similar soils: 40 percent. Contrasting soils: 5 percent. Delmita soils are moderately deep to petrocalcic horizon and are on similar positions.

Jimenez soils have loamy-skeletal control sections and are on higher positions. Quemado soils have loamy-skeletal control sections and are on higher positions.

Soil Description:
Cuevitas.
Landscape: Inland, dissected coastal plains. Landforms: Interfluves. Geomorphic positions, two-dimensional: Summit, shoulder. Down-slope shape: Convex. Across-slope shape: Convex. Parent material: Non-calcareous, loamy alluvium over petrocalcic derived from calcareous loamy alluvium of Miocene-Pliocene age.
Typical Profile.
A—0 to 9 inches; neutral fine sandy loam. Bkkm1—9 to 16 inches; cemented material. Bkkm2—16 to 80 inches; cemented material.
Properties and Qualities.
Slope: 0 to 3 percent. Percent of area covered by surface fragments: About 3 percent subangular channers, about 8 percent subangular flagstones. Depth to first restrictive layer: 6 to 16 inches to petrocalcic. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.001 to 0.06 in/hr (Very slow). Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 1.1 inches (Very low). Natural drainage class: Well drained. Runoff: Low. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 7s. Ecological site name: Shallow Sandy Loam 20-30" PZ. Ecological site number: R083CY487TX. Typical vegetation: Native woody species include mesquite, blackbrush, guajillo, leatherstem, cenizo, and pricklypear cactus. Native grass species include Arizona cottontop, fall witchgrass, hooded windmillgrass, plains bristlegrass, silver bluestem, slim tridens, and tanglehead.

Randado.
Landscape: Inland, dissected coastal plains. Landforms: Interfluves. Geomorphic positions, two-dimensional: Summit, shoulder. Down-slope shape: Linear. Across-slope shape: Convex. Parent material: Loamy alluvium, non-calcareous loamy alluvium over petrocalcic derived from calcareous loamy alluvium.
Typical Profile.
A—0 to 8 inches; neutral fine sandy loam. Bt—8 to 16 inches; neutral fine sandy loam. Bkkm1—16 to 26 inches; cemented material. Bkkm2—26 to 80 inches; cemented material.
Properties and Qualities.
Slope: 0 to 3 percent. Percent of area covered by surface fragments: About 5 percent angular channers. Depth to first restrictive layer: 8 to 20 inches to petrocalcic. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.001 to 0.06 in/hr (Very slow). Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic.

Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 1.9 inches (Very low). Natural drainage class: Well drained. Runoff: Low. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 4e. Ecological site name: Shallow Sandy Loam 20-30" PZ. Ecological site number: R083CY487TX. Typical vegetation: Native woody species include mesquite and pricklypear cactus. Native grass species include Arizona cottontop, hooded windmillgrass, tanglehead, pink pappusgrass, silver bluestem, fall witchgrass, slim tridens, sand dropseed, and bristlegrass.

<u>Jimenez-Quemado complex, 1 to 8 percent slopes</u>. Map Unit Symbol: JQD.

Setting:
Major land resource area: MLRA 83B—Western Rio Grande Plain.
Composition:
Jimenez and similar soils: 50 percent. Quemado and similar soils: 45 percent. Contrasting soils: 5 percent. Aguilares soils have fine-loamy control sections, are very deep, and are on lower positions. Copita soils have fine-loamy control sections, are moderately deep to sandstone, and are on slightly lower positions. Maverick soils are clayey, are moderately deep to densic material, and are on similar positions. Nido soils have fine-loamy control sections, are shallow to sandstone, and are on lower positions.

