

**Guadalupe Fescue  
(*Festuca ligulata* Swallen)  
5-Year Status Review:  
Summary and Evaluation**



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

**March 2025**

# **5-YEAR REVIEW**

## **Guadalupe Fescue (*Festuca ligulata* Swallen)**

### **1.0 GENERAL INFORMATION**

#### **1.1 Reviewers:**

##### **Lead Regional or Headquarters Office:**

Angela Anders, Recovery and Restoration Branch Supervisor, Southwest Regional Office, Albuquerque, New Mexico

##### **Lead Office:**

Chris Best, State Botanist, Austin Ecological Services Field Office, Austin, Texas

#### **1.2 Purpose of 5-Year Reviews:**

Section 4(c)(2) of the Endangered Species Act (ESA) requires the U.S. Fish and Wildlife Service (USFWS) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species or whether its status should change from endangered to threatened or threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

#### **1.3 Methodology used to complete the review:**

The USFWS provides notice of status reviews via the *Federal Register* and requests new information on the status of the species (e.g., life history, habitat conditions, and threats). Data for this status review were solicited from interested parties through a *Federal Register* notice announcing this review on January 11, 2023 (88 FR 1602-1604). The Austin Ecological Services Field Office conducted this review and considered both new and previously existing information from federal and state agencies, municipal and county governments, non-governmental organizations, academia, and the public. Primary sources of information used in this analysis were: 1) Element Occurrence (EO) records and spatial data from the Texas Parks and Wildlife Department's (TPWD) Texas Natural Diversity Database (TXNDD); 2) a recently completed Traditional Section 6-funded population study at Big Bend National Park (BIBE), which provided the first quantitative estimates of the

species' population size at the park; 3) an ongoing 3-year investigation, also funded through a Traditional Section 6 grant, to survey and monitor populations in the U.S. and Mexico and to initiate seed collection, propagation, and pilot reintroduction efforts in the U.S. and Mexico; and 4) spatial data from state and federal agencies in the U.S. and Mexico, including Digital Elevation Models (DEMs), digital ortho-corrected aerial images, topographic maps, surface geology, and protected natural areas in both Texas and Mexico. We also reviewed all new, available scientific literature on the species and communicated with several of its leading experts.

#### **1.4 Background:**

##### **1.4.1 FR Notice citation announcing initiation of this review:**

88 FR 1602–1604

##### **1.4.2 Listing History:**

###### Original Listing

**FR Notice:** 82 FR 42245–42260

**Date listed:** September 7, 2017

**Entity listed:** *Festuca ligulata*

**Classification:** Endangered

##### **1.4.3 Associated Rulemakings:**

Not Applicable.

##### **1.4.4 Review History:**

No previous 5-year review.

##### **1.4.5 Species' Recovery Priority Number at start of 5-year review:**

A Recovery Priority Number has not yet been assigned to this species.

##### **1.4.6 Recovery Plan or Outline:**

**Name of plan or outline:** Recovery Plan for Guadalupe Fescue (*Festuca ligulata* Swallen)

**Date issued:** August 2, 2022

**Dates of previous plans/amendment or outline, if applicable:** Not Applicable.

## **2.0 REVIEW ANALYSIS**

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) establish the procedures for determining whether a species meets the definition of “endangered species” or “threatened species.” The ESA defines an “endangered species” as a species that is “in danger of extinction throughout all or a significant portion of its range,” and a “threatened species” as a species that is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The ESA requires that we determine whether a species meets the definition of “endangered species” or “threatened species” due to any of the five factors described below.

Section 4(a) of the Act describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an “endangered species” or a “threatened species.” In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. Finally, we recommend whether the species meets the definition of an “endangered species” or a “threatened species” only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

### **2.1 Distinct Population Segment (DPS) policy (1996):**

Not Applicable.

## **2.2 Updated Information and Current Species Status**

### **2.2.1 Biology and Habitat**

The USFWS listed Guadalupe fescue as endangered in 2017 and reported new information on the species’ biology and habitat in the recovery plan (USFWS 2022, entire). We report here additional new information primarily from two Section 6-funded grants administered by Texas Parks and Wildlife Department. Grant F19AP00206 (*Population status assessments of four plant species in Big Bend National Park*) developed improved population size estimates and distribution models of four listed plants at BIBE, including Guadalupe fescue. This project was led by a team from the University of Texas at Austin; for brevity, we refer to this work here as the UT-A project. The final grant report (Whiting

and Fowler 2022, entire) as well as Whiting’s doctoral dissertation (Whiting 2022, entire) document this work. Grant TX E-206/F21AP00172 (*Fescue Rescue: A bi-national augmentation project for restoring Sky Island Guadalupe fescue populations*), now in the third year of performance, is searching for new populations in Mexico, censusing extant wild populations, collecting seeds from two wild populations, propagating plants, and reintroducing the propagated plants into the source populations. This ongoing project is coordinated by researchers from the University of Maine at Farmington and Wesleyan University in collaboration with researchers from the Universidad Autónoma Agraria Antonio Narro (UAAAN, Saltillo, Coahuila) and the Comisión Nacional de Areas Naturales Protegidas (CONANP), the Mexican federal agency that administers protected natural areas; in this report we abbreviate this as the UMF-WU project. The interim grant reports (Barton et al. 2022, entire; Barton et al. 2023, entire; Barton 2024, entire) and numerous project-related emails document ongoing results from this grant. The UMF-WU project carries forward work conducted from 2019 through 2021, supported by the NPS Southwest Border Resource Protection Project, that continued Guadalupe fescue surveys and initiated recovery efforts in Texas and Coahuila; we refer to this work here as the SWBRPP. This project is documented in Poulos et al. (2021, entire) and Poulos et al. (2023, entire). Additionally, both Section 6-funded projects were modified to investigate the effects on Guadalupe fescue of a wildfire that occurred at BIBE in April 2021. Personnel of the Austin Ecological Services Field Office, BIBE, and volunteers contributed to field work, mapping, and data analyses for both projects.

#### **2.2.1.1 New information on the species’ biology and life history:**

Periodic wildfire and leaf litter reduction may be necessary for long-term survival of Guadalupe fescue populations. Poulos et al. (2009, p. 1241) reported a mean fire return interval (MFI) of 19.4 years for wildfires in the Chisos Mountains; the MFI for fires that scarred at least 10 percent of trees was 36.5 years. Nevertheless, prior to 2021, the last wildfire in Boot Canyon was in 1944, the year that the Park was established (Zimmerman and Moir 1998, p. 12); hence, this most recent fire return interval spanned 77 years. The long absence of wildfire in the Chisos Mountains led to an increased density of small-diameter trees and a deep accumulation of leaf litter. This high fuel load increased the risk of a much more intense wildfire that could kill all or most of the vegetation and sterilize the soil. The impact of an intense wildfire would potentially be catastrophic to the remaining Guadalupe fescue population (USFWS 2016a, p. 19). Recovery plan actions A.1.1 and A.1.2 (USFWS 2022, p. 16) call for fuel reductions, experimental prescribed burns, and research on the species’ response to fire; if beneficial, actions A.1.3 and A.1.4 would establish larger-scale prescribed burning on a 15- to 20-year cycle. The results of prescribed burning will be communicated with researchers and managers of protected natural areas in Coahuila where Guadalupe fescue populations may occur (Action A.1.5).

Beginning on April 8, 2021, the South Rim 4 wildfire burned through Boot Canyon at BIBE (Figure 1). By April 14 it had consumed 369 hectares (ha) (912 acres (ac)), including 80 to 90 percent of the Guadalupe fescue habitat (BIBE 2021, entire); by June 1, when fully extinguished, the fire perimeter (encompassing both burned and

unburned patches) totaled 543 ha (1,341 ac) (Barton et al. 2022, p. 10). Fortuitously, the UT-A and UMF-WU projects had both conducted rigorous censuses and mapping of the population in 2019. This created a windfall opportunity to document the effects of the fire on this species.

Two months after the fire, Whiting (2022, pp. 92–95, 99, Table 3.2) assessed burn severity in 48 plots that were established in 2019 in Guadalupe fescue habitat (see discussion in Section 2.2.1.2). Although more than 84 percent of the area within plots had burned, in most places the burn severity was low to medium in the litter and canopy layers (Figure 3.1); about one third of the herbaceous layer was severely burned. The relatively low severity is attributed to the early season and mild weather prior to and during the fire.

A population census of the 48 plots on October 19–21, 2021 detected 113 individuals, a decline of 58 percent from 2019. Subsequent plot censuses in October 2022 and October 2023 detected almost no change in population sizes (Whiting 2024, entire; Figure 2.1). Although the post-fire population increased in the only unburned plot and decreased in most burned plots, due to the small sample size, the plot data does not reveal a clear correlation between fire severity and mortality (Figure 2.2). One plot with low burn severity had the highest population decline; however, these plants were in the bed of a creek and may have been washed away by heavy runoff or buried under debris after the fire.

Based on qualitative observation, survival appeared higher for individuals growing in talus slopes, where the grass meristems were shielded from heat by loose rocks (Figure 3.3). Finally, although the fire is an obvious cause of mortality, the population decline may be due in part to the extreme drought in 2020, when rainfall was 182 millimeters (mm) (7.1 inches (in)); average annual rainfall at the Chisos Basin is 466 mm (18.33 in) (National Centers for Environmental Information 2024, unpaginated). This population decline post-fire is comparable to the population decline of 59 percent following the very dry years of 2011 and 2012 (USFWS 2016a, p. 6).

Barton et al. (2022, pp. 10–11) documented a decline of 56 percent for the Boot Canyon Guadalupe fescue population from 2019 to 2021. Heavy rainfall in August 2021, four months after the fire, eroded channels in the exposed soil and washed away some plant identification tags. Post-fire, 32.8 percent of previously tagged individuals died, and 23.6 percent were missing. Compared to 2019, the percent of living individuals that flowered declined from 51 percent to 7 percent, and the total number of flower spikelets declined from 8,151 to 290.

These authors attribute the population decline and reduced reproductive output to the fire but acknowledge that the fire may benefit Guadalupe fescue in the longer term. In Poulos et al. (2023, pp. 33–36) they report that, compared to random points in the surrounding habitat, Guadalupe fescue occupies rockier microsites with a more open forest canopy and understory. The Campo Dos population in *Area de Protección de*

*Flora y Fauna* (APFF) Maderas del Carmen (discussed in Section 2.2.1.5) occurs entirely within the perimeter of a 2007 wildfire. Therefore, wildfire may benefit the species' long-term persistence by restoring more favorable habitat conditions.

