Tooth Cave Ground Beetle
(*Rhadine persephone*)
5-Year Status Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
Austin, Texas
August 11, 2023

5-YEAR REVIEW
Tooth Cave Ground Beetle (*Rhadine persephone*)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office:
Vanessa Burge, Recovery Biologist, Southwest Regional Office, Albuquerque, New Mexico, vanessa_burge@fws.gov

Lead Field Office:
Michael Warriner, Supervisory Fish and Wildlife Biologist and Jenny Wilson, Fish and Wildlife Biologist, Austin Ecological Services Field Office, Austin, Texas, michael_warriner@fws.gov

Cooperating Field Office(s):
Not applicable

Cooperating Regional Office(s):
Not applicable

1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species ESA (ESA) 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, be changed in status from endangered to threatened, or be changed in status from 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 Service conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the ESA (16 U.S.C. 1531 et seq.). The Service provides notice of status reviews via the *Federal Register* and requests information on the status of the species. 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). We considered both new and previously existing information from federal and state agencies, municipal and county governments, non-governmental organizations, researchers, and the general public.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

88 FR 1602, January 11, 2023

1.4.2 Listing history:

<u>Original Listing</u>
FR notice: 53 FR 36029
Date listed: September 16, 1988
Entity listed: Tooth Cave ground beetle (*Rhadine persephone*)
Classification: Endangered

<u>Revised Listing, if applicable</u>
FR notice: Not applicable
Date listed: Not applicable
Entity listed: Not applicable
Classification: Not applicable

1.4.3 Associated Rulemakings:

Not applicable

1.4.4 Review History:

Status reviews for the Tooth Cave ground beetle were conducted in 1988 for the final listing of the species (53 FR 36029), 1994 for the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, entire), and 2009 (Service 2009, entire) and 2018 (Service 2018a, entire) for 5-year reviews.

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

2C

1.4.6 Recovery Plan or Outline

Name of plan or outline: Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas
Date issued: 1994
Dates of previous plans/amendment or outline, if applicable: Amendment 1, 2019

2.0 REVIEW ANALYSIS

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth 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. The Service recommends 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):

No, this species is an invertebrate, so the DPS policy does not apply.

2.2 Updated Information and Current Species Status

2.2.1 Biology and Habitat

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

No new information.

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:

No new information.

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 numbers 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 2018 5-year review for the Tooth Cave ground beetle listed 61 caves with records of the species (Service 2018a, pp. 10-11, 16-18). Our current review documented 64 caves with records of the ground beetle as well as one-time collection of the species from a subterranean cavity intersected by a borehole excavation. Additional caves with the species are Godzilla and Homestead Caves and Persephone Caverns. The karst fauna region distribution of the Tooth Cave ground beetle was redefined based on a recent biogeographic reassessment of those regions (Veni and Jones 2021, entire). Prior to this effort, the beetle occupied the Jollyville Plateau and Cedar Park Karst Fauna Regions. Veni and Jones (2021, pp. 37-38, 40) updated the boundaries of the Jollyville Plateau, McNeil-Round Rock, and Rollingwood Karst Fauna Regions. Those researchers also subdivided the Cedar Park Karst Fauna Region into distinct eastern and western portions (i.e., East and West Cedar Park Karst Fauna Regions) (Veni and Jones 2021, pp. 34, 40). As a result of this study, the Tooth Cave Ground beetle now occurs in the Jollyville Plateau, East Cedar Park, and West Cedar Park Karst Fauna Regions.

An important consideration for this 5-year review was whether occupied caves warranted consolidation into single populations based on geographic proximity (Service 2018b, pp. 24, 49-50). Although there are no data specific to the Tooth Cave ground beetle, research indicates that troglobitic arachnids and insects may disperse through networks of subterranean voids (e.g., mesocaverns). In central Texas, some troglobitic beetles (i.e., *Rhadine*), bristletails (i.e., *Texoredellia*), and spiders (e.g., *Cicurina* and *Tayshaneta*) have exhibited genetic connectivity among occupied caves (Avise and Selander 1972, p. 15; Paquin and Hedin 2004, p. 3250; Paquin and Hedin 2005, pp. 4-5, 14-15; Ledford et al. 2012, pp. 11, 18-23; Espinasa et al. 2016, pp. 233, 236, 238). Subterranean dispersal of troglobitic invertebrates, along with resultant gene flow in some cases, has been suggested to occur in cave systems of Australia

(Moulds et al. 2007, pp. 8, 10), Brazil (Jaffé et al. 2016, pp. 11-12), and regions of the United States (i.e., Kentucky; Turanchik and Kane 1979, pp. 65- 67).

Ledford et al. (2012, pp. 11, 18-23, 51) documented significant genetic similarity (i.e., mitochondrial and nuclear DNA) among Tooth Cave spider (*Tayshaneta myopica*) populations at Gallifer, Root, Tooth Caves and Tight Pit in Travis County. Genetic similarity among Tooth Cave spiders sampled from those sites implies dispersal of individuals between caves over time through interconnected subterranean dispersal corridors such as fissures or mesocaverns (Ledford et al. 2012, pp. 11, 51). The greatest distance between genetically similar Tooth Cave spider populations at Tight Pit and Gallifer, Root, and Tooth Caves is approximately 292 meters (m) [958 feet (ft)].

