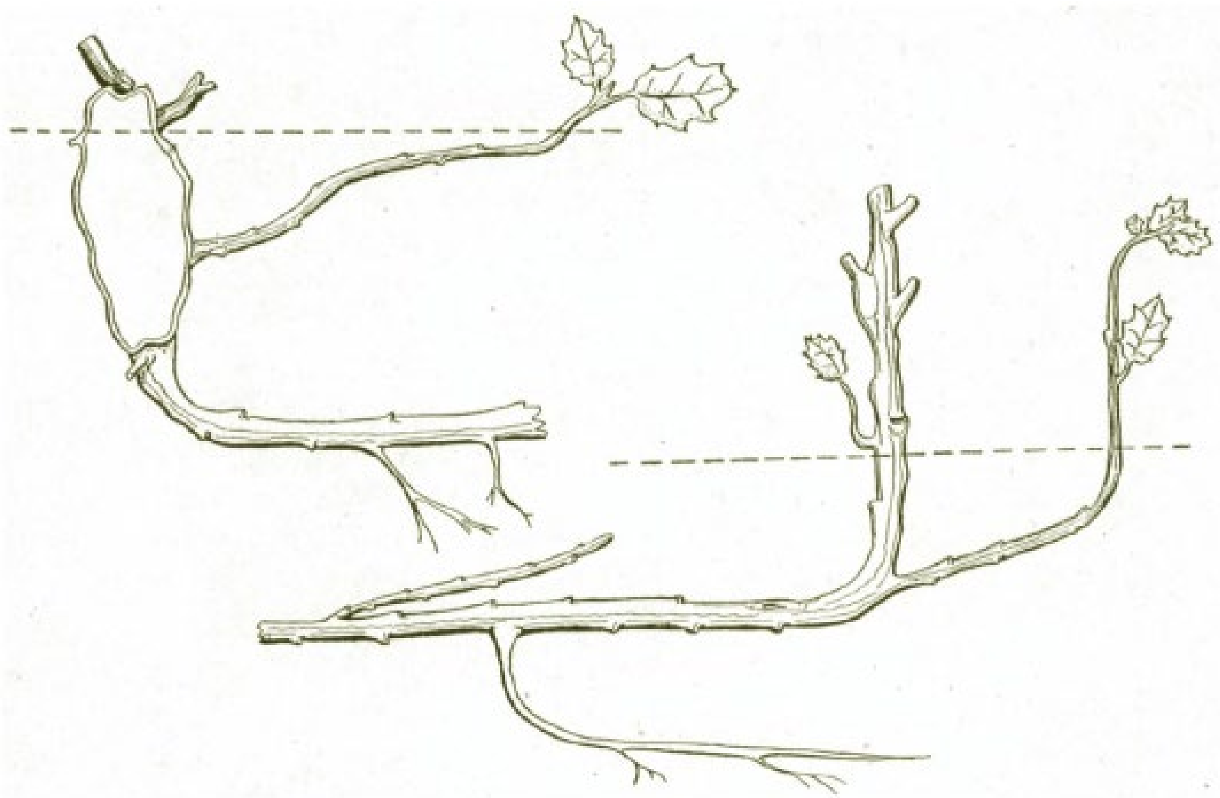
Hinckley Oak
(*Quercus hinckleyi* C.H. Muller)

5-Year Review:
Summary and Evaluation



Drawing by Allan Cole, stems of *Quercus hinckleyi* with attached rhizomes, in Muller 1951

Austin Ecological Services Field Office
Austin, Texas

5-YEAR REVIEW
Hinckley Oak (*Quercus hinckleyi)*

1.0 GENERAL INFORMATION

1.1 Methodology used to complete the review.

The U.S. Fish and Wildlife Service (USFWS) previously evaluated the biology and status of Hinckley oak in 2009 (USFWS 2009). We announced the current 5-year review in the Federal Register on March 19, 2020. This review updates the previous review with new information from the Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (TXNDD), monitoring reports, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and Internet web sites. The 5-year review was prepared without peer review by personnel of the Austin Ecological Services Field Office.

The first use of technical terms and words with arcane meanings in the lexicons of science and government are underlined, and are defined in the glossary on pages 22–25. For convenience, the first uses of scientific units are spelled out, and are also summarized on page 21. Photographic credits are on page 21. This is the second status review since the species was listed (1988).

Recommended citation:

U.S. Fish and Wildlife Service. 2020. Hinckley oak (*Quercus hinckleyi* C.H. Muller) five-year review: Summary and evaluation. Austin Ecological Services Field Office, Austin, Texas. 26 pp.

1.2 Listing History.

Species: *Quercus hinckleyi*
Date listed: August 26, 1988
FR citation(s): 53 FR 32824
Classification: Threatened
Critical habitat/4(d) rule/Experimental population designation/Similarity of appearance listing: Critical habitat was not designated, and there were no other associated rulemakings.
Listed as threatened by the State of Texas on December 30, 1988.

1.3 Federal Register citation announcing the species is under active review.

85 FR 15795: Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 10 Species in Arizona, Arkansas, Kansas, Missouri, New Mexico, Oklahoma, Texas, and Mexico. March 19, 2020.

1.4 Species' Recovery Priority Number at start of 5-year review.

Prior to this review, the Recovery Priority Number for Hinckley oak was 8. This indicates that the degree of threat was moderate, the recovery potential was high, the taxon was a species, and the species' recovery is not expected to conflict with construction, development projects, or other forms of economic activity.

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

Not applicable; DPS applies only to vertebrates.

1.6 Recovery Plan or Outline.

U.S. Fish and Wildlife Service. 1992. Hinckley Oak (*Quercus hinckleyi*) Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 39 pp.

Date issued: September 30, 1992.
Dates of previous revisions, if applicable: n/a

2.0 REVIEW ANALYSIS

2.1 Review of Recovery Criteria.

Recovery Plan Criteria

> "Attain at least 20 viable self-sustaining populations in at least 4 geographically distinct population centers and attain a total of at least 10,000 individual plants. Demonstrate population viability at recovery levels for 10 consecutive years." (p. iii).
>
> [Hinckley oak may be delisted] "...when at least 20 populations have been established in at least 4 geographically distinct population centers (metapopulations) in the southern half of Brewster and Presidio counties. The total number of individuals should be at least 10,000, and no occurrence with less than 5 distinct (non-clonal) individuals should qualify as a population. Further criteria for delisting should be that the populations have been self-sustaining with both sexual and vegetative reproduction for 10 consecutive years, without suffering introgression (gene exchange) from neighboring *Quercus* species." (p. 9).