Poulos et al. (2023, p. 34) documented a significant negative correlation of the distance between Guadalupe fescue plants at Boot Canyon and seed fill rates; plants that are further from their nearest neighbor had lower fertilization rates. This is an expected consequence of wind pollination. Considering the small stature of Guadalupe fescue and its low population densities, this result emphasizes that outcrossing and population recruitment may be reduced by pollen limitation; this limitation would be exacerbated if the species is an obligate outcrosser.

In synthesis, these investigations reveal that Guadalupe fescue individuals are relatively vulnerable to fire, compared to most grasses. The Boot Canyon population was reduced by low to moderate burn severity, and we do not yet know if it will recover during the early years after the fire. As the fire return interval lapses into decades, it is likely that populations would slowly decline due to increases in canopy shade, understory competition, and litter depth. Ultimately, after a very long fire interval, populations could decline drastically or be extirpated by fires of high severity. Poulos et al. (2009, pp. 1241, 1243) found that 98.5 percent of historical wildfires in the Chisos Mountains occurred during dormant or early earlywood growth (primarily during the spring). Guadalupe fescue evolved under the influence of this fire regime. The South Rim 4 wildfire also occurred during the spring, but it followed a very long interval of fuel accumulation. Under such conditions, a wildfire during the hot mid-summer months would likely have had a much more severe, perhaps catastrophic impact on Guadalupe fescue and its habitat.

Figure 1. South Rim 4 wildfire and Guadalupe fescue sample universe, Big Bend National Park.



-  Fire perimeter, April 8–June 1, 2021
-  Sample universe (Guadalupe fescue habitat)

Image date: September 29, 2022  
(18 months after the fire)

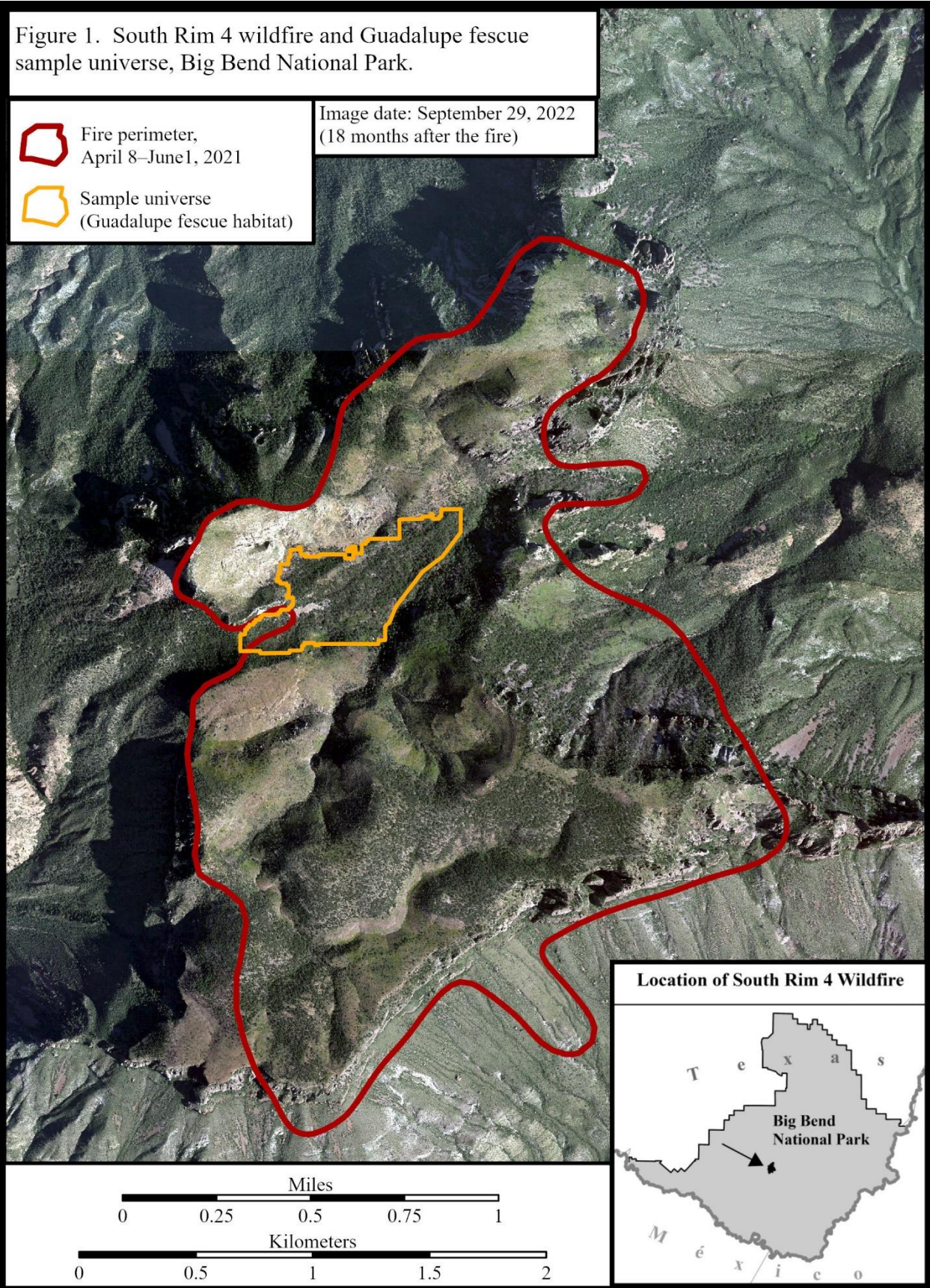


Figure 2.1. Total number of individuals on 48 plots, 2019–2023.

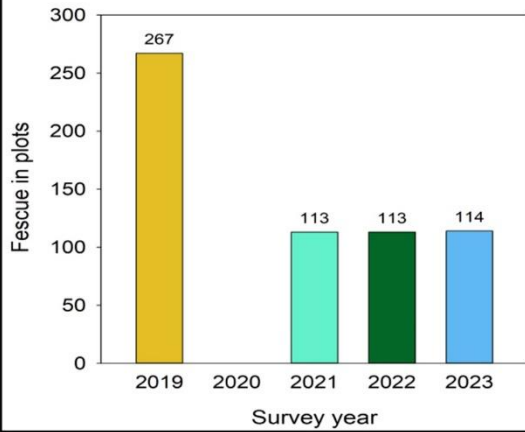


Figure 2.2. Number of individuals on 7 occupied plots with differing burn severity, 2019–2023.

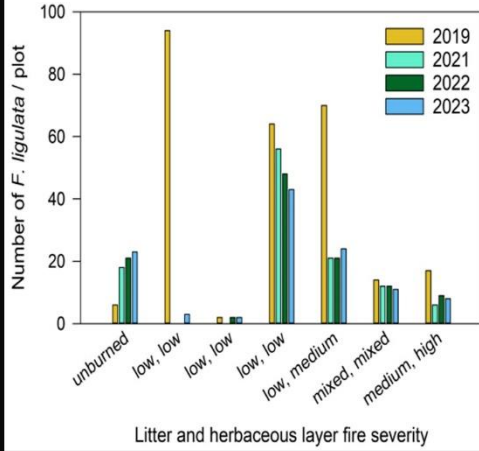


Figure 2. Guadalupe fescue census plots 2019–2023 (Whiting 2022, entire; 2024, entire).

Figure 3. Effects of South Rim 4 wildfire on Guadalupe fescue.

- 3.1 Plot with moderate burn severity, June 2021.
- 3.2 Tagged plant, apparently dead, October 2021.
- 3.3 Surviving plants recovering in talus slope.
- 3.4 Burned plant that has resprouted.
- 3.5 One surviving tagged plant and 4 that are presumed dead.



**2.2.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, birth rate, seed set, germination rate, age at mortality, mortality rate, etc.), or demographic trends:**

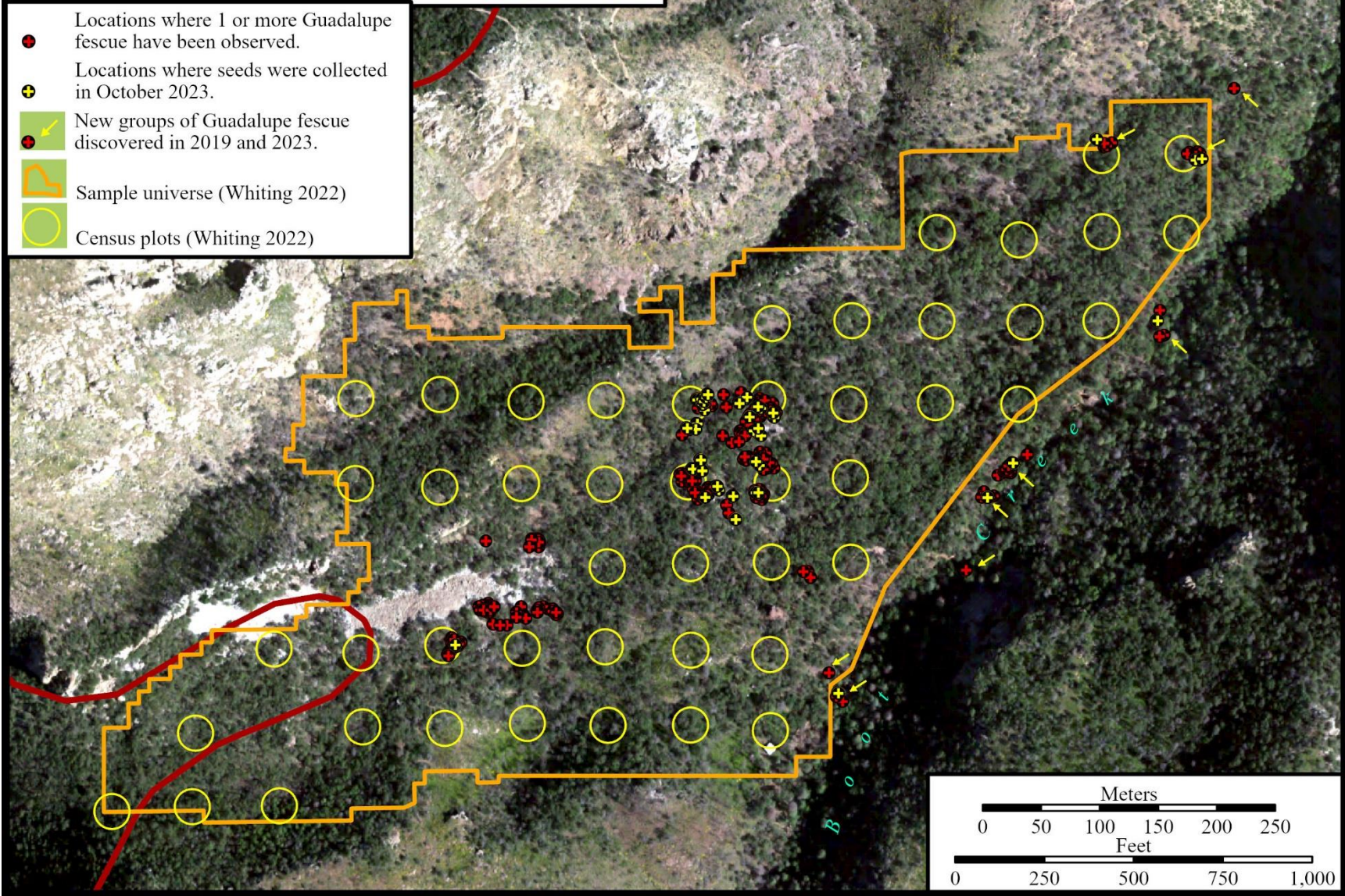
Population size is one of the principle metrics of species viability (USFWS 2016b, p. 12). The Guadalupe fescue's Recovery Plan (USFWS 2022, p. 11) estimated that viable populations of the species require a minimum size (MVP) of 1,275 individuals. It may be possible to count every individual of small, spatially uniform populations. However, like many rare plant species, Guadalupe fescue has extremely uneven (patchy) distribution; this greatly complicates determining population sizes. The UMF-WU project counted 323 Guadalupe fescue individuals in Boot Canyon in 2019 (Poulos et al. 2021, p. 2)—far below the MVP level. This is an accurate count for a very discrete habitat area, but it is impossible to know whether or not the population extends beyond where the highly qualified surveyors had time to search. In most cases, it is not practical to attempt to count every individual of larger, dispersed populations, so population sizes must be estimated from samples.