Soil Description:
<u>Jimenez.</u>
Landscape: Inland, dissected coastal plains. Landforms: Knobs on paleo-terraces. Down-slope shape: Linear. Across-slope shape: Convex. Parent material: Gravelly, loamy alluvium.
Typical Profile.
A—0 to 13 inches; moderately alkaline extremely gravelly loam. Bkkm1—13 to 25 inches; cemented material. Bkkm2—25 to 60 inches; moderately alkaline variable.
Properties and Qualities.
Slope: 1 to 8 percent. Percent of area covered by surface fragments: About 10 percent rounded cobbles, about 50 percent rounded medium and coarse gravel. Depth to first restrictive layer: 7 to 18 inches to petrocalcic. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.2 to 0.6 in/hr (Moderately slow). Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 1.0 inches (Very low). Natural drainage class: Well drained. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 7s. Ecological site name: Gravelly Ridge 18-35" PZ. Ecological site number: R083BY419TX. Typical vegetation: Native vegetation includes tanglehead, cottontop, slender grama, green sprangletop, fall switchgrass, bristlegrass, threeawn, guajillo, blackbrush, cenizo, and baretta along the Rio Grande, and several forbs such as bush sunflower and perennial legumes.

Quemado.
Landforms: Knobs on paleoterraces. Down-slope shape: Linear. Across-slope shape: Convex. Parent material: Gravelly, loamy alluvium.
Typical Profile.
A—0 to 6 inches; slightly alkaline very gravelly sandy loam. Bt—6 to 12 inches; slightly alkaline very gravelly sandy loam. Bkkm1—12 to 14 inches; cemented material. Bkkm2—14 to 60 inches; cemented material.
Properties and Qualities.
Slope: 1 to 8 percent. Percent of area covered by surface fragments: About 10 percent rounded cobbles, about 50 percent rounded medium and coarse gravel. Depth to first restrictive layer: 10 to 20 inches to petrocalcic. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.2 to 0.6 in/hr (Moderately slow). Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 1.1 inches (Very low). Natural drainage class: Well drained. Runoff: Medium. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 7s. Ecological site name: Gravelly Ridge 18-35" PZ. Ecological site number: R083BY419TX. Typical vegetation: Native vegetation includes tanglehead, cottontop, slender grama, green sprangletop, fall switchgrass, bristlegrass, threeawn, guajillo, blackbrush, cenizo, and baretta along the Rio Grande, and several forbs such as bush sunflower and perennial legumes.

Zapata-Rock outcrop complex, 1 to 8 percent slopes. Map Unit Symbol: ZRD.

Setting.
Major land resource area: MLRA 83C—Central Rio Grande Plain.
Composition.
Zapata and similar soils: 80 percent. Rock outcrop and similar soils: 10 percent. Contrasting soils: 10 percent. Gullied land is severely eroded land and is on similar positions. Jimenez soils have loamy-skeletal control sections and are on higher positions. Quemado soils have loamy-skeletal control sections and are on higher positions.

Soil Description.
Zapata.
Landscape: Inland, dissected coastal plains. Landforms: Ridges on interfluves. Geomorphic positions, two-dimensional: Summit, shoulder. Geomorphic positions, three-dimensional: Interfluve. Down-slope shape: Linear. Across-slope shape: Convex. Parent material: Calcareous loamy alluvium.
Typical Profile.
A—0 to 6 inches; moderately alkaline very gravelly loam. Bkkm1—6 to 13 inches; cemented material. Bkkm2—13 to 80 inches; cemented material.
Properties and Qualities.

Slope: 1 to 8 percent. Percent of area covered by surface fragments: About 14 percent angular channers. Depth to first restrictive layer: 4 to 10 inches to petrocalcic. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.2 to 0.6 in/hr (Moderately slow). Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 0.8 inches (Very low). Natural drainage class: Well drained. Runoff: Medium. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 7s. Ecological site name: Shallow Ridge 20-25" PZ. Ecological site number: R083CY485TX. Typical vegetation: Native vegetation includes sprangletop, switchgrass, sideoats grama, feathery bluestem, threeawn, slim tridens; shrubs such as guajillo, ephedra, feather dalea, colubrina, false-mesquite; and forbs such as zexmenia, gaura, menodora, and bundleflower.

Rock outcrop.
Slope: 1 to 8 percent. Salinity, representative within 40 inches: Not saline. Salinity, maximum within 40 inches: Not saline. Sodicity, representative within 40 inches: Not sodic. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 0.8 inches (Very low). Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: Not assigned. Ecological site name: Not assigned. Ecological site number: Not assigned. Typical vegetation: Not specified.