The most recent update to the Element Occurrence (EO) records for Hinckley oak (Texas Natural Diversity Database (TXNDD) 2020) lists 11 EOs in Presidio and Brewster counties (not 12 as reported in USFWS 2009). However, only 9 EOs have been confirmed in the last 55 years (see Section 2.2.1.3). A recent population genetics investigation (Backs 2014) detected only 123 genetically unique individuals at 4 sites pertaining to 2 metapopulations. Although sexual reproduction occurs in the sense that viable acorns are produced, no recruitment has been observed, either by sexual or vegetative reproduction, at any EO. The populations appear to have stable numbers, due to the very long lifespans of extant individuals. Although genetic introgression has occurred between Hinckley oak and sympatric oak species, Backs (2014) found no evidence of genetic swamping, and observed that the relatively small numbers of hybrid individuals conserve some of the species' overall genetic diversity. We conclude that the recovery criteria have not been met. Nevertheless, several important recovery actions have been accomplished (discussed in Section 2.2.1.3 Conservation genetics and genomics).

2.2 Updated Information and Current Species Status.

2.2.1 Biology and Habitat.

2.2.1.1 Description, taxonomic classification, and phylogenetics.

Quercus hinckleyi C.H. Muller continues to be recognized as a distinct, valid species (Nixon and Muller 1997a; Integrated Taxonomic Information Service 2020; Natural Resources Conservation Service 2020; Tropicos 2020).

A recent phylogenetic study of the global oak genome (Hipp 2017; Hipp *et al*. 2020) indicates that *Q. hinckleyi* is sister to *Q. pungens* (sandpaper oak) and *Q. vaseyana* (Vasey shin oak). Other closely related oak species include *Q. polymorpha* (net-leaf white oak), *Q. mohriana* (Mohr oak), and *Q. laceyi* (Lacey oak). The close relationship between the first three species is not surprising, considering the evidence of introgression among these species (Backs 2014, discussed in Section 2.2.1.3 Conservation genetics and genomics).

2.2.1.2 New information on the species' biology, life history, habitat, and ecosystem.

Reproduction.

Muller (1951) observed no seedlings or young individuals at the species' type location, but reported that the species forms rhizomes up to 15 centimeters (cm) (5.9 inches (in)) in length from which clusters of stems emerge. He therefore posited that the colony of less than 100 plants, covering an area of 500 square meters (m^2) (0.12 acres (ac)), may consist of a single clone that has persisted since the last pluvial period of the Pleistocene. Based on microsatellite DNA data, Backs (2014) identified 123 genetically unique colonies (genets) in three locations (including Muller's type location). The two smallest groups had only 7 unique genotypes among 58 plants (ramets), and produced very few acorns. The larger group had 116 genets among 146 ramets, and produced larger numbers of acorns. Since sexual reproduction in oaks is predominantly by outcrossing, the probability of fertilization between compatible individuals is relatively low in small colonies consisting mostly of clones. The greater proportion of unique genets in the larger population indicates that recruitment through sexual reproduction has occurred in the past. However, Backs and other observers have not observed recruitment, even in the larger population. This may be due to severe browsing of acorns and seedlings by herbivores, or perhaps to a climate that is now too hot and dry for seedling establishment.

Habitat.

We have no new information.

Ecology.

We have no new information.

2.2.1.3 Number and geographic distribution of populations, conservation genetics and genomics, estimate of potential habitat, and estimate of minimum viable population.

Number and geographic distribution of populations.

The previous five-year review (USFWS 2009) states that Hinckley oak has been documented at 12 EOs; however, since the TXNDD report discontinued EO no. 6, there actually were 11 EOs (see Table 1). As noted in the prior review, EO no. 7 is an anecdotal report from the Dead Horse Mountains in Big Bend National Park. This report has never been confirmed through herbarium specimens, and a floristic survey of this mountain range from 2003 through 2006 (Fenstermacher *et al*. 2008) did not find any individuals of this species; we conclude that there are no documented populations there. In addition, the exact location of EO 5 is unknown, and the site has not been relocated since it was reported in 1964. Therefore, there are 9 documented extant EOs in Texas.

Several sources indicate that Hinckley oak occurs in adjacent areas of Mexico (Brown 1996; Denvir 2016; Wikipedia 2020). This may be due to a misinterpretation of the Flora of North America treatment (Nixon and Muller 1997):

> "This species is known only from two sites in the United States, El Solitario and near Shafter, Texas. The Shafter population includes some individuals with characteristics that suggest hybridization with *Quercus pungens* Liebmann. These plants are larger, with more pubescent twigs and leaves, and hemispheric acorn cups to 10 mm deep. Such plants have recently been collected in adjacent Mexico."

"Such plants" refers to apparent hybrids; however, Backs (2014) found that the ancestry of apparent hybrids among these species may consist of up to 99 percent of one species. Although potentially suitable habitats do exist in the Mexican states of Coahuila and Chihuahua, no herbarium specimens or confirmed documentation exists for populations in Mexico (Backs 2016; Beckman *et al*. 2019; CONABIO 2020). Hence, the 9 extant EOs in Texas are the only known global occurrences. There have been no documented changes in the number of populations or the number of individuals in populations since the prior 5-year review (USFWS 2009).

Table 1. Hinckley Oak Element Occurrences (TXNDD 2020) and site characteristics.

Element Occurrence or Source ID	County	Population Size[1] (Date)	Elevation Range[2,3]		Geological Formation[4]
			m (ft)	ft	
EO1; ID6828	Presidio	153 (1987)	1323–1343[a]; 1311[b]	4340–4406; 4300[b]	Kt
EO2; ID4973	Presidio	50 (1988)	1182–1198[a]	3878–3930	Ksh
EO3; ID2091	Presidio	37 (1987)	1331–1383[a]	4367–4537	Kst
EO4; ID5551	Presidio	"few"	1167–1426[a]; 1067[b]	3829–4678; 3500[b]	Ksh
EO5; ID2915	Presidio	"sparse"	Unknown	Unknown	Limestone
EO7; ID152	Brewster	Unknown	Unknown	Unknown	Unknown
EO8; ID3275	Presidio	±1000	1218–1378[a]	3996–4521	Kst
EO9; ID5231	Presidio	4	1253–1323[a]	4111–4340	Kt
EO10; ID5230	Presidio	Unknown	1315–1377[a]	4314–4518	Kst
EO11; ID2903	Presidio	Unknown	1242–1343[a]	4075—4406	Kst
EO12; ID6420	Brewster	Unknown	1129–1470[a]; 1311[b]	3704–4823; 4300[b]	Kst, Kbd, Kt

[1] Numbers of distinct ramets; numbers of individuals cannot be determined, due to clonal reproduction.