For our assessment, we assumed that populations of the Tooth Cave ground beetle, given adequate geological connectivity, are capable of subterranean dispersal and gene flow among karst features. To account for potential genetic connectivity of populations, we assigned a maximum dispersal radius of 300 m (984 ft) from each cave occupied by the species. That value is a conservative estimate that is most similar to distances exhibited by the Tooth Cave spider. Given the extent of geological connectivity surrounding caves, actual Tooth Cave ground beetle dispersal distances may be greater or less than that value. Genetic analyses would be necessary to provide more certainty regarding actual dispersal distances. We did not apply this methodology to surface sites given the lack of detailed data on habitat conditions at these locations.

For each cave occupied by the Tooth Cave ground beetle, we established a 300-m (984-ft) radius around individual sites in ArcGIS with the entrance as a center-point. If the respective radiuses of adjacent caves over-lapped (or caves were within 600 m (1968 ft) of each other), those sites were grouped into what we refer to as a cave cluster and those caves were assumed to be part of the same interconnected Tooth Cave ground beetle population. If a cave’s radius did not overlap with any other cave, we labeled that site an individual cave and considered it an isolated population. Based on that methodology, we grouped Tooth Cave ground beetle occurrences into seven cave clusters and 13 individual caves (Table 1).

Table 1. Tooth Cave ground beetle cave clusters and individual caves.

Karst Fauna Region	County	Ownership
East Cedar Park		
Cave Cluster(s)		
Big Oak and Raccoon Caves	Williamson	TXDOT/Private
Lakeline Cave Cluster	Williamson	Private
Individual Cave(s)		
Broken Arrow Cave	Travis	City of Austin
Jug Cave	Williamson	TXDOT
Rolling Rock Cave	Travis	City of Austin
West Cedar Park		
Cave Cluster(s)		
Buttercup Cave Cluster	Williamson	TXDOT/Private/City
Individual Cave(s)		
Treehouse Cave	Williamson	City of Cedar Park
Two Hole Cave	Williamson	City of Cedar Park
Whitestone Pit Cave	Williamson	City of Cedar Park
Whitewater Cave	Williamson	City of Cedar Park
Wilcox Cave	Williamson	City of Cedar Park
Jollyville Plateau		
Cave Cluster(s)		
Cuevas (Tomen Park) Cave Cluster	Travis	Travis County
Down Dip Sink and Garden Hoe Cave	Travis	City of Austin
Four Points Cave Cluster	Travis	Private
Stovepipe Cave Cluster	Travis	City of Austin
Twisted Elm Cave and Puzzle Pit	Travis	Private
Individual Cave(s)		
Dies Ranch Treasure Cave	Travis	Unknown
Geode Cave	Travis	Travis County
Lamm Cave	Travis	Private
Pond Party Pit	Travis	City of Austin
Spider Cave	Travis	City of Austin

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

The population needs of the Tooth Cave ground beetle are the factors that provide for a high probability of population persistence over the long-term at an occupied location (e.g., low degree of threats and high survival and reproduction rates). Since population estimates for the Tooth Cave ground beetle are unavailable, nor do we know what reproductive rates sustain a healthy population, we applied measures of surface habitat elements (i.e., area of naturally vegetated open space, distance of cave entrance to nearest edge, and status of cave cricket foraging area) surrounding a cave as surrogates to assess population resiliency. For a full discussion of this methodology, see Service (2018b, pp. 31-32).

Variables related to surface land uses and native vegetation can influence cave invertebrate communities, even at some distance (i.e., 50-250 m [164-820 ft]), from a cave's entrance (Pellegrini et al. 2016, pp. 23-34). Jaffé et al. (2018, pp. 9, 11) found that anthropogenic land use in the form of agriculture within 50 m (164 ft) of a cave significantly reduced troglobitic invertebrate species richness. Those researchers partially attributed reductions to chemical contamination in the form of herbicide, pesticide, and/or fertilizer use (Jaffé et al. 2018, p. 17). Reduction of nutrients into caves, due to loss of surrounding native vegetation to agricultural conversion, was cited as another potential contributor to reduced species richness (Jaffé et al. 2018, p. 17). It is likely that urbanization may have similar impacts on cave systems (Pelligrini et al. 2016, p. 28).

Construction of development projects (e.g., single- or multi-family housing, commercial buildings, and paved roadways) often entails the partial or complete mechanical removal of natural vegetation, and potentially topsoil, from a site (Theobald et al. 1997, p. 26; Zipperer 2011, pp. 188-189) followed by replacement with built structures, impervious cover, and/or non-native, managed landscaping (McKinney 2002, pp. 884, 886; McKinney 2008, p. 168). Once completed, such urban landscape features can have long-term impacts on surrounding natural communities (Theobald et al. 1997, pp. 27-28, 31-33). Compared to some other anthropogenic drivers of species decline, including agriculture, forestry, or grazing, the impacts of urbanization on native habitats are more persistent resulting in highly modified sites with decreased potential for maintenance or reestablishment of native species (Rebele 1994, p. 177; Theobald et al. 1997, p. 33; Huxel and Hastings 1999, p. 312; Marzluff and Ewing 2001, p. 281; McKinney 2002, pp. 883-886, 889; Hansen et al. 2005, pp. 1899-1900).