4. Duval County (Natural Resources Conservation Service 2011, pp. 50–51).

Piedras and Cuevitas soils, 1 to 5 percent slopes. Map Unit Symbol: PRC.

Setting.
Major land resource area: MLRA 83C—Central Rio Grande Plain. Elevation: 245 to 800 feet. Mean annual precipitation: 22 to 29 inches. Mean annual air temperature: 70 to 73 degrees F. Frost-free period: 270 to 330 days. Map unit prime farmland class: Not prime farmland.
Composition.
Piedras and similar soils: 60 percent. Cuevitas and similar soils: 35 percent. Contrasting soils: 5 percent.

Soil Description.
Piedras.
Landscape: Inland, dissected coastal plains. Landforms: Interfluves. Geomorphic positions, two-dimensional: Summit, shoulder. Down-slope shape: Convex. Across-slope shape: Convex. Parent material: Noncalcareous, loamy alluvium over petrocalcic derived from calcareous loamy alluvium of Miocene-Pliocene age.
Typical Profile.

A—0 to 2 inches; neutral fine sandy loam. Bk—2 to 10 inches; slightly alkaline extremely cobbly fine sandy loam. Bkkm1—10 to 13 inches; cemented material. Bkkm2—13 to 80 inches; cemented material.
Properties and Qualities.
Slope: 1 to 5 percent. Percent of area covered by surface fragments: About 15 percent angular channers, about 5 percent subangular channers, about 5 percent angular flagstones. Depth to first restrictive layer: Petrocalcic layer at 8 to 26 inches. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.001 to 0.06 in/hr (Very slow). Salinity, maximum within 40 inches: Not saline. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 2.0 inches (Very low). Natural drainage class: Well drained. Runoff: High. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 6s. Ecological site name: Shallow Sandy Loam 20-25" PZ. Ecological site number: R083CY487Texas. Typical vegetation: Native woody species include mesquite, blackbrush, guajillo, leatherstem, and pricklypear. Native grass species include tanglehead, Arizona cottontop, hooded windmillgrass, silver bluestem, fall witchgrass, plains bristlegrass, sand dropseed, and slim tridens.

Cuevitas.
Landscape: Inland, dissected coastal plains. Landforms: Interfluves. Geomorphic positions, two-dimensional: Summit, shoulder. Down-slope shape: Convex. Across-slope shape: Convex. Parent material: Noncalcareous, loamy alluvium over petrocalcic derived from calcareous loamy alluvium of Miocene-Pliocene age.
Typical Profile.
A1—0 to 1 inch; neutral fine sandy loam. A2—1 to 9 inches; neutral fine sandy loam. Bkkm1—9 to 16 inches; cemented material. Bkkm2—16 to 80 inches; cemented material.
Properties and Qualities.
Slope: 1 to 3 percent. Percent of area covered by surface fragments: About 3 percent subangular channers, about 8 percent subangular flagstones. Depth to first restrictive layer: Petrocalcic layer at 6 to 14 inches and 8 to 20 inches. Slowest soil permeability to 60 inches, above first cemented restrictive layer: 0.6 to 2.0 in/hr (Moderate). Slowest permeability to 60 inches, within and below first cemented restrictive layer: 0.001 to 0.06 in/hr (Very slow). Salinity, maximum within 40 inches: Not saline. Sodicity, maximum within 40 inches: Not sodic. Representative total available water capacity to 60 inches: About 0.9 inches (Very low). Natural drainage class: Well drained. Runoff: High. Flooding frequency: None. Ponding frequency: None.
Interpretive Groups.
Land capability nonirrigated: 7s. Ecological site name: Shallow Sandy Loam 20-25" PZ. Ecological site number: R083CY487Texas. Typical vegetation: Native woody species include mesquite, blackbrush, guajillo, leatherstem, ceniza, and pricklypear. Native grass species include Arizona cottontop, fall witchgrass, hooded windmillgrass, plains bristlegrass, silver bluestem, slim tridens, and tanglehead.

5. Jim Wells County (Soil Conservation Service 1979, p. 24).

Olmos association, undulating. Map Unit Symbol: 26.