[2] Values followed by (a) were determined by overlaying EO shapefiles on digital elevation models (U.S. Geological Survey 2020).

[3] Values followed by (b) were reported by observer.

[4] Determined by overlaying EO shapefiles on a digitized geological map (Stoeser *et al*. 2005):

Symbol	Geological Formation and Description
Kbd	Buda Limestone and Del Rio Clay, undivided. Cretaceous limestone, mudstone.
Ksh	Shafter Formation. Early Cretaceous mixed clastic, carbonate, sandstone, and marl; limestone, sandstone, shale.
Kst	Santa Elena Limestone, Sue Peaks Formation, Del Carmen Limestone, and Telephone Canyon Formation, undivided. Early Cretaceous limestone, shale.
Kt	Maxon Sandstone and Glen Rose Limestone, undivided. Early Cretaceous sandstone, limestone.

Figure 1. Photographs of Hinckley oak.

1a. Hinckley oak shrub behind Dr. Martin Terry, near Shafter, Texas.

1b. Detail showing the size of Hinckley oak leaves and acorns.

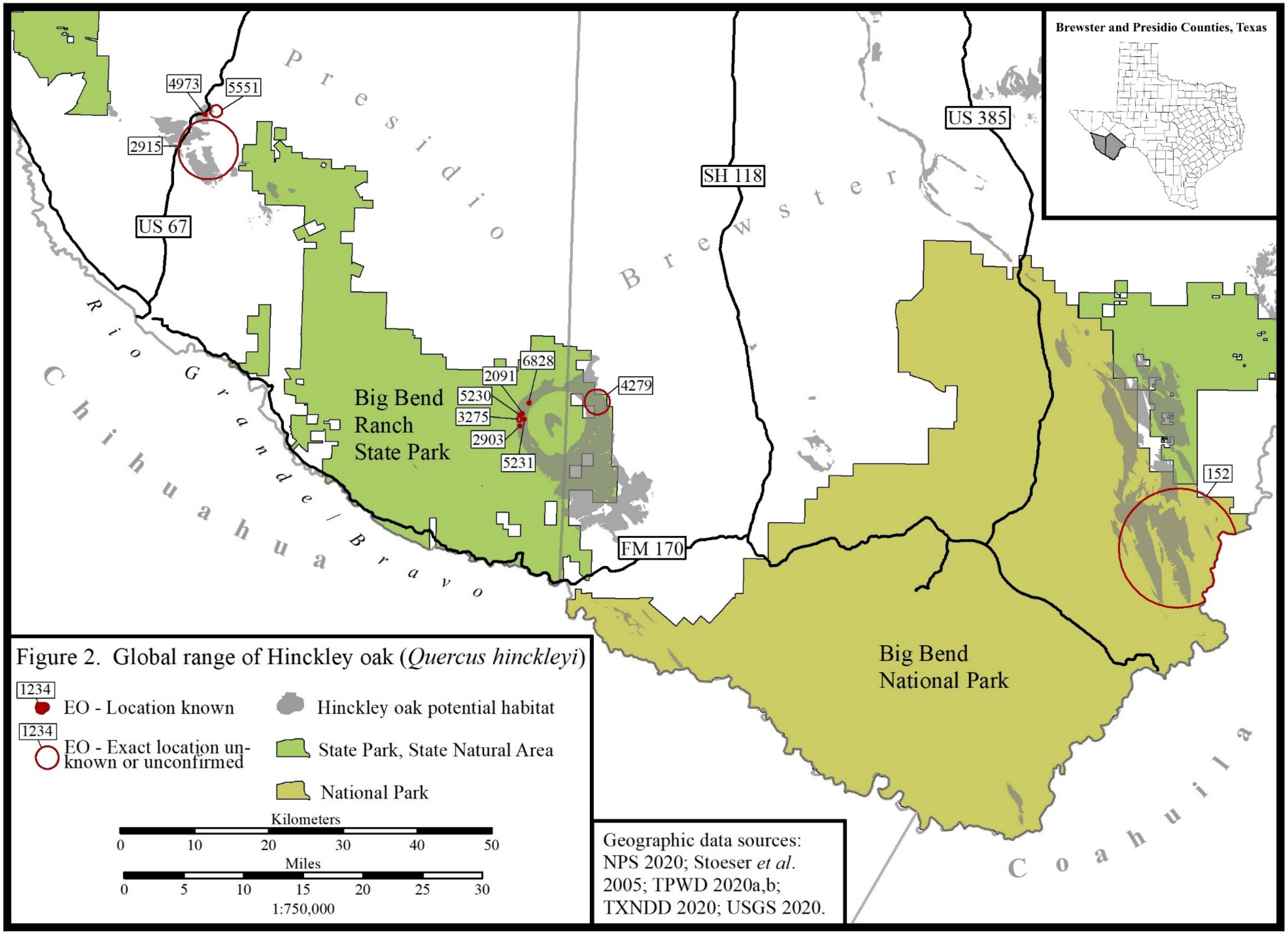


Figure 2. Global range of Hinckley oak (*Quercus hinckleyi*)

Conservation genetics and genomics.

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). Recovery action 3212 of the recovery plan (USFWS 1992) states, "Assess present genetic viability, evaluate requirements to achieve stability, and develop recommendations for augmentation." The effective population size is the number of genetically unique individuals of a population. Since Hinckley oak reproduces both sexually, through seeds, and asexually, through the emergence of stems from rhizomes, visual observation cannot determine the effective sizes of its populations. Recovery action 3231 states, "Determine types of reproduction and their contribution to populations."