From 1993 through 2017, researchers collected data on the Boot Canyon population from six monitoring plots that were intentionally placed where there were dense clusters of individuals. Analyses of this data yielded valuable information about the species' life span, reproductive output, and response to precipitation (summarized in USFWS 2016a, Appendix B). Although the monitoring plot populations declined over time, due to their biased placement, this data cannot be used to reliably estimate population size or demographic trends. For one thing, densely grouped individuals are more likely to decline due to density-dependent factors, such as parasitism, pathogenicity, or herbivory. Furthermore, no sample plots were placed in unoccupied habitat; therefore, it was not possible to detect migration of the population beyond the occupied plots (Whiting and Fowler 2022, p. 39).

The UT-A project (Whiting 2022, pp. 88–103; Whiting and Fowler 2022, pp. 25–58) estimated the total population size of Guadalupe fescue in Boot Canyon using a regularly-spaced array of circular plots distributed throughout the “sampling universe”, which is the area of suitable habitat characteristics that was sampled. These habitat characteristics were determined from the mappable attributes of the known population at Boot Canyon: elevations greater than 1,800 meters (m) (5,905 feet (ft)), and a vegetative cover of oak-conifer woodland. Practical constraints limited sampling to occupied habitats within BIBE. Additionally, due to concerns for personal safety, the sampling universe excluded slopes greater than 30°. The sampling universe totaled 23.21 ha (57.35 ac), within which 48 circular, 15-m (49-ft) radius plots were placed at a spacing of 70 m (230 ft) (Figure 4). The plot size was based on results from a preliminary sampling (Best 2018, entire). In 2019, surveyors found 267 individuals in 7 of the 48 plots, and the estimated total population size was 1,826. As discussed in Section 2.2.1.1, in 2021 the plot census declined to 113 and the estimated total declined to 773. However, due to uneven distribution and wide variation in numbers per plot, the confidence intervals are very large.

Because the UT-A project sampled throughout the area of suitable habitat, new groups of individuals were discovered that were 375 m (1,171 ft) from the nearest previously documented plants. Additionally, on October 19, 2023, the UT-A team conducted an exploratory survey along Boot Creek, just outside the sampling universe, where they found 76 additional individuals where none had previously been found. Although all these newly discovered plants were close to campsites and a trail, they had not been observed during the previous 30 years of surveys. These experiences demonstrate the difficulty of detecting all individuals of a cryptic plant species that is unevenly distributed over steep terrain.

Figure 4. Guadalupe fescue census plots, plant locations, and October 2023 seed collection.



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

No new information.

**2.2.1.4 Taxonomic classification or changes in nomenclature:**

No new information.

**2.2.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased number of corridors, pollinator availability, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.):**

The UMF-WU project supported Guadalupe fescue surveys in six Chihuahuan Desert mountain ranges where populations have been documented: The Chisos Mountains, BIBE, Texas, and McKittrick Canyon, Guadalupe Mountains National Park, Texas; Sierra del Carmen and Sierra El Jardín, in APFF Maderas del Carmen, northern Coahuila; Sierra la Madera, in *Área de Protección de Recursos Naturales* (APRN) Don Martín, central Coahuila; and in mountains near El Fraile, in southern Coahuila (Figure 5). Lands designated as APFF and APRN are types of protected natural areas administered by CONANP and are analogous to U.S. National Wildlife Refuges and U.S. National Forests, respectively.

During the final year of the project (2024), the investigators plan to survey in the Sierra Rica, APFF Cañón de Santa Elena, in eastern Chihuahua (Figure 5), where there are potential habitats that have not previously been surveyed. Surveys of the historical population sites at McKittrick Canyon (Figure 5) and Sierra El Jardín (Figures 5, 6) did not record extant populations (Barton et al. 2022, p. 7; Barton et al. 2023, p. 8). Surveys of the Campo Dos population in the Sierra del Carmen now document 199 individuals distributed over a span of 0.9 kilometers (km) (0.6 miles (mi)) (Barton et al. 2024, p. 3; Figures 5, 6). The project participants discovered a new population in Cañón del Caballo/Cueva de la Sal that has three sub-populations totaling 758 individuals (Barton 2024, p. 9; Figures 5, 6).

The location of the Sierra El Jardín collection shown in Figures 5 and 6 is based on the geographic coordinates in the specimen label (29.1° N, -102.61667° W). The label also states:

“Canyon Hundido on N side of Pico Centinela, Sierra del Jardin, 8 km. E of Rancho El Jardin by winding road. Habitat: Pinares, encinares, chaparrales, bosque deciduo. Steep canyon through igneous sierra. Gravelly and sandy loam derived from extrusive igneous rocks. Assoc. with *Quercus* spp., *Pinus* ssp., *Acer*, *Tilia*, *Garrya*, *Ceanothus*, *Fenlera*, *Pseudotsuga*.”

The elevation at the designated position is about 1670 m (5,480 ft) and is on a ridge rather than a canyon. Since geographic coordinates were interpolated manually from topographic maps in 1973, this position is likely to have low precision. Based on the specimen label description of the site, the distance from Rancho El Jardín, and the associated vegetation, the actual collection site appears to be at least 1.4 km further south, in steep wooded canyons immediately below Pico El Centinela. Two possible locations that fit the label description are: 29.110312° N, -102.613262° W; and 29.113241° N, -102.601554° W.

The UMF-WU project also confirmed an extant population in the Sierra La Madera (Barton 2022, p. 1; Barton et al. 2023, p. 7; Figures 5, 7). Guadalupe fescue had been collected from three sites in the Sierra La Madera during the 1970s (see Table 1 and Figure 7). In 1973, Henrickson and Wendt collected herbarium specimens in Cañón (Cañada) La Hacienda (according to the specimen label). The geographic coordinates they cited are in a different canyon 2 km (1.2 mi) to the east; as described above, the manually plotted geographic position may lack precision. The UMF-WU researchers believe the actual site may be in or near Cañada El Agua (Barton et al. 2023, p. 7; Poulos 2024, p. 1). In 1977, Wendt and Valdés-Reyna collected the species from two sites in Cañón (Cañada) del Desiderio, about 13 km (8.1 mi) northwest of Cañada La Hacienda. In August 2022, UMF-WU researchers hiked 10 hours up steep, rugged terrain to reach the remote Henrickson and Wendt site near Cañada La Hacienda, where they found 10 individuals (Barton et al. 2023, pp. 6–7). However, they were not able to determine the total size and geographic extent of that population.

Table 1. Guadalupe fescue collection sites in the Sierra la Madera, Coahuila, Mexico.

Collector(s)	Date	Herbarium	Catalog No.	Site Name	Geographic Coordinates	No.
J.S. Henrickson and T. Wendt	Aug 5, 1973	Lundell	LL 00438014	Cañón de la Hacienda <sup>1</sup>	27.05° N, -102.4° W	1
J.S. Henrickson and T. Wendt	Aug 5, 1973	University of Arizona	ARIZ 406871	Cañón de la Hacienda <sup>1</sup>	27.05° N, -102.4° W	1
T. Wendt and J. Valdés-Reyna	Jul 27, 1977	University of Arizona	ARIZ 237645	Cañón del Desiderio	27.10833° N, -102.54167° W	2
T. Wendt and J. Valdés-Reyna	Jul 27, 1977	University of Texas	TEX 00438059	Cañón del Desiderio	27.10833° N, -102.54167° W	2
T. Wendt and J. Valdés-Reyna	Jul 27, 1977	University of Texas	TEX 00438065	Cañón del Desiderio	27.10833° N, -102.54167° W	2
T. Wendt and J. Valdés-Reyna	Jul 27, 1977	University of Texas	TEX 00438064	Cañón del Desiderio	27.12361° N, -102.52528° W	3
Barton <i>et al.</i>	Aug 2022	NA	NA	Cañada El Agua	27° 06' 30" N, -102° 32' 30"	4

1. The collectors believed they were in Cañón de la Hacienda, but may have been in an adjacent cañada (see explanation in text).