The soils in this association are on uplands. The surface is convex. Slopes range from 1 to 8 percent. Areas are irregular, oval, or oblong in shape and range from 20 to several hundred acres in size.

This association is made up of about 72 percent Olmos soils and similar soils and 28 percent other soils. The areas of this map unit are much larger than those of other map units in the county, and the composition is more variable. Mapping has been controlled for the anticipated use of the areas.

Olmos soils are on ridgetops and upper side slopes. They have a surface layer that is about 9 inches thick. The layer, in the upper 3 inches, is friable, moderately alkaline, grayish brown gravelly loam that is about 3 to 5 percent concretions and fragments of calcium carbonate mostly less than 5 millimeters wide and about 20 percent caliche fragments. In the lower 6 inches it is friable, moderately alkaline, grayish brown gravelly loam that is about 5 to 10 percent concretions and fragments of calcium carbonate mostly less than 1 centimeter wide and about 30 percent caliche fragments. The underlying material, in the upper 4 inches, is white and pink, strongly cemented, laminar caliche that has solution channels filled with gray and dark gray material. Below that, it is white, weakly cemented, nodular caliche that has interstices filled with light brownish gray loamy material.

The soils in this association are well drained. Runoff is medium. Permeability is moderate, and the available water capacity is very low. The root zone is shallow. The hazard of water erosion is moderate to severe.

Included in mapping are small areas of Goliad, Lacoste, Parrita, Pernitas, and Pettus soils and a few eroded areas where the caliche is at or near the surface. Also included is a soil that is similar to Olmos soils except that it has a lighter colored surface layer. Included soils make up about 28 percent of any mapped area.

6. Starr County (Soil Conservation Service 1972, pp. 27–28, 37, 48–49).

Jimenez-Quemado association. Map Unit Symbol: Jq.

Areas of this association are broad, dissected, irregularly shaped, and as much as 500 acres in size. They are on high terraces 20 to 50 feet above the flood plains along the Rio Grande. In most areas the Jimenez soils occupy the slope breaks extending from the top of the ridge to the bottom of the slope and the narrow valleys between the ridges. Quemado soils occur as narrow areas on the ridgetops. The slopes are convex; the slope range is 3 to 20 percent.

Jimenez soils make up about 52 percent of the acreage, the Quemado soils make up about 38 percent, and included soils make up the rest. The Jimenez and Quemado soils are shallow, undulating to hilly, and very gravelly loams or fine sandy loams and are underlain by strongly cemented caliche. The Jimenez soils contain free lime, but the Quemado soils do not. These soils have the profile described as representative of their respective series.

Included in mapping were areas of Ramadero loam in the narrow valleys, a few spots of McAllen and Brennan soils, and a few areas of outwash sediments in some of the narrow valleys. Also included were some steep escarpments and rock outcrops, which are adjacent to the flood plains of the Rio Grande.

Jimenez Series.

The Jimenez series consists of excessively drained, undulating to hilly, very gravelly soils that are shallow over caliche. These soils are on high terraces and ridges along the Rio Grande. They have a high content of lime. The slope range is 3 to 20 percent.

In a representative profile the surface layer, about 10 inches thick, is brown very gravelly loam. About 60 to 70 percent, by volume, of this layer is rounded siliceous gravel. The underlying material, to a depth of 20 inches, is caliche that is strongly cemented in the uppermost 2 inches and weakly cemented below.

Internal drainage is medium, permeability above the caliche is moderately rapid, and the available water capacity is low.

The A horizon ranges from 5 to 15 inches in thickness, from grayish brown to brown in color, and from very gravelly loam to very gravelly fine sandy loam in texture. The amount of gravel in the solum ranges from 50 to 75 percent, by volume. The laminar upper surface of the C1cam horizon ranges from 14 inch to 2 inches in thickness. Cementation ranges from moderate to strong. The caliche ranges from 3 to more than 15 feet in thickness.

Quemado Series.

The Quemado series consists of well-drained, undulating to hilly, very gravelly soils that are shallow over caliche. These soils are on terraces and ridges along the Rio Grande. The slope range is 2 to 20 percent.