To address these recovery actions, Backs (2014; see also Backs *et al*. 2015, Backs *et al*. 2016) investigated the genetic variability, reproductive modes, inbreeding, and population structure of *Q. hinckleyi*, based on 8 microsatellite DNA loci that were previously used for taxa of section *Quercus* (white oaks). Table 2 summarizes the data from leaf tissue collected from 204 individual ramets (stems) at two sites near Shafter and two sites near El Solitario in Big Bend Ranch State Park (BBRSP). The latter sites are nearly contiguous, and were combined in Backs *et al*. (2016). The "sites" in this study correspond closely to the TXNDD EOs, but do not include all EOs, and some sites may actually comprise more than one EO; hence, we do not know what proportion of the species' total populations were sampled, but it is likely that most populations were sampled. Although there were only 7 unique genotypes (genets) among the 58 ramets at the Shafter sites, the other two sites were genetically more diverse. All 8 loci were polymorphic, with 9 to 18 alleles each. Population structure analysis revealed that sites S1, S2, and B1a group as a population, which had 50 unique alleles; site B1 is a separate population, which had 27 unique alleles. The mean observed heterozygosity (H_o) and mean expected heterozygosity (H_e) were 0.807 and 0.853, respectively. The mean fixation index (F_{IS}) of 0.036 indicated no inbreeding. Collectively, the results indicate that, despite its small population sizes and ability to form clonal colonies, *Q. hinckleyi* has levels of genetic diversity and heterozygosity that are comparable to non-threatened oak species.

Table 2. *Quercus hinckleyi* ramets and genotypes from four sites (Backs 2014).

Site	Ramets Sampled	Unique Genotypes
S1	42	4
S2	16	3
B1	129	102
B1a	17	14
Total	204	123

Q. hinckleyi tissues were identified in late Pleistocene packrat middens in the Livingston Hills, south of Shafter, Presidio County, and in Ernst Tinaja, Brewster County (Van Devender *et al*. 1978; Van Devender and Spaulding 1979); hence, the species may have been much more abundant and wide-ranging when the climate was more mesic. Backs observed at the Shafter sites that clones of the same genet were as much as 30 m (98 ft) apart, and compared this to a 25 x 8 m (82 x 26 ft) clonal colony of Palmer oak (*Q. palmeri*) discovered in southern California that is estimated to be over 13,000 years old (May *et al*. 2009). Additionally, although there were only 7 genets, these preserved a high degree of genetic diversity. If these very small populations were primarily reproducing sexually, we would expect a loss of genetic diversity and high inbreeding. These facts support a hypothesis that, while the climate warmed and the species retreated to its present locations, long-lived clones have conserved a relatively large amount of the species' genetic diversity.

Small, isolated populations of rare species may also be threatened by hybridization with closely related species, either through genetic assimilation or through outbreeding depression (Rieseberg 1991). Naturally occurring hybridization is common in the Genus *Quercus*, but only within members of the same taxonomic section (Nixon 1997). The recovery plan (USFWS 1992), recovery action 3213, states, "Assess incidence of (and potential threat from) hybridization with nearby *Quercus* species and develop management strategies to address any problems."

Terry and Scoppa (2010) investigated morphometric leaf data of *Q. hinckleyi* and two related, sympatric species, *Q. pungens* and *Q. vaseyana*; all three species are classified within section *Quercus* (white oaks; Nixon and Muller 1997b). They determined that one morphologically intermediate individual near Shafter may be a hybrid between *Q. hinckleyi* and *Q. vaseyana*.

Backs (2014) also investigated hybridization between these three oak species using data from the 8 microsatellite DNA loci described above. She collected leaf samples from 204 ramets that were identified in the field as *Q. hinckleyi*, as well as 2 ramets identified as possible hybrids, 9 ramets identified as *Q. pungens* growing near *Q. hinckleyi* at BBRSP, and 20 *Q. pungens* and 15 *Q. vaseyana* from Guadalupe Mountains National Park (GUMO). Both species from GUMO formed a single genetic group that was distinct from *Q. pungens* at BBRSP. Six of the 204 individuals identified as *Q. hinckleyi* are likely to be hybrids and had levels of introgression from *Q. pungens/vaseyana* ranging from 17 to 90 percent. Six ramets of *Q. pungens* at BBRSP had from 21 to 99% introgression from *Q. hinckleyi*; this may explain the genetic differentiation of *Q. pungens* at BBRSP and *Q. pungens/vaseyana* at GUMO. The individual reported as a hybrid by Terry and Scoppa (2010) had 50 percent ancestry each of *Q. hinckleyi* and *Q. pungens/vaseyana*. The other putative hybrid had 99 percent *Q. pungens/vaseyana* ancestry. While there is introgression from *Q. pungens/vaseyana* into *Q. hinckleyi* and vice-versa, over 95 percent of individuals identified as *Q. hinckleyi* had predominantly *hinckleyi* ancestry, and there is no evidence of genetic swamping. Backs recommended conserving the *Q. pungens* x *Q. hinckleyi* hybrids at BBRSP, since these serve as reservoirs of *hinckleyi* genetic variation.

Estimate of potential habitat.

The previous 5-year review recommends development of a potential habitat model to guide surveys for currently unknown populations. To determine the elevations and geological formations of occupied habitats, we used the ArcGIS software to overlay the geographic positions of documented Hinckley oak EOs on digital elevation models (U.S. Geological Survey 2020) and a digital geologic map of Texas (Stoeser *et al*. 2005) (see Table 1). To estimate potential habitat, we created a shapefile from the intersection of elevations ranging from 1,050 to 1,500 m (3,445 to 4,921 ft) and the occupied geological formations. The resulting model, shown in gray in Figure 2, identified 63,631 ha (157,231 ac) of potential habitat in Presidio and Brewster Counties.

Estimate of Minimum Viable Population (MVP) size.

MVP refers to the smallest population size that has 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.

MVP or Population Viability Analysis have not been calculated for Hinckley oak, nor do we possess all the baseline demographic and life history data needed to perform these calculations. Table 3 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 of about 2,500 individuals. We added an intermediate column (B) to Pavlik's table, corresponding to an MVP of 1,000 individuals, to account for species with intermediate or unknown traits. The bold letters in the table indicate values, if known, for Hinckley oak. Five factors require fewer individuals: Perennial lifespan, woody habit, abundant ramets, high individual survivorship, and climax successional status. Four factors require more individuals: outcrossing breeding system, low fecundity, brief longevity of seed viability, and high environmental variation. Muller (1951) and Backs (2014) noted that existing clones may have persisted since the late Pleistocene; hence, individual survivorship is very high. Although the occupied habitats may have been affected by prior livestock grazing, the soils, plants, and animals are essentially intact climax communities. The relatively small number of seeds produced and lack of in-situ recruitment indicate very low fecundity. White oak acorns are able to germinate as soon as they mature, but lose viability rapidly upon drying (Dirr and Heuser Jr. 1987). High environmental variation is due to the wide variation in annual precipitation. The estimated MVP for Hinckley oak is:

$$\frac{((5 \times 50) + (0 \times 1{,}000) + (4 \times 2{,}500))}{9} = \text{approximately } 1{,}100 \text{ individuals.}$$

Table 3. Minimum viable population guidelines applied to Hinckley oak (adapted from Pavlik 1996, p. 137).