In 1941, Stanford et al (1941, entire). collected Guadalupe fescue from a site northwest of El Fraile, a village in southern Coahuila (Figure 5, 8). Herbarium specimens from this collection are stored at Missouri Botanical Garden (MO 1221316) and the University of Arizona (ARIZ 15004). The herbarium labels state:

“On south slope of mountain, 24 kilo. northwest of Fraile; burned-off land with Juniper and Arbutus present.”

It is most likely that the collectors were traveling along the existing road from El Fraile to General Cepeda. Figure 8 indicates two possible collection sites measured along the road or by linear distance from El Fraile (we do not know which method the collectors used to measure distance).

The SWBRPP project searched potential habitats near El Fraile and reported the discovery of a population of Guadalupe fescue in the Sierra El Fraile, 2.4 km southeast of the eponymous village (Poulos et al. 2021, pp. 2, 10). We mentioned this site in the recovery plan (USFWSW 2022, entire). However, specimens from this site were subsequently determined to be Chisos bluegrass (*Poa strictiramea*), which is very similar in appearance (Barton et al. 2022, Appendix A). We conclude that the Stanford site has not yet been re-surveyed and should continue to be ranked as a historical population. Nevertheless, there is a large amount of intact habitats in the Sierra El Quemado, Sierra la Concordia, and other mountain ranges near this historical collection site. It is certainly possible that populations of Guadalupe fescue remain there.

In 1939, E.G. Marsh, Jr. collected a herbarium specimen (no. 1950; TEX00438036) in the Sierra La Gloria (Figure 5), near Monclova, Coahuila, that was later identified as Guadalupe fescue. We have no information on the specific location, so this minimal record cannot be mapped or confirmed. Nevertheless, since potential habitats do occur in this mountain range, populations may persist there.

On April 11–12, 2024, a team from CONANP (Fire Management Officer Arnulfo Hernández and Hydrologist Octavia Zarate Sánchez), NPS (Botanist Carolyn Whiting), USFWS (Botanist Chris Best), and Rio Bravo Restoration (Jeff Renfrow; <https://www.riobravorestoration.org/>) conducted a plant survey in APFF Maderas del Carmen, Coahuila. They discovered a new population of Guadalupe fescue about 7.5 km (4.7 mi) southeast of the Campo Dos population (Best 2024a, unpaginated; Figures 5, 6). About 50 individuals were observed along an unnamed tributary arroyo of Cañón El Moreno at an elevation of about 2,000 m (6,562 ft). However, the total extent of this population was not determined. During this survey, Hernández observed that fuel loads at higher elevations in the Sierra del Carmen were very high and many months of low rainfall had created dangerously dry conditions. He concluded that the risk of catastrophic, stand-replacing wildfire was very high.

Table 2 below summarizes information about the documented populations of Guadalupe fescue. Guadalupe fescue has now been documented in 10 sites (not

including the unconfirmed collection from Sierra La Gloria). One historical and one extant site are in Texas. In Coahuila, Mexico, there are four historical sites and four extant sites. Elevations range from 1,433 m (4,700 ft) to at least 2,750 m (9,022 ft). Populations occur on both limestone and igneous substrates. Thorough censuses have been conducted at Boot Canyon, Cañón del Caballo, and Campo Dos; these populations may be closer to viable sizes (however, see the discussion in Section 2.3.1.2). The numbers of individuals observed at Cañada del Desiderio and Cañón El Moreno are very low, but neither population has been thoroughly surveyed. In summary, the five extant populations represent an improved species status compared to the two extant populations known when the species was listed as endangered, in 2017. This improvement is due to increased population surveys that were supported through two Section 6-funded projects.

Table 2. Revised summary of documented populations of Guadalupe fescue (Poulos et al. 2021; Barton et al. 2022, Barton et al. 2023; Barton et al. 2024; Best 2024a; see list of herbarium records).

No.	Site Name	Status	Elevation (m); substrate	Most recent observation	Most recent population size
1	McKittrick Canyon, Guadalupe Mts., Texas	Historical	1433–1980; limestone	1952	Unknown
2	Boot Canyon, Chisos Mts., Texas	Extant	1981–2085; igneous, granitic talus	2023	323 counted; 1,800 estimated
3	24 km NW of El Fraile, Coahuila	Historical	2900 (according to label); unknown	1941	Unknown
4	Cañón Hundido, Sierra El Jardín, Coahuila	Historical	Unknown; igneous gravel, sand, andesite	1973	Unknown
5	Cañada La Hacienda, Sierra La Madera, Coahuila	Extant	± 1800; limestone	2022	Unknown
6	Cañada del Desiderio, upper canyon, Sierra La Madera, Coahuila	Historical	± 2750; limestone	1977	≥ 10
7	Cañada del Desiderio, mid canyon, Sierra La Madera, Coahuila	Historical	± 2370; limestone	1977	Unknown
8	Campo II, Sierra del Carmen	Extant	2340–2400; rhyolite, granite, syenite	2023	191
9	Cañón del Caballo/Cueva de la Sal	Extant	1888–1997; rhyolite, granite, syenite	2023	758
10	Tributary of Cañón El Moreno	Extant	2020; rhyolite, granite, syenite	2024	± 50

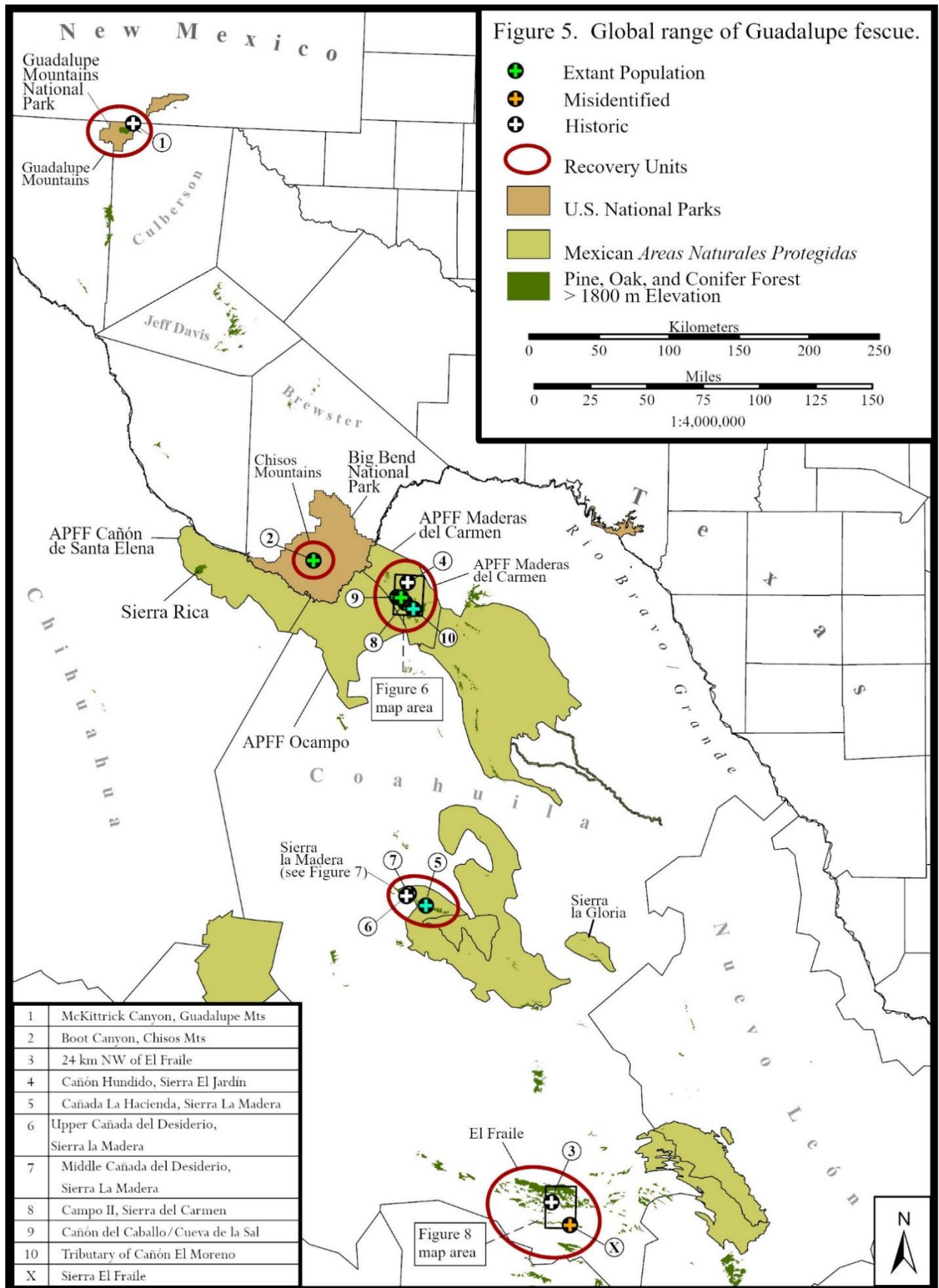
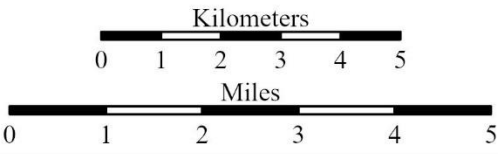
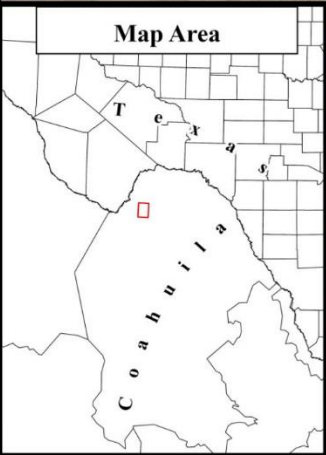
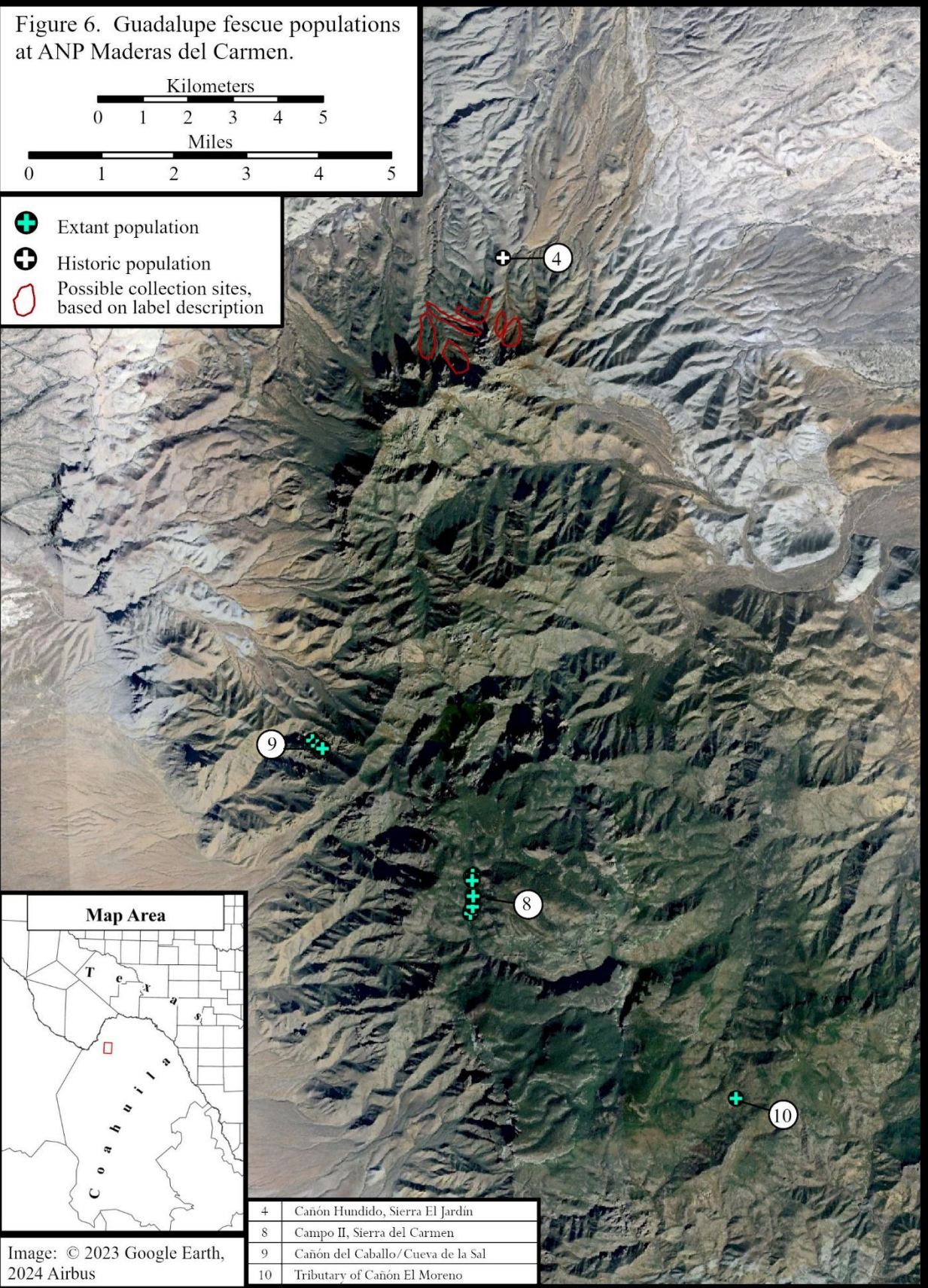