In a representative profile the surface layer, about 5 inches thick, is reddish-brown very gravelly loam that is about 50 percent gravel. The next layer, about 7 inches thick, is reddish-brown, friable, very gravelly loam that is about 55 percent gravel. The underlying material, to a depth of about 24 inches, consists of strongly cemented caliche and about 50 percent embedded gravel. Internal drainage is medium, permeability above the layer of caliche is moderately rapid, and the available water capacity is low.

In Starr County, the Quemado soils are mapped only in an association with Jimenez soils.

The A horizon ranges from 3 to 6 inches in thickness, from dark brown to brown or reddish brown in color, and from very gravelly loam to very gravelly fine sandy loam in texture. The amount of gravel in this horizon ranges from 50 to 75 percent, by volume. The Bt horizon ranges from 5 to 9 inches in thickness, from reddish brown to brown in color, and from loam to fine sandy loam in texture. Coarse, rounded pebbles of quartz, limestone, hard caliche, and igneous rocks make up 40 to 60 percent, by volume, of this layer. Reaction in the A and Bt horizons ranges from neutral to mildly alkaline. The C horizon ranges from moderately and strongly cemented in the upper part to weakly cemented in the lower part. The caliche in the lower part is massive. The pebbles on the surface are smooth and uncoated.

<u>Zapata Series</u>.

The Zapata series consists of well-drained, gently sloping soils that are very shallow over caliche. These soils occupy low ridges on upland divides. The slope range is 1 to 5 percent.

In a representative profile the surface layer consists mainly of grayish brown loam and contains angular caliche fragments. The fragments make up about 5 to 10 percent of the layer. The underlying material, to a depth of 30 inches, is indurated caliche. The uppermost 3 inches of the caliche is fractured, but the rest is strongly cemented to weakly cemented.

Internal drainage through cracks and fractures in the caliche is medium. Permeability above the caliche is moderate. The available water capacity is low.

The A horizon ranges from 2 to 10 inches in thickness, from grayish brown to light brown in color, and from fine sandy loam to clay loam in texture. It is 2 to 25 percent gravel and caliche fragments, by volume. The C1cam horizon is indurated and strongly cemented, but the rest of the C horizon becomes more weakly cemented as depth increases.

<u>Zapata soils</u>. Map Unit Symbol: Zp.

These soils are gently sloping. Areas of these soils are irregularly shaped to elongated. They occupy the low ridges of upland divides. The slope range is 1 to 5 percent.

Included in mapping were areas of soils that are 35 percent gravel and caliche fragments, by volume, and areas of reddish, noncalcareous soils that are similar to Zapata soils. Also included were a few caliche outcrops.

The entire acreage is used for range. The use of mechanical equipment is difficult because the soil is very shallow over a layer of cemented caliche. There are many caliche pits within areas of these soils. Runoff is medium. Capability unit VIIs–2; nonirrigated; Shallow Ridge range site.

7. Hidalgo County (Soil Conservation Service 1981, pp. 36–37, 46).

<u>Jimenez-Quemado complex, 1 to 8 percent slopes</u>. Map Unit Symbol 32.

This map unit consists of very shallow to shallow, gently sloping Jimenez and Quemado soils that are so intricately mixed that separating them at the scale used for mapping was not practical.

These soils are on convex uplands. Areas are small, dissected, and irregular in shape and range from 25 to 50 acres.

Jimenez very gravelly loam makes up about 60 percent of the map unit, and Quemado very gravelly sandy loam makes up about 30 percent.

Typically, Jimenez soil has a surface layer of brown very gravelly loam about 8 inches thick. The underlying material to about 10 inches is indurated caliche that is about 35 percent, by volume, embedded siliceous gravel. Below that, the material is mostly cemented caliche that is about 50 percent embedded siliceous gravel. The soil is calcareous throughout.

Jimenez soil is excessively drained. Surface runoff is medium, and permeability is moderate. The available water capacity is very low. The root zone is very shallow. The hazard of water erosion is moderate, and the hazard of soil blowing is slight.