Factor	A. MVP of 50 individuals for species with these traits.	B. Intermediate MVP of 1,000 individuals for species with intermediate or unknown traits.	C. MVP of 2,500 individuals for species with these traits.
Life span	**Perennial**	Intermediate/unknown	Annual
Breeding System	Selfing	Intermediate/unknown	**Outcrossing**
Growth Form	**Woody**	Intermediate/unknown	Herbaceous
Fecundity	High	Intermediate/unknown	**Low**
Ramet Production	**Common**	Intermediate/unknown	Rare or None
Survivorship	**High**	Intermediate/unknown	Low
Longevity of Seed Viability	Long	Intermediate/unknown	**Short**
Environmental Variation	Low	Intermediate/unknown	**High**
Successional Status	**Climax**	Intermediate/unknown	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. Furthermore, population surveys that do not distinguish mature plants from seedlings would appear to fluctuate wildly, depending on how recently seeds had germinated and the proportion of surviving seedlings; thus, basing MVP on mature individuals will also make it easier to judge when the level has been attained.

Determinations of MVP usually take into account the effective population size (n_e), rather than the total number of individuals (n); 10 genetically identical individuals (clones) would have an effective population size of 1. However, Backs detected only 123 genets in 2 of the species' remaining metapopulations; the species' total n_e is certainly far below our estimated level. Considering that Hinckley oak clones, over time, can become separated and live as independent individuals from the standpoint of demographic stochasticity, in this case it appears appropriate to apply MVP to the number of mature ramets.

2.2.1.4 Conservation.

The population genetics investigation discussed above (Backs 2014; Backs *et al*. 2015; Backs *et al*. 2016) provides valuable information to benefit the species' conservation. These investigators' recommendations are included in Section 4.

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

We describe here, and summarize in Table 4 (below), new information or changes to the threats described in the previous 5-year review (USFWS 2009). Unless stated otherwise, the threats listed previously remain applicable.

Listing factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.

Beckman *et al*. (2019) cited the construction of the Trans-Pecos Pipeline through Presidio County as a potential threat to known EOs near Shafter. However, the pipeline was completed in 2017, and the alignment ran west of the town of Shafter and did not affect the known EOs.

Listing factor B: Overutilization for commercial, recreational, scientific, or educational purposes.

Beckman *et al*. (2019) reported that 10 individuals of Hinckley oak exist at 6 ex-situ institutions, verifying that seeds and/or cuttings have been taken from wild populations. While excessive collection of seeds and cuttings from the remaining wild populations presents a potential threat to the species, conservation in *ex-situ* refugia may also be an important protection against catastrophic losses of one or more populations. Currently, we have no information on the extent or impacts of the collection of plant materials on this species. The populations at BBRSP are legally protected by TPWD; the collection of seeds or cuttings of state-listed plants on public lands requires a TPWD permit. The populations near Shafter are on private land, and are more easily accessed, and are therefore more vulnerable to collection.

Listing factor C. Disease or predation.

Backs (2014) discussed the potential threat of herbivory by Desert Bighorn Sheep (*Ovis canadensis nelsoni*). BBRSP reintroduced 141 Desert Bighorn Sheep to the Bofecillos Mountains, within the park, in 2010 and 2011 (Borderlands Research Institute 2020a). About 50 percent of the diet of Desert Bighorn Sheep in this region consists of browse (Borderlands Research Institute 2020b); however, we have no information on the palatability of Hinckley oak to Desert Bighorn Sheep.

Listing factor E. Other natural or man-made factors affecting its continued existence.

The recovery plan (USFWS 1992) includes the small number of populations and small population sizes as threats that resulted from climate changes in the last 8,000 to 11,000 years. As stated in the previous 5-year review, Hinckley oak may continue to decline in response to ongoing climate changes, but we are currently unable to project the severity of this potential threat. The previous 5-year review did not list population size and number among the current threats. We reiterate here that the small size and number of populations is a primary threat to the species' continued survival. The effective population sizes of the Shafter and El Solitario populations are 7 and 116 individuals, respectively. These very small effective population sizes are mitigated to some extent by the apparent longevity of established plants; nevertheless, recruitment has not been observed at any of the EOs.

The population genetics investigation discussed above (Backs 2014; Backs *et al*. 2015; Backs *et al*. 2016) demonstrated that the species as a whole still possess levels of genetic diversity and heterozygosity that would be found among non-threatened oak species. Nevertheless, the small populations near Shafter consist of only 7 clones; this may explain the small number of acorns produced at those sites. Hybridization with sympatric white oak species has occurred at a low incidence that is fairly typical for members of the genus; hence, the authors cited state that Hinckley oak is currently not threatened by genetic swamping.

Table 4. Factors affecting the survival of Hinckley oak.

Factor	USFWS 2009	This 5-year review
A. The present or threatened destruction, modification, or curtailment of its habitat or range.	Future US Hwy 67 expansion potentially threatened Shafter populations, but has not occurred. 7 EOs are protected at BBRSP.	The Trans-Pecos Natural Gas Pipeline was constructed through Presidio County in 2016–2017, posing a potential threat; however, the pipeline construction did not impact the known EOs.
B. Overutilization for commercial, recreational, scientific, or educational purposes.	Potentially threatened by collection of acorns or cuttings for horticultural purposes.	Individuals of Hinckley oak are reported from 6 institutions, but the extent of recent collection of acorns or cuttings is unknown.
C. Disease or predation.	Deer, small mammals, and birds consume as well as disperse acorns, but potential harm and benefit have not been documented. An unknown pathogen attacks leaves, but frequency and severity are unknown.	The reintroduction of native Desert Bighorn Sheep to BBRSP presents a potential threat of increased herbivory.
D. The inadequacy of existing regulatory mechanisms.	Not previously protected by any state or federal regulations. Now state and federally protected as a threatened species.	ESA confers very limited protections to listed plants on private land.
E. Other natural or man-made factors affecting its continued existence.	Potentially threatened by genetic swamping from *Q. pungens* var. *vaseyana*. Potentially threatened by climate change; prior climate changes restricted species to current range and rarity.	A primary threat is the small number and small sizes of populations. Climate change is a potential threat of unknown severity. Recent genetic data indicate that there are only 123 genetically unique individuals remain. The extant populations possess levels of genetic diversity and heterozygosity that are similar to non-threatened oak species. Although hybridization has occurred with sympatric *Q. pungens*/*vaseyana*, currently there is no evidence of genetic swamping.