Figure 6. Guadalupe fescue populations at ANP Maderas del Carmen.



- + Extant population
- + Historic population
- Possible collection sites, based on label description



4	Cañón Hundido, Sierra El Jardín
8	Campo II, Sierra del Carmen
9	Cañón del Caballo/Cueva de la Sal
10	Tributary of Cañón El Moreno

Image: © 2023 Google Earth, 2024 Airbus

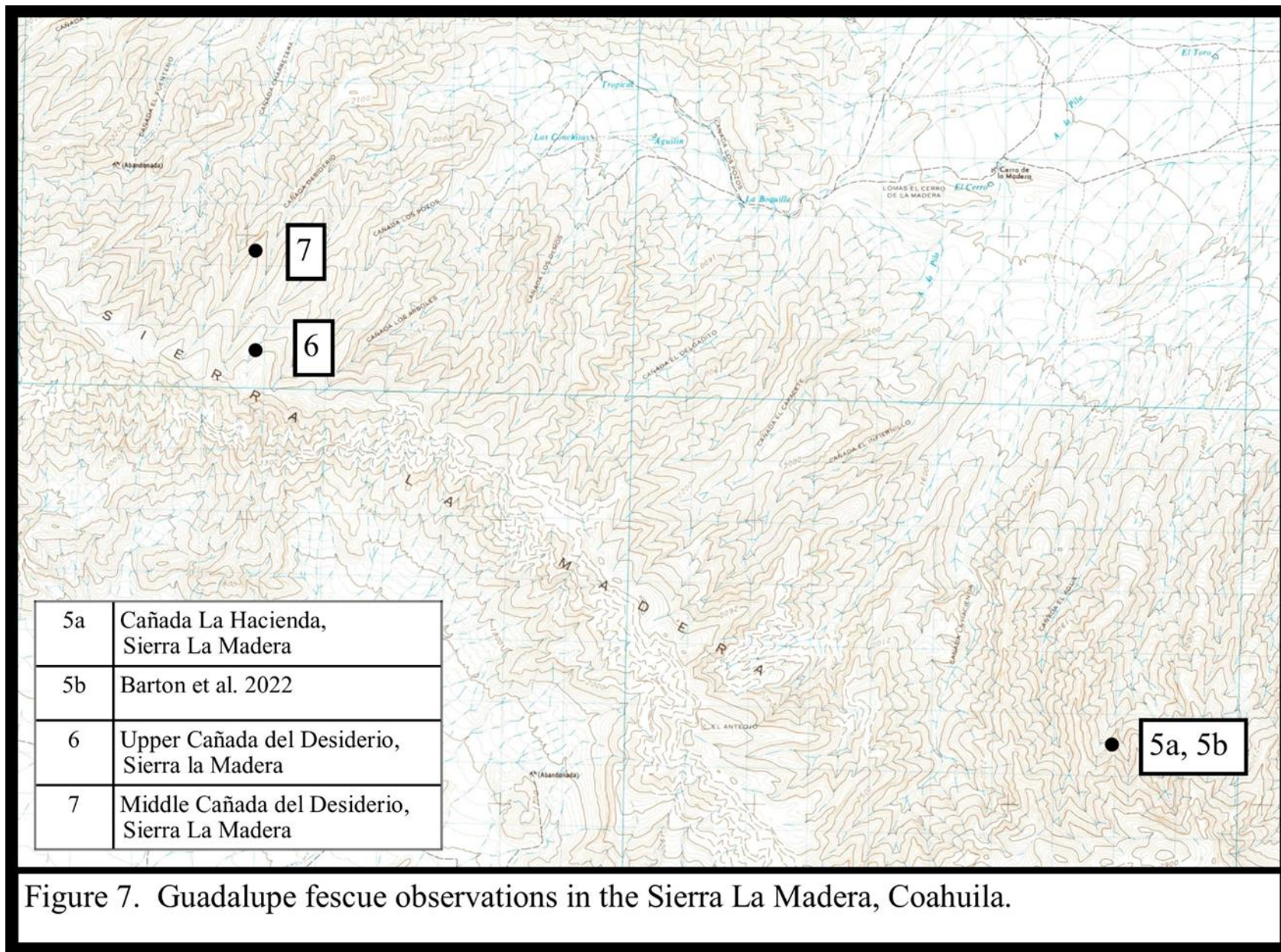
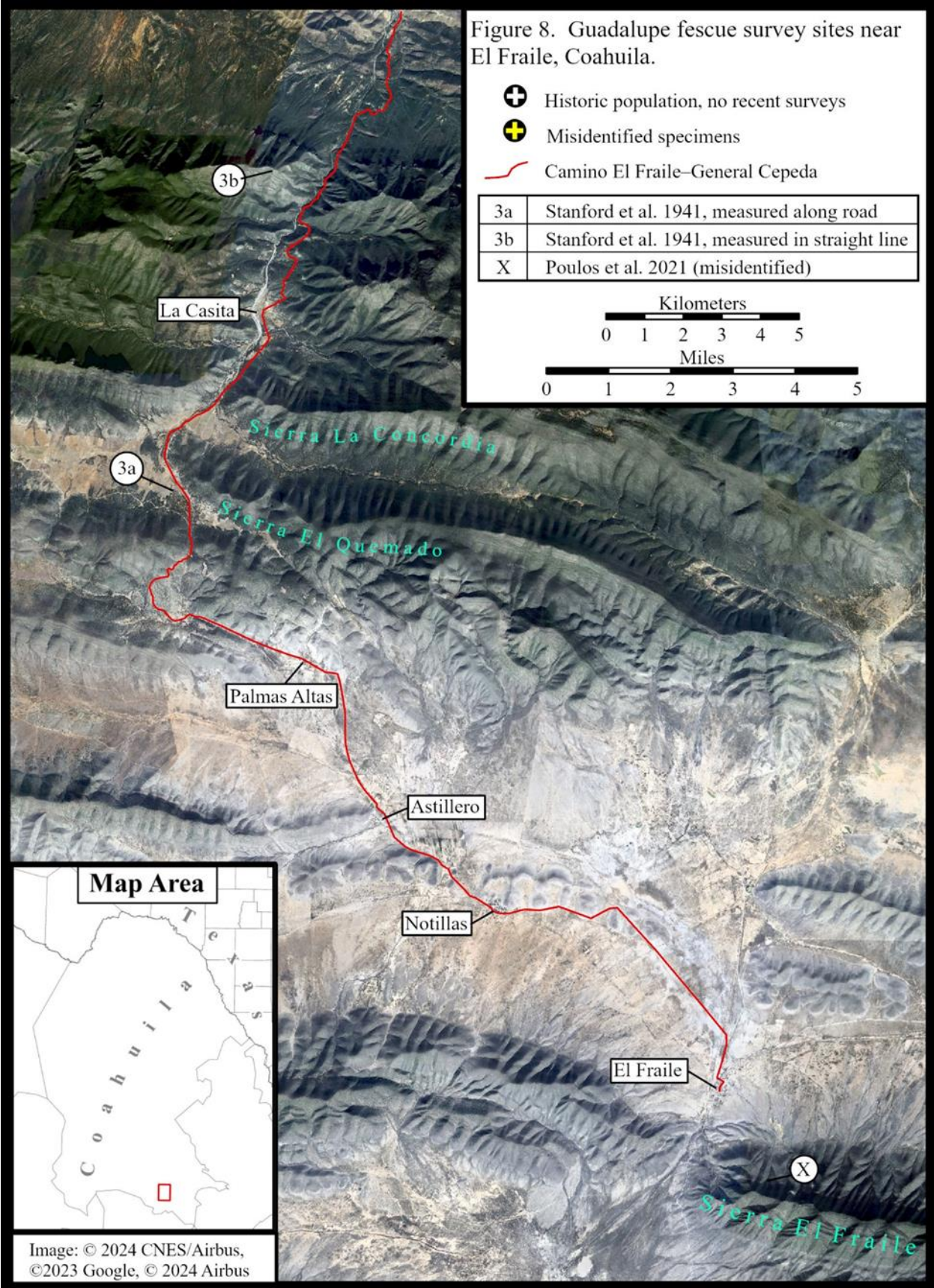


Figure 7. Guadalupe fescue observations in the Sierra La Madera, Coahuila.