Typically, Quemado soil has a surface layer of dark brown very gravelly sandy loam about 6 inches thick. The next layer, from 6 to 12 inches, is brown very gravelly sandy clay loam. The underlying material to about 18 inches is indurated caliche that is about 40 percent, by volume, embedded siliceous gravel. Below that, the material is weakly cemented caliche that is about 50 percent embedded siliceous gravel. The soil is noncalcareous above the caliche.

Quemado soil is well drained. Surface runoff is medium, and permeability is moderate. Available water capacity is very low. The root zone is very shallow. The hazard of water erosion is moderate, and the hazard of soil blowing is slight.

Included in mapping are small areas of Ramadero, Brennan, and McAllen soils. These soils are in slightly lower positions. The included soils make up 10 percent or less of this map unit.

These Jimenez and Quemado soils are used as rangeland or are mined commercially for gravel. They are not suited to use as cropland.

Potential is low for rangeland. In open grassland, the potential plant community for Jimenez and Quemado soils consists of grasses, including tanglehead, Arizona cottontop, and sideoats grama; woody plants, including kidneywood and vine ephedra; and forbs, including orange zexmenia and bush sunflower.

With continuous heavy grazing by livestock, tanglehead, Arizona cottontop, and sideoats grama decrease in the plant community. These plants are replaced by the less desirable hooded windmillgrass, pinhole bluestem, and slim tridens. If heavy grazing continues for many years, Texas bristlegrass, threeawn, guajillo, blackbrush, cenizo, and other woody plants dominate the site.

Potential is low for wildlife habitat including habitat for deer, javelins, doves, and quail.

These Jimenez and Quemado soils are in capability subclass Vlls, nonirrigated, and in the Gravelly Ridge range site.

Randado-Cuevitas complex, 0 to 3 percent slopes. Map Unity Symbol: 51.

This map unit consists of shallow to very shallow, nearly level or gently sloping soils that are so intricately mixed that separating them was not practical because of the scale selected for mapping. These soils are on convex uplands. Areas are small and irregular in shape and range from 10 to 45 acres.

Randado fine sandy loam makes up about 55 percent of the unit, and Cuevitas fine sandy loam makes up about 25 percent. Other soils make up the rest.

Typically, Randado soil has a surface layer of reddish brown fine sandy loam about 9 inches thick. The subsoil, between depths of 9 and 16 inches, is reddish brown sandy clay loam. Below this layer there is indurated caliche. The soil is noncalcareous above the caliche.

This soil is well drained. Runoff is slow, and permeability is moderate. The available water capacity is very low. When this soil is dry, the surface is hard and crusty. The root zone is shallow. The hazards of water erosion and soil blowing are moderate.

Cuevitas soil has a surface layer of reddish brown fine sandy loam about 8 inches thick. Below the surface layer there is indurated caliche. The soil is noncalcareous down to the caliche.

This soil is well drained. Runoff is medium, and permeability is moderate. The available water capacity is very low. When the soil is dry, the surface is hard and crusty. The root zone is very shallow. The hazards of water erosion and soil blowing are moderate.

Included with this unit in mapping are small areas of Delmita soils and areas of rock outcrop. The included areas make up 20 percent or less of this map unit.

These Randado and Cuevitas soils are used as rangeland. A few areas are idle. The soils are not suited to use as cropland.

Potential for rangeland is low. In rangeland, the dominant grasses in the potential plant community for both Randado and Cuevitas soils are silver bluestem, tanglehead, and Arizona cottontop in open grassland; woody plants include guajillo and kidneywood; and forbs include orange zexmenia and bush sunflower.

With continuous heavy grazing by livestock, silver bluestem, tanglehead, and Arizona cottontop decrease in the plant community. These plants are replaced by the less desirable hooded windmillgrass, fall witchgrass, and slim tridens. If heavy grazing continues for many years, Texas tridens, red grama, threeawn, blackbrush, leatherstem, and other woody plants dominate the site.

Potential is low for wildlife habitat including habitat for deer, javelina, doves, and quail because of insufficient plant cover.

Potential for urban and recreation uses is low because of rock outcrops and the shallow depth to indurated caliche.

These Randado and Cuevitas soils are in capability subclass Vis, nonirrigated; they are in the Shallow Sandy Loam range site.

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