2.4 Synthesis.

We now know that there are 9 confirmed extant EOs in Presidio and extreme western Brewster counties (not 12, as stated in the previous 5-year review). Most new information about the species derives from recent genetic analyses (Backs 2014) of most of the extant populations. Only 123 genetically unique individuals were identified among 204 plants, and the two sites near Shafter had only 7 individuals among 58 plants. Despite the low numbers of individuals, the species has levels of genetic diversity and heterozygosity that are comparable to non-threatened oak species. This is likely due to the very long life spans of the species' clones — perhaps thousands of years. Genetic introgression has occurred between Hinckley oak and its two most closely-related species, sandpaper oak and Vasey shin oak, but this has not risen to the level of genetic swamping; 95 percent of individuals identified as Hinckley oak have little or no introgression from other oaks. Furthermore, existing Hinckley oak hybrids are reservoirs of the species' overall genetic diversity.

Based on the elevation ranges and occupied geological formations of known populations, we estimate that 63,631 ha (157,231 ac) of potential habitat exists in Presidio and Brewster counties. It is likely that substantial amounts of potential habitat also exist in adjacent areas of Chihuahua and Coahuila, Mexico. We estimate an MVP size of 1,100 individuals, and recommend that in the specific case of Hinckley oak, this criterion should be applied to the numbers of observed plants rather than the numbers of genetically unique individuals.

Hinckley oak was listed as a threatened species because, despite its small population size and limited distribution, none of its populations were in imminent danger of destruction; but if not protected by law, it could become endangered in the foreseeable future (53 FR 32824). The principle threats of small population size and few populations (factor E) remain unchanged. The species is potentially threatened by climate changes (factor E), but we are currently unable to project the severity and immediacy of this threat. The potential threats of low genetic diversity, inbreeding, and genetic swamping through hybridization with other oak species (all factor E) could become more severe in the future, if individuals or populations are lost, but currently have low severity. Recent potential threats from highway and pipeline construction (factor A) did not affect the known EOs. Most of the extant EOs are now protected at BBRSP. The recent reintroduction of Desert Bighorn Sheep at this state park presents a potential new threat from browsing (factor C), but we have no evidence of the extent that this may have happened. We conclude that the overall status of Hinckley oak has not changed since the previous 5-year review (USFWS 2009), and recommend that the classification remain as threatened.

3.0 RESULTS

3.1 Recommended Classification.

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ The species is extinct
____ The species does not meet the definition of an endangered species or a threatened species (i.e., is recovered, or new information on status and threats indicate species does not meet definitions)
____ The listed entity does not meet the statutory definition of a species.
X__ No change is needed

3.2 New Recovery Priority Number.

11.

Brief Rationale.

The degree of threat remains moderate. However, given the small numbers of individuals and restricted geographical range, as well as the real but currently un-quantifiable threats from climate changes, we now classify the recovery potential as low. The taxon remains a full species. We do not anticipate that the species' recovery will conflict with construction or development.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. Survey potential habitats on accessible lands in Presidio, Brewster, and adjacent counties (recovery plan action 41), as well as in *Areas Naturales Protegidas* and *Parques Nacionales* in the Mexican states of Coahuila and Chihuahua.

2. Monitor condition of existing populations periodically, and conduct complete censuses approximately every 5 years (recovery plan action 15). Protect known hybrid individuals to conserve additional *Quercus hinckleyi* genetic diversity (Backs *et al*. 2016). Map individual clones to aid conservation of unique genotypes (Backs *et al*. 2015).

3. Support efforts to propagate, by seeds as well as cuttings or micropropagation, for augmentation, reintroduction, and ex-situ conservation (recovery plan actions 3211, 3212, and 334). Attempt hand pollination to maximize outcrossing and conserve unique genotypes (Backs *et al*. 2015).

4. Establish a germ plasm bank (refugium of live plants) for *ex-situ* conservation of as many of the species' unique genotypes as possible. Note that white oak acorns lose viability rapidly in storage; hence, seed banking is not a viable option. (Recovery plan action 2; Beckman *et al*. 2019).

5. Develop an augmentation and reintroduction program to increase size and genetic diversity of individual populations and to increase the number of populations (recovery plan action 42, 5, 6; Backs *et al*. 2015).

6. Conduct public outreach to promote public support for the species conservation (recovery plan action 7).

7. When possible, given workloads, conduct a Species Status Assessment (SSA), and use the SSA to revise the recovery plan. Establish recovery criteria that quantify the levels of resilience, redundancy, and ecological and genetic representation necessary for long-term species viability. Explain how each criterion and time frame was derived, how populations and metapopulations should be delimited, specify whether individuals may be ramets, genets, or both, and clarify whether sexual reproduction means simply the production of viable acorns or actual recruitment from acorns. Revise the reproduction and recruitment time frame to reflect realistic patterns observed in woody plants of the Chihuahuan Desert. Clarify that the species' recovery can include populations in Mexico, if any are discovered.

5.0 LITERATURE CITED.

Backs, J.R. 2014. Population structure and gene flow in two rare, isolated Quercus species: *Q. hinckleyi* and *Q. pacifica*. Ph.D. Thesis, University of Illinois at Chicago. 100 pp.

Backs, J.R. 2016. A Tough, Little Survivor: the West Texas Oak, *Quercus hinckleyi*. International Oaks 27: 75–82.

Backs, J.R., M. Terry, and M.V. Ashley. 2016. Using genetic analysis to evaluate hybridization as a conservation concern for the threatened species, *Quercus hinckleyi* C.H. Muller (Fagaceae). International Journal of Plant Sciences 177(2): 122-131.

Backs, J.R., M. Terry, M. Klein, and M.V. Ashley. 2015. Genetic analysis of a rare isolated species: A tough little West Texas oak, *Quercus hinckleyi* C.H. Mull. Journal of the Torrey Botanical Society 142: 302–313.

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

Beckman, E., J.R. Backs, A. Meyer, and M. Westwood. 2019. Species profile: *Quercus hinckleyi*. Pp. 128–133 in: E. Beckman, A. Meyer, G. Man, D. Pivorunas, A. Denvir, D. Gill, K. Shaw, and M. Westwood. Conservation Gap Analysis of Native U.S. Oaks. The Morton Arboretum, Lilse, IL. https://www.mortonarb.org/files/species-profile-quercus-hinckleyi.pdf. Accessed July 21, 2020.