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

We discussed the April 2021 wildfire at Boot Canyon in Section 2.2.1.1. Although the fire appears to have reduced the population size, it also improved habitat conditions by reducing canopy cover, fuel loads, and litter depth. A wildfire occurred at the Campo Dos site in APFF Maderas del Carmen in 2007 (Barton et al. 2022, p. 36). Recent surveys indicate that this population and its habitat remain healthy. We have no information on the fire history of the other extant or historical population sites.

The SSA (USFWS 2016a, pp. 14–16 and Figure 6) estimated that 95 percent of potential habitats occur in Mexico. Recent aerial photography indicates that abundant pine-oak forest and woodland habitats remain in the areas of potential habitat in Mexico, with little evidence of disturbance or development (Figures 6, 8). Field surveys by the UMF-WU team confirm that excellent habitat conditions persist at the extant population sites in the Sierra del Carmen and Sierra La Madera.

### **2.2.1.7 Other:**

No new information.

### **2.2.1.8 Conservation Measures:**

The recovery plan (USFWS 2022) outlined recovery actions to promote the species' recovery. These actions include studies and other activities to increase knowledge about the species' distribution and abundance and to augment the species' population sizes and genetic diversity. Specifically, recovery action E.2.5 states:

If the investigations of gene flow, conservation genetics, and population sizes described in E.2.1–3 conclude that inbreeding, small population sizes, or limited gene flow currently threaten extant populations, propagate and reintroduce Guadalupe fescue individuals in strategic sites of the same metapopulation to augment population sizes and genetic diversity and to promote gene flow between isolated individuals, clusters, and populations...

We begin this discussion of ongoing recovery efforts with a brief review of grass morphology, terminology, and reproductive biology. Guadalupe fescue panicles (flower stalks) contain numerous florets (individual flowers); typically, two to three florets occur in clusters called spikelets that are borne on panicle branches (Figure 9.1). If fertilized through wind pollination, each floret may develop a single caryopsis (seed) (Figure 9.2). However, the proportion of florets that produce a viable caryopsis is highly variable among grass species and is also highly variable within a species by ecotype and from season to season; neither the size of the panicle nor the number of spikelets and florets reveal the number of viable caryopses

concealed within. We refer to the proportion of florets that contain a fully formed caryopsis as the “seed fill rate.”

The extant populations are all below the MVP level. Like virtually all grasses, Guadalupe fescue is fertilized through wind pollination. Wind pollination is most effective when pollen sources are abundant and recipient plants are near pollen sources during the brief period when pollen is released and stigmas are receptive (USFWS 2016a, pp. 4–5). Due to the small stature of Guadalupe fescue, individuals produce relatively little pollen. Due to low population sizes, the amount of outcrossing between individuals is likely to be low; similarly, the highly clustered distribution greatly reduces the probability of gene flow between widely scattered clusters. If the species is self-compatible, its populations may persist through self-fertilization, but this in turn means that populations are likely to be highly inbred (Fowler 2015, p. 1). Therefore, the controlled propagation and reintroduction actions stipulated in E.2.5 are likely to be important conservation tools for this species. Techniques for native plant propagation and reintroduction vary widely among species and can take several years of experimental trials to perfect. For these reasons, we encouraged researchers to initiate pilot propagation and reintroduction efforts to develop the necessary protocols.

The SWBRPP project began seed collection, controlled propagation, and reintroduction of Guadalupe fescue at Boot Canyon, BIBE, in Texas, and in the Sierra del Carmen, APFF Maderas del Carmen, in Coahuila. These efforts were carried forward by the same team of researchers in the UMF-WU project. The results of these ongoing projects are summarized below.

In the fall of 2019, the UMF-WU project collected Guadalupe fescue seeds in Boot Canyon, BIBE, and Campo Dos, APFF Maderas del Carmen. In this and all subsequent seed collections, no more than 10 percent of annual seed production was collected to conform to Center for Plant Conservation recommendations (Center for Plant Conservation 2019, p. 1-13). These first collections had a seed fill rate of 61 percent at Boot Canyon and 31 percent at Campo Dos (Poulos et al. 2021, pp. 4, 11, figure 11; these percentages are reversed in Poulos et al. 2023, p. 34). These are relatively high seed fill rates for a native grass in a wild, arid environment.

The seeds were dried, stored at 4° Celsius (°C) (39° Fahrenheit (°F)), and planted in nurseries the following August through November. The Boot Canyon seedlings were propagated at the greenhouse of Sul Ross State University (SRSU), in Alpine, Texas (elevation 1,397 m (4,582 ft)), and the Campo Dos seedlings were propagated at the UAAAN nursery in Saltillo, Coahuila (elevation about 1,700 m (5,600 ft)). The seeds exhibited no dormancy (after 10 to 12 months of storage) and germinated within 2 weeks after planting. However, only 8 percent of Boot Canyon seeds and 33 percent of Campo Dos seeds germinated. The very low germination percent of Boot Canyon seeds may have been due to a black fungus that had colonized most of the seeds (Poulos et al. 2021, p. 14). At SRSU, 56 seedlings were later planted in an outdoor plot (Poulos et al. 2021, p. 8). Unfortunately, many seedlings died during the extreme

cold weather of February 2021; due to the COVID pandemic, University personnel were not present to protect the seedlings. At UAAAN, 85 seedlings were also planted in an outdoor plot (Poulos et al. 2021, p. 8).

Guadalupe fescue seeds were collected in Boot Canyon several times during the 1990s and cryogenically preserved at the seed bank of Desert Botanical Garden (DBG) in Phoenix, Arizona. Beginning in January 2022, Steve Blackwell of DBG communicated with participants of the UMF-WU and UT-A projects to report that he had begun germinating samples of these collections; despite three decades in storage, germination ranged from 87 to 96 percent (Blackwell 2022a, 2022b). After several months of excellent growth in an outdoor nursery (elevation 388 m (1,273 ft)), all of the seedlings died from an apparent damping-off fungus during the summer after the plants were moved into a greenhouse (Blackwell 2022c).

In September 2022, Blackwell sent a sample of seeds to Austin Ecological Services Field Office staff (Chris Best) that had been collected in 1991 in Boot Canyon. Our analysis indicated that the sample contained 700 florets with an estimated 350 filled caryopses (Best 2023a, unpaginated). In March and April 2023, 120 seeds germinated and initially grew well, but all died in late May and June, during a period of high humidity, of an apparent fungal pathogen.

In 2021 through 2023, the UMF-WU team again collected seeds from Boot Canyon. Due to the 2021 South Rim 4 wildfire at Boot Canyon, very few individuals flowered that fall, and seeds were collected from only 10 individuals. The UMF-WU project successfully grew Guadalupe fescue seedlings at the SRSU greenhouse in 2022 from these seeds, as well as Boot Canyon seeds from the DBG seed bank (Figure 9.4). In October 2022, they transplanted 21 of the seedlings in Boot Canyon near existing colonies of Guadalupe fescue (Barton et al. 2023, p. 11). In this experimental reintroduction, seedlings were planted at varying distances from mature plants to test the effect of inter-plant distance on fertilization rates. The seedlings were hand-watered at planting time and six more times through December 2022, at which time all seedlings were alive. In June 2023, after a period of rainy weather, 56 additional seedlings were transplanted at Boot Canyon (Barton 2023a, unpaginated). By August, after two months of unusually hot, dry weather, 20 of the October cohort (95 percent) had survived, and 14 of the survivors (70 percent) were flowering. In contrast, only 22 of the more recent June cohort (39 percent) had survived, none of which were flowering (Barton 2023b, unpaginated).

Despite the hot, dry summer weather, 97.7 percent of the wild Boot Canyon plants survived from October 2022 through August 2023, of which 75 percent were flowering (Barton 2023b, unpaginated). Flowering individuals produced a mean of 5.9 panicles and 88.4 spikelets per plant; the total population produced 7,512 spikelets. Although the Boot Canyon population flowers primarily in September and October, in response to monsoonal rainfall, some plants flowered earlier in response to the May and early June rainfall. Despite the increase in flowering in 2023, very few florets contained filled seeds (Barton 2024, p. 9). On October 16–19, 2023, a