For this review, we evaluated 2022 aerial imagery of areas surrounding occupied caves in ArcGIS for the following habitat elements: amount of open space with natural vegetation contiguous with a cave entrance, distance of the cave entrance to nearest edge, and status of the cave cricket foraging area (Service 2018b, p. 51). As we lack maps of every cave's footprint, cave entrances served as center-points for measurements. We assigned each cave cluster and individual cave site to one of four resiliency categories, high, moderate, low, or impaired, based on values generated for each habitat element (Service 2018b, p. 52). Finally, we noted whether a site possessed legally binding perpetual protection along with the amount of acreage protected if that information was available.

Habitat elements at high and moderate resiliency sites provide the greatest probability for persistence of Tooth Cave ground beetle populations and the associated karst ecosystem. However, a site's continued status as high or moderate resiliency is dependent on the perpetuation of the needed surface and subsurface habitat elements. A cave cluster with a high or moderate resiliency designation may contain an individual cave or caves with lower resiliency, but if at least one cave in the cluster was potentially capable of supporting a high to moderate resiliency population, we assigned that higher resiliency category to the entire cluster. Low resiliency and impaired cave clusters and individual caves potentially lack habitat elements of sufficient quality to support persistent populations of Tooth Cave ground beetle over the long-term.

Impacts to a cave’s surface or subsurface drainage basin can be a significant source of stressors for Tooth Cave ground beetle populations. To characterize habitat for a particular site, it is important to determine whether development activities are affecting drainage basins, altering either the quantity or quality of hydrologic inputs into the karst ecosystem. At this time, however, we do not have adequate assessments of drainage basins for most occupied sites. Therefore, we did not include an assessment of actual impacts to drainage basins in this evaluation. For these analyses, we assumed that larger tracts of open space were more likely to include intact drainage basins, particularly when the cave entrance was some distance from the edge. In using this approach, we recognize that drainage basin impacts may be occurring undetected even in high and moderate resiliency sites. Thus, it would be important to delineate and protect these areas in the future to ensure Tooth Cave ground beetle population.

Based on our review, the East Cedar Park Karst Fauna Region contains two cave clusters and three individual caves occupied by the Tooth Cave ground beetle (Table 2). Since our 2018 5-year review, the Big Oak and Raccoon Caves Cluster declined in resiliency from low resiliency to impaired due to loss of natural habitat to development. Both cave clusters in this karst fauna region are now impaired due to reductions in natural open space and cave cricket foraging area. Two individual caves have maintained high resiliency since 2018.

Table 2. Current resiliency of Tooth Cave ground beetle sites (cave clusters and individual caves) in the East Cedar Park Karst Fauna Region.

Cave Cluster or Individual Cave	Open Space Area ha (ac)	Distance of Cave to Nearest Edge m (ft)	Percent of Cave Cricket Foraging Area Impacted	Current Resiliency
Big Oak and Raccoon Caves				**Impaired**
Big Oak Cave	3.6-16 (9-40)	<120 (<394)	51%-75%	Impaired
Raccoon Cave	<3.6 (<9)	<120 (<394)	76%-100%	Impaired
Lakeline Cave Cluster				**Impaired**
Lakeline Cave	<3.6 (<9)	<120 (<394)	76%-100%	Impaired
Lakeline Mall Well Trap No. 6 Cave	NA	NA	NA	Destroyed
Individual Cave(s)				
Broken Arrow Cave	>40 (>100)	>120 (>394)	0	High
Jug Cave	NA	<120 (<394)	NA	Destroyed
Rolling Rock Cave	>40 (>100)	>120 (>394)	0	High

The West Cedar Park Karst Fauna Region contains the Buttercup Cave Cluster that consists of 26 caves occupied by the Tooth Cave ground beetle (Table 3). The majority of those caves are low resiliency or impaired. That cave cluster maintains its overall high resiliency due to the presence of two high resiliency caves. All five individual caves hosting the beetle are impaired.

Table 3. Current resiliency of Tooth Cave ground beetle sites (cave clusters and individual caves) in the West Cedar Park Karst Fauna Region.

Cave Cluster or Individual Cave	Open Space Area ha (ac)	Distance of Cave to Nearest Edge m (ft)	Percent of Cave Cricket Foraging Area Impacted	Current Resiliency
Buttercup Cave Cluster				**High**
A.J. and B.L. Wilcox Cave	3.6-16 (9-40)	<120 (<394)	51%-75%	Impaired
Animal Canyon Cave	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Bluewater Cave No. 2	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Boulevard Cave	<3.6 (<9)	<120 (<394)	51%-75%	Impaired
Buttercup Blowhole Cave	