Borderlands Research Institute. 2020a. Recent Bighorn Restoration: Big Bend Ranch State Park. https://bri.sulross.edu/big-game/desert-bighorn-sheep/big-bend-ranch-state-park-restoration/ Accessed August 25, 2020.

Borderlands Research Institute. 2020b. Diets of Desert Bighorn Sheep. https://bri.sulross.edu/big-game/desert-bighorn-sheep/diets-of-bighorns/ Accessed August 25 2020.

Brown, B.A. 1996. *Quercus hinckleyi* Hinckley's oak. NatureServe Explorer 2.0. https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.152274/Quercus_hinckleyi. Accessed July 21, 2020.

CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad). 2020. Search of Mexican Herbaria through REMIB (Red Mundial de Información sobre Biodiversidad) for *Quercus hinckleyi*. http://www.conabio.gob.mx/remib/doctos/remib_esp.html. Accessed July 20, 2020.

Denvir, A. 2016. Celebrating and Protecting Mexico's Amazing Oak Diversity. GlobalTrees.org. https://globaltrees.org/news-blog/celebrating-and-protecting-mexicos-amazing-oak-diversity/ Accessed July 21, 2020.

Dirr, M. and C.W. Heuser, Jr. 1987. The Reference Manual of Woody Plant Propagation: From seed to tissue culture. Varsity Press, Inc. Athens, Georgia. 239 pp.

Hipp, A.L. 2017. American oaks in an evolutionary context. Pp. 10–11 in: D. Jerome, E. Beckman, L. Kenny, K. Wenzell, C.-S. Kua, and M. Westwood. The red List of US Oaks. The Morton Arboretum, Lisle, Illinois. 60 pp.

Hipp, A.L., P.S. Manos, M. Hahn, M. Avishai, C. Bodénès, J. Cavender-Bares, A.A. Crowl, M. Deng, T. Denk, S. Fitz-Gibbon, O. Gailing, M.S. González-Elizondo, A. González-Rodríguez, G.W. Grimm, X.-L. Jiang, A. Kremer, I. Lesur, J.D. McVay, C. Plomion, H. Rodríguez-Correa, E.-D. Schulze, M.C. Simeone, V.L. Sork, and S. Valencia-Avalos. 2020. Genomic landscape of the global oak phylogeny. New Phytologist 226: 1198–1212. doi: 10.1111/nph. 16162. www.newphytologist.com Accessed August 27, 2020.

Integrated Taxonomic Information Service. 2020. *Quercus hinckleyi* C.H. Mull. Taxonomic serial no.: 19354. https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=19354#null Accessed July 20, 2020.

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

May, M.M., M.C. Provance, A.C. Sanders, N.C. Ellstrand, and J. Ross-Ibarra. 2009. A Pleistocene clone of Pamer's oak persisting in southern California. PLoS One 4(12): e8346. doi:10.1371/journal.pone.0008346.

Muller, C.H. 1951. The significance of vegetative reproduction in *Quercus*. Madroño 11: 129–137.

National Park Service. 2020. NPS_-_Land_Resources_Division_Boundary_and_Tract_Data_Service.shp. https://public-nps.opendata.arcgis.com/datasets/nps-boundary-1 Accessed July 15, 2020.

Natural Resources Conservation Service. 2020. The PLANTS Database. Plants Profile for *Quercus hinckleyi* (Hinckley oak). *https://plants.usda.gov/core/profile?symbol=QUHI*. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed July 20, 2020.

Nixon, K.C. 1997. *Quercus* Linnaeus. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 21+ vols. New York and Oxford. Vol. 3. www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=127839 Accessed July 20, 2020.

Nixon, K.C. and C.H. Muller. 1997a. *Quercus hinckleyi* C. H. Muller. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 21+ vols. New York and Oxford. Vol. 3. www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=233501044 Accessed July 20, 2020.

Nixon, K.C. and C.H. Muller. 1997b. *Quercus* Sect. *Quercus* Linneaus. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 21+ vols. New York and Oxford. Vol. 3. www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=302029 Accessed July 20, 2020.

Pavlik B. 1996. Defining and measuring success. In D. Falk, C. Millar, and P. Olwell [eds.], Restoring diversity: strategies for reintroduction of endangered plants, 127–155. Island Press, Washington, D.C., USA.

Rieseberg, L.H. 1991. Hybridization in rare plants: Insights from case studies in *Cercoparpus* and *Helianthus*. Pp. 171–181 in: D.A. Falk and K.E. Holsinger, eds., Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, New York and Oxford. 283 pp.

Stoeser, D.B., G.N. Green, L.C. Morath, W.D. Heran, A.B. Wilson, D.W. Moore, and B.S. Van Gosen. 2005. Txgeol_dd_polygon.shp. U.S. Geological Survey, Denver, CO. http://pubs.usgs.gov/of/2005/1351/. Accessed: May 27, 2010.

Terry, M. and S. Scoppa. 2010. *Quercus hinckleyi* X *Q. vaseyana*, a putative hybrid from Presidio County, Texas. Phytologia 92: 400–406.

Texas Natural Diversity Database. 2020. Element occurrence shapefiles and printouts for *Quercus hinckleyi*. Wildlife Diversity Program of Texas Parks and Wildlife Department. July 24, 2020.

Texas Parks and Wildlife Department. 2020a. TPWDStateParksBoundary Shapefile. https://tpwd.texas.gov/gis/#data. Accessed July 27, 2020.

Texas Parks and Wildlife Department. 2020b. WildlifeManagementAreas Shapefile. https://tpwd.texas.gov/gis/#data. Accessed July 27, 2020.

Tropicos 2020. *Quercus hinckleyi* C.H. Mull. https://www.tropicos.org/name/13100078. Accessed July 20, 2020.

U.S. Fish and Wildlife Service. 1992. Hinckley Oak (*Quercus hincklevi*) Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 39 pp.

U.S. Fish and Wildlife Service. 2009. Hinckley oak (*Quercus hinckleyi*) 5-year review: Summary and evaluation. Trans-Pecos Sub-Office, Alpine, Texas. 18 pp.

U.S. Geological Survey. 2020. Digital Elevation Models NED13-10m_2803.img, NED13-10m_2902.img, NED13-10m_2903.img, and NED13-10m_2904.img, downloaded from Texas Natural Resources Information System (https://data.tnris.org/). Accessed April 29 and July 24, 2020.