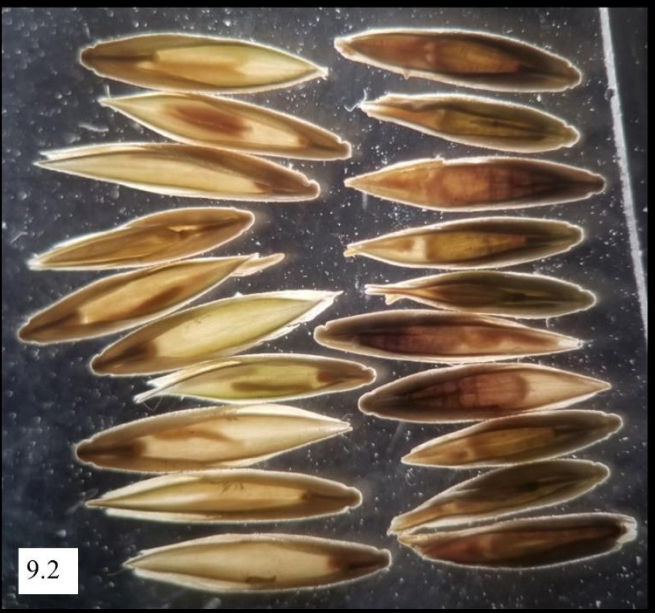
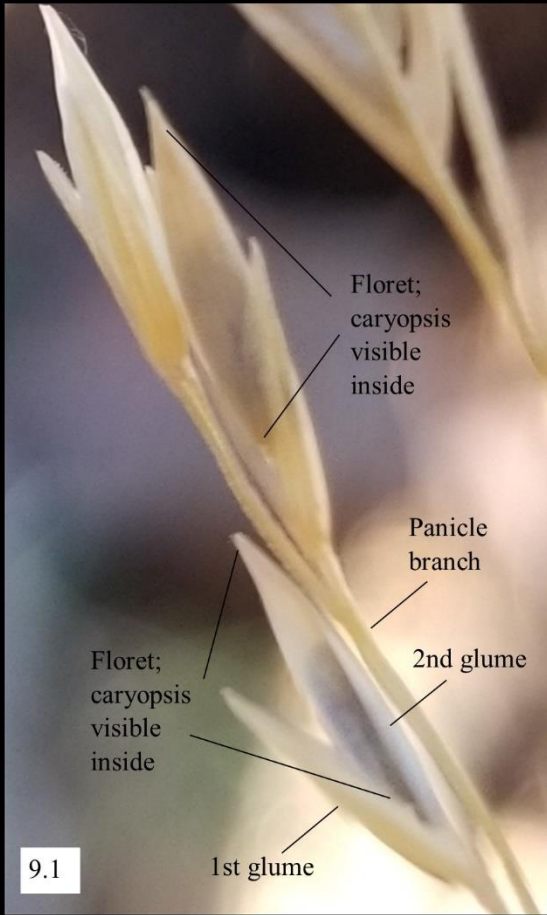
sample of 57 individuals had 1,092 panicles, from which 115 panicles were harvested (Figures 4, 9.1, and 9.2); since at least 100 individuals were flowering at that time, this collection represented far less than 10 percent of the population reproductive output. The 115 panicles had 4,955 florets, but estimated seed fill was only 2.1 to 2.8 percent (Best 2024b, unpaginated). Although hot, dry weather can greatly reduce the viability half-life of grass pollen (Wang et al. 2004, pp. 523–530; Ge et al. 2011, pp. 1–8), temperatures and rainfall had returned to normal levels during the September–October 2023 flowering period; hence, the cause of low seed fill remains unexplained. Finally, the seed analysis revealed that seed fill can be determined by observing mature florets under magnification with transmitted light; this could be accomplished in the field to improve the efficiency of future seed collections (Best 2024b, unpaginated; Figure 9.2).

Beginning in October 2022, the UMF-WU team also transplanted 16 seedlings from Campo Dos seeds in Cañón del Caballo. After two years, only two of these transplants (13 percent) had survived. This low survival rate is attributed to the inability to provide supplemental watering during the initial months, due to the remote location (Barton et al. 2024, p. 8). Additionally, photographs suggest that the transplanted seedlings may have been much smaller than those transplanted at Boot Canyon (Barton et al. 2023, Figure 4).

In summary, the percent of Guadalupe fescue plants that flower and their reproductive output is highly variable from year to year. The percent of seed fill is also extremely variably and is not proportional to the amount of flowering, and the factors that influence seed fill rates have not been determined. However, seed fill can be estimated in the field by examining mature florets under magnification.

Cryogenically preserved seeds of Guadalupe fescue have had very high germination rates even after more than 30 years; nevertheless, the longevity of seeds in the soil seed reserve remains unknown. The seeds germinate easily, but virtually all seedlings grown at low elevation sites and/or high humidity have died from fungal pathogens; these pathogens have not been observed in the wild populations. Seedlings have been successfully grown at two nurseries with higher elevations and arid climates. Well-established seedlings planted with supplemental watering in the fall have had very high survival rates and have flowered within one year. Conversely, smaller seedlings and seedlings planted during the summer have had low survival rates. These initial recovery actions completed by the UMF-WU project demonstrate that nursery propagation of Guadalupe fescue is challenging but can be done successfully, and reintroduction of nursery-grown seedlings into the wild can be highly successful.

Figure 9. Propagation of Guadalupe fescue. 9.1 Mature panicle branch with 3 spikelets. 9.2 Florets observed with transmitted light, 25X; 10 on right have caryopses, 10 on left are empty. 9.3 Seedling transplanted at Boot Canyon, April 2023. 9.4 Seedlings propagated at Desert Botanical Garden.



## **2.2.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):**

### **2.2.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range:**

Beginning on April 4, 2021, the South Rim 4 wildfire burned 84 percent of the Guadalupe fescue habitat at Boot Canyon, BIBE. The fire reduced the Guadalupe fescue population by 56 to 58 percent, and the population had not recovered through October 2023. Nevertheless, due to the mostly low to moderate severity of the fire, habitat suitability at Boot Canyon has improved. Due to the reduction in fuel load, the risk of a catastrophic, stand-replacing fire at Boot Canyon is now lower. Conversely, the risk of severe wildfire in the Sierra del Carmen remains very high. We are not aware of any other changes to the species' habitats or range.

### **2.2.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:**

The Center for Plant Conservation (CPC) recommends limiting seed collections of wild rare plants to no more than 10 percent of an individual plant's reproductive output and/or no more than 10 percent of the population reproductive output in a season; for many rare plant species, this intensity of collection can be sustained for multiple years (Center for Plant Conservation 2019, p. 1-13). Guadalupe fescue seed collection for trial propagation and reintroduction efforts has followed the CPC guidelines. In addition, progeny from the seeds that were collected have now been transplanted back into source populations as surviving, reproductive individuals. As propagation techniques improve, the recruitment of propagated individuals is likely to be far greater than recruitment from the same numbers of seeds if they had been allowed to disperse naturally into the habitat. Therefore, it is unlikely that the amounts of seeds collected will reduce recruitment of the wild population, and do not constitute overutilization.

### **2.2.2.3 Disease or predation:**

We have no new information on herbivory or pathogens that affect wild populations of Guadalupe fescue. However, we now know that one or more unidentified fungal pathogens have killed virtually all propagated Guadalupe fescue plants that were situated at lower elevations and/or high humidity. Fungal pathogens have not been recorded in any of the wild populations.

### **2.2.2.4 Inadequacy of existing regulatory mechanisms:**

No new information.

#### **2.2.2.5 Other natural or manmade factors affecting its continued existence:**

No new information.

### **2.3 Synthesis**

Two Section 6-funded projects have generated a wealth of new information about Guadalupe fescue and have initiated several recovery actions listed in the recovery plan. Due to the long absence of natural wildfire in Boot Canyon at BIBE, fuel loads had increased to a very dangerous level. The South Rim 4 wildfire burned through Boot Canyon, including most of the Guadalupe fescue habitat, from April 8 through June 1, 2021. Due to the early season, the fire severity was mostly low to moderate, and the fuel load was safely reduced without detriment to the existing habitat. Nevertheless, the population of Guadalupe fescue declined by 56 to 58 percent after the fire and has not increased since then; this decline may be due in part to severe drought during the previous year. We now know that the species has low fire tolerance. One project also revealed that, within an occupied habitat, Guadalupe fescue occupies microsites that have relatively open tree and shrub canopies and rocky substrates with low litter depth. All of these findings underscore the importance of managing habitats through more frequent prescribed burning and/or fuel reductions. These Section 6 project objectives addressed recovery actions A.1.2 and A.1.5.

The Section 6 projects conducted repeated censuses of the Boot Canyon population, as called for in recovery action E.3.1. Specifically, they documented 323 individuals of Guadalupe fescue in Boot Canyon in 2019, and representative samples supported an estimated population of 1,826—about 43 percent greater than the estimated MVP of 1,275. The estimated population declined to 773 after the wildfire, 61 percent of the MVP. Recovery criterion IV.1.4 states, “Populations or metapopulations may be considered self-sustaining when the MVP level of 1,275 mature individuals has been reached, and subsequent unaided recruitment equals or exceeds mortality over a 10-year span, which is the expected minimum time to distinguish annual variability from longer-term trends.” The data indicate that the Boot Canyon population is relatively close to achieving this criterion.

One Section 6 project searched for populations at Guadalupe Mountains National Park, and also conducted surveys at known population sites in Coahuila, Mexico. Three extant populations have now been confirmed in the Sierra del Carmen, within APFF Maderas del Carmen in northern Coahuila. Two of these populations were discovered during the last four years. Another historical population last seen 47 years ago has now been re-confirmed in Cañada de la Hacienda, Sierra de la Madera, in central Coahuila. There are now five known extant populations, three of which have been comprehensively censused; none of the populations currently meets the MVP size. These surveys respond to recovery actions 3.1.1 and 3.1.2.

One Section 6 project collected seeds from Boot Canyon, BIBE, and Campo 2, APFF Maderas del Carmen, and conducted pilot propagation and reintroductions efforts. Researchers from Desert Botanical Garden independently contributed to this work and found that Guadalupe fescue seeds maintained high viability rates after more than 30 years in cold

storage. Like many grass species, the seed fill rate in wild populations is highly variable; the cause of this variation has not been determined. Unidentified fungal pathogens have killed all or most Guadalupe fescue seedlings propagated at low-elevation, higher-humidity sites. Seedlings were successfully grown at two higher elevation, arid sites and were successfully reintroduced at Boot Canyon. Strategic population augmentation may now be used to alleviate a lack of gene flow within populations and to augment population sizes. These efforts contribute to recovery action E.2.5.

Despite the progress of several recovery actions, the species remains threatened by the small size, number, and isolation of its remaining populations. The risk of severe wildfire in the Sierra del Carmen, and perhaps other habitats in Coahuila, is very high. Gene flow within populations is likely to be very low, resulting in increasing levels of inbreeding and potentially to reduced fitness. We project that climate warming will reduce the amount of suitable habitat over the coming decades, reducing the species' habitats to smaller areas at higher elevations. We conclude that the species' status under the ESA should remain endangered.

### **3.0 RESULTS**

#### **3.1 Recommended Classification:**

No change is needed.

#### **3.2 New Recovery Priority Number (indicate if no change; see 48 FR 43098): 2**

##### **Brief Rationale:**

A recovery priority number was not previously assigned to Guadalupe fescue. To consider downlisting to a threatened status, recovery criterion IV.1.1. requires 10 or more protected, viable, self-sustaining populations or metapopulations, with at least one population or metapopulation in each of the 5 recovery units. Guadalupe fescue has only five known extant populations, all of which are currently well below the estimated MVP level of 1,275 individuals. There are no extant populations in two of the five recovery units. The known populations are genetically isolated from each other by expanses of low-elevation Chihuahuan Desert, and gene flow within populations is limited by small population sizes and population clustering.