Van Devender, T.R., C.E. Freeman, and R.D. Worthington. 1978. Full-glacial and recent vegetation of Livingston Hills, Presidio County, Texas. The Southwestern Naturalist 23: 289–301.

Van Devender, T.R. and W.G. Spaulding. 1979. Development of Vegetation and Climate in the Southwestern United States. Science 204: 701–710.

Wikipedia. 2020. *Quercus hinckleyi*. https://en.wikipedia.org/wiki/Quercus_hinckleyi#cite_ref-tnc_2-1 Accessed August 18, 2020.

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Abbreviations of scientific units.

Abbreviation	Scientific Unit
ac	acres
cm	centimeters
ft	feet
ha	hectares
in	inches
km	kilometers
m	meters
mi	miles
mm	millimeters

Acronyms.

ESA	Endangered Species Act
MVP	Minimum viable population
TPWD	Texas Parks and Wildlife Department
TXNDD	Texas Natural Diversity Database
USFWS	U.S. Fish and Wildlife Service

Glossary of Scientific and Technical Terms.

Term	Definition
Allele	Alternate forms of a gene.
Augmentation	Introduction of additional individuals or propagules to an existing population.
Breeding System	The ability of a plant species to reproduce via outcrossing, self-fertilization, apomixis, or a combination (Wikipedia 2015).
Browsing	Herbivory of the leaves and stems of woody plants (as opposed to grazing).
Cretaceous	Geologic period and system from 145 ± 4 to 66 million years (Ma) ago (Wikipedia 2016).
Critical habitat	"…(i) the specific areas within the geographical area occupied by the [threatened or endangered] species, at the time it is listed in accordance with the provisions of section 4 of [the ESA], on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of [the ESA], upon a determination by the Secretary that such areas are essential for the conservation of the species." U.S. Congress 1988.
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).
Ecosystem	The interactions of a community of living organisms with its non-living (abiotic) environment (Wikipedia 2020).
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).
Endangered	"…any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." U.S. Congress 1988.
Ex-situ	Off site (as opposed to *in situ*). Usually a controlled environment, such as a botanical garden, arboretum, or laboratory.
Fixation index	"…a measure of population differentiation due to genetic structure. It is frequently estimated from genetic polymorphism data, such as single-nucleotide polymorphisms (SNP) or microsatellites." Wikipedia 2020.
Floristics	The study of the plant species composition of a specific area.
Genet	Clonal colony of genetically identical individuals (Wikipedia 2020).

Term	Definition
Genetic drift	A change in allele frequencies within a population over time.
Genetic swamping	Overwhelming one genotype of a species with far greater numbers of individuals from another genotype.
Genomics	The study of the genome (total genetic diversity) of a taxon.
Germ bank	Genetic repository consisting of living tissues of organisms.
Heterozygous	A diploid (or polyploid) organism possessing two (or more) alleles at a specific gene locus on homologous chromosomes.
Inbreeding	Sexual reproduction between closely related individuals.
Introgression	Gene flow from one species into the gene pool of another by the repeated backcrossing of an interspecific hybrid with one of its parent species (Wikipedia 2013). Introgression may also occur between infra-species.
Locus	The specific position of a gene on a chromosome.
Metapopulation	A group of spatially separated populations of the same species that interact at some level (Wikipedia 2013).
Microsatellite DNA	Repeating sequences of 2 to 6 base pairs in DNA that may be used as genetic markers in kinship and population studies (Wikipedia 2012).
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.
Outbreeding depression	The reduction in reproductive fitness in the first or later generations following attempted crossing of populations (Frankham et al. 2011, p. 466).
Outcross	In plants, sexual fertilization involving the union of gametes from different individuals.
Phylogeny	The study of evolutionary relatedness among various groups of organisms (e.g., species, populations), which is discovered through molecular sequencing data and morphological data matrices (Wikipedia 2013).
Pleistocene	Geological epoch beginning about 2,588,000 years ago and ending about 11,700 years ago (Wikipedia 2013).
Pluvial	A location or period of relatively high precipitation.
Polymorphism	In genetics, a gene locus for which multiple alleles exist.
Population structure	The proportions of a population comprised by different age groups or reproductive stages.
Ramet	An individual, genetically identical plant reproduced as a clone of the parent plant.

Term	Definition
Recovery priority system	The system used for assigning recovery priorities to listed species and to recovery tasks. Recovery priority is based on the degree of threat, recovery potential, taxonomic distinctness, and presence of an actual or imminent conflict between the species' conservation, adverse human activities, and other threats (NMFS and USFWS 1990; 55 FR:24296-24298, June 15, 1990; USFWS and NMFS 2000; 65 FR 56919-56920, September 20, 2000).
Recruitment	Addition of new individuals to a population.
Refugium	A protected site managed specifically for the continued existence of individuals of a population or species that has been or is likely to be extirpated in the wild.
Reintroduction	Restoration of populations of a species where it is currently absent but within its former range and habitat.
Rhizome	Horizontal stems that grow under the surface of the ground.
Section	In botany, a section is a taxonomic rank below the genus and subgenus, but above series and species (Wikipedia 2013).
Shapefile	A digital geospatial vector data storage format developed by Esri. (Wikipedia 2015).
Species	One of the basic units of taxonomic identity (Wikipedia 2013). Multiple species definitions exist, including the biological, phylogenetic, evolutionary, etc. The biological definition ("... groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups" (Mayr 1942)) is adopted in the ESA but does not apply well to all organisms.
Sympatry	Members of a clade that occupy the same habitat or geographic area.
Taxon	(Plural, taxa). A natural group of organisms at any rank in the taxonomic hierarchy (Anderson 2001).
Taxonomy	Scientific classification of living organisms.
Threatened	"…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." United States Congress 1988.

Literature cited in glossary.

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

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

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

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

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

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

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

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

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

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

Wikipedia.org. 2020. Articles on Cretaceous, digital elevation model, ecosystem, ex-situ, fixation index, genet, introgression, mating system, metapopulation, microsatellite DNA, phylogeny, Pleistocene, section, shapefile. http://en.wikipedia.org/ August 31, 2020.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of HINCKLEY OAK (*Quercus hinckleyi*)

Current Classification:

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable.

Not applicable.

FIELD OFFICE APPROVAL

Lead Field Supervisor, Fish and Wildlife Service, Austin Ecological Services Field Office:

Approve ADAM ZERRENNER Digitally signed by ADAM ZERRENNER Date: 2020.09.09 15:09:15 -05'00'