The species is restricted to pine-oak woodlands at high elevations of Chihuahuan Desert mountain ranges. The warming of the climate will further restrict the amount of suitable habitat to ever-smaller areas at higher elevations. We now know that this grass is vulnerable to high-severity wildfires. Catastrophic, stand-replacing wildfires are more likely as long fire-return intervals lead to heavy fuel loads; such fires are also becoming more likely as the climate warms. In summary, the degree of threat is high. However, the recovery potential is also high.

The known extant populations occur within a U.S. National Park or within federal protected natural areas in the Mexican state of Coahuila; therefore, it is relatively easy for conservation agencies and organizations to access and monitor the populations and to manage their habitats. Because many potential habitats remain in Mexico that have not been surveyed, it is possible that additional populations may exist. Finally, Guadalupe fescue continues to be recognized as a distinct, valid species. We do not anticipate that the species' recovery will conflict with economic development. In 48 FR 43098, a full species with a high threat level, a high recovery potential, and without recovery conflicts is ranked with a Recovery Priority Number of 2.

#### **4.0 RECOMMENDATIONS FOR FUTURE ACTIONS**

1. Continue to communicate, coordinate, and cooperate with conservation agencies and academic researchers in Mexico and in Texas to promote the conservation and recovery of Guadalupe fescue.
2. Continue to monitor the known extant populations annually; census extant populations at least once every five years.
3. Survey potential habitats in Texas and in Mexico to search for previously undiscovered populations.
4. Promote fuel reduction and prescribed burning (where this is feasible) to reduce the risk of catastrophic, stand-replacing wildfires.
5. Continue to develop and improve effective propagation techniques. Augment existing population sizes to promote high rates of outcrossing and gene flow within populations. Establish ex-situ seed-increase plantings to enable reintroduction, augmentation, and scientific research without incurring a continuing need to collect seeds from wild populations, and to create refugium populations so that wild populations may be restored after catastrophic losses.
6. Determine the causes of mortality of seedlings grown in low elevation, humid locations. Investigate whether any pathogenic organisms detected could affect the extant populations.
7. Replenish Guadalupe fescue seed reserves at Desert Botanical Garden and other seed banks.
8. Investigate the population genetics of extant Guadalupe fescue populations to determine the levels of heterozygosity, inbreeding, and population and metapopulation differentiation, and the extent of gene flow within and among populations.

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## 6.0 ADDITIONAL INFORMATION:

### Recommended citation:

U.S. Fish and Wildlife Service. 2024. Guadalupe fescue (*Festuca ligulata* Swallen) five-year review: Summary and evaluation. Austin Ecological Services Field Office, Austin, Texas. 39 pp.

### Photographic credits:

Cover: Carolyn Whiting, National Park Service.

Figures 3.1, 3.2, 3.3, 3.4, 3.5, 9.1, 9.2, and 9.3: Chris Best, U.S. Fish and Wildlife Service.

Figure 9.4: Steve Blackwell, Desert Botanical Garden.

### Geographical data sources:

Figure	Citation
1	National Park Service 2019; Big Bend National Park 2021; U.S. Department of Agriculture 2022; Whiting and Fowler 2022.
4	U.S. Department of Agriculture 2022; Whiting and Fowler 2022; Best 2024b
5	Comisión Nacional de Áreas Naturales Protegidas 2019; National Park Service 2019; Poulos <i>et al.</i> 2021; Barton <i>et al.</i> 2022; Whiting and Fowler 2022; Instituto Nacional de Estadística y Geografía 2024; herbarium specimens listed in Table 3.
6	Google Earth, August 9, 2024.
7	Instituto Nacional de Estadística y Geografía 1980.
8	Google Earth, August 9, 2024.

Table 3. *Festuca ligulata* herbarium search through SEINet.

Principal Collector	Additional Collectors	Date	Collection No.	Location	Herbarium	Catalog No.	Geographic Coordinates
J.A. Moore	J.A. Steyermark	22-Jul-1931	3576 (Isotype)	Upper McKittrick Canyon, Guadalupe Mountains	Harvard	00023729	n/a
J.A. Moore	J.A. Steyermark	22-Jul-1931	3576 (Isotype)	Upper McKittrick Canyon, Guadalupe Mountains	Missouri Botanical Garden	2701701	n/a
C.H. Mueller		4-Aug-1931	7815	Chisos Mts.	University of Texas	TEX00481701	n/a
E.G. Marsh, Jr.		4-Mar-1939	1950	Sierra La Gloria	University of Texas	TEX00438036	n/a
L.R. Stanford	K.L. Rutherford, R.D. Northcraft	15-Jul-1941	s.n.	24 km NW of Fraile, Coah.	University of Arizona	15004	25.05° N, -101.3° W

Principal Collector	Additional Collectors	Date	Collection No.	Location	Herbarium	Catalog No.	Geographic Coordinates
H.H. Nixon		10-Aug-1952	N-5	McKittrick Canyon, Guadalupe Mountains	Lundell	00317177	n/a
H.H. Nixon		10-Aug-1952	N-5	McKittrick Canyon, Guadalupe Mountains	Lundell	00481702	n/a
H.H. Nixon		10-Aug-1952	N-5	McKittrick Canyon, Guadalupe Mountains	Sul Ross State University	3423	n/a
B.H. Warnock		24-Sep-1967	21424	Chisos Mts., Big Bend National Park	Sul Ross State University	3424	n/a
M.C. Johnston	F. Chiang-Cabrera, W. Wendt, D.H. Riskind	27-Jul-1973	11790	Canyon Hundido, Sierra El Jardin	Lundell	00438031	29.1° N, -102.61667° W
J.S. Henrickson	T. Wendt	5-Aug-1973	11910	Canyon de la Hacienda, Sierra La Madera	Lundell	00438014	27.05°N, -102.4° W
J.S. Henrickson	T. Wendt	5-Aug-1973	11910	Canon de la Hacienda, Sierra La Madera	University of Arizona	406871	27.05° N, -102.4° W
T. Wendt	J. Valdés-Reyna	27-Jul-1977	s.n.	Cañón del Desiderio, Sierra La Madera	University of Arizona	237645	27.10833° N, -102.5417° W
T. Wendt	J. Valdés-Reyna	27-Jul-1977	VR-1063	Cañón del Desiderio, Sierra La Madera	University of Texas	TEX00438059	27.10833° N, -102.54167° W
T. Wendt	J. Valdés-Reyna	27-Jul-1977	2065	Cañón del Desiderio, Sierra La Madera	University of Texas	TEX00438064	27.12361° N, -102.52528° W
T. Wendt	J. Valdés-Reyna	27-Jul-1977	2068	Cañón del Desiderio, Sierra La Madera	University of Texas	TEX00438065	27.10833° N, -102.54167° W
W. Hodgson	J. Poole, L. Ecker	16-Oct-1990	6071	Chisos Mts., Big Bend National Park	Desert Botanical Garden	DES00034192	29.241667°N, -103.295833° W
W.C. Hodgson	J. Poole, L. Slauson	9-Oct-1991	6410	Chisos Mts., Big Bend National Park	Arizona State University	268460	29.233333° N, -103.283333° W
W. Hodgson	J. Poole, L. Slauson	9-Oct-1991	6410	Chisos Mts., Big Bend National Park	Desert Botanical Garden	DES00038688	29.233333° N, -103.283333° W

## Appendix 1. Propagation trial of Guadalupe fescue seeds provided by Desert Botanical Garden.

In September 2022, Desert Botanical Garden provide a sample of Guadalupe fescue seeds to USFWS that had been collected in 1991 in Boot Canyon. Our analysis indicated that the sample contained 700 florets with an estimated 350 filled caryopses (Best 2023a, unpaginated).

In March 2023, the florets were hydrated in aerated water up to two days, then planted in a steam-sterilized germination medium. An estimated 32 to 35 percent of filled caryopses germinated from 5 days until 53 days after planting in an outdoor nursery. Seeds germinated when nighttime temperatures had warmed to at least 18° C (64° F). This suggests that Guadalupe fescue seeds germinate in the wild during the late summer monsoon season, rather than springtime, when many native grasses germinate. The young seedlings showed evidence of salt toxicity when watered with City of Austin tap water, but subsequently improved when watered with rainwater. Seedlings maintained under high humidity quickly succumbed to a fungal pathogen. Forty-one seedlings (34 percent) died from salt toxicity or fungal attack. The remaining 79 seedlings were transferred to cavity trays with 5 by 15 cm (2 by 6 in) cells.

To colonize the root systems with native rhizosphere symbionts, the growth medium consisted of one part screened soil collected in Boot Canyon near Guadalupe fescue plants and two parts medium vermiculite. The seedlings were kept in an outdoor nursery (elevation 259 m (850 ft)) with partial direct sunlight and grew rapidly for the first 6 weeks (Best 2023b, unpaginated). Following heavy rainfall in late May, a fungal pathogen first appeared on the leaves, then spread downward to the bases of the plants; all died within the next month. The ambient temperatures at that time were comparable to Boot Canyon mid-summer temperatures, and not likely to be the direct cause of mortality, but humidity was very high. The pathogen appeared when a locally abundant introduced annual grass, rescue grass (*Bromus catharticus*), was heavily infested with a powdery mildew (Best 2023c, unpaginated). Rescue grass is parasitized in North America and elsewhere by *Blumeria graminis*, a powdery mildew fungus with an extensive host range, and may serve as a reservoir for infection of other grass species with powdery mildew (Klingeman *et al.* 2017, p. 449; Zhu *et al.* 2021, p. 1211). Whether or not *B. graminis* is the causal pathogen, it is evident that a pathogenic fungus infests and kills Guadalupe fescue seedlings grown under humid conditions.

**U.S. FISH AND WILDLIFE SERVICE**

**5-YEAR REVIEW of Guadalupe Fescue (*Festuca ligulata*)**

**Current Classification:** Endangered

**Recommendation resulting from the 5-Year Review:**

No change needed

**Listing, Reclassification, or Delisting Priority Number, if applicable:** n/a

**FIELD OFFICE APPROVAL:**

**Karen Myers, Lead Field Supervisor, U.S. Fish and Wildlife Service, Austin Ecological Services Field Office, Austin, Texas**

Approve \_\_\_\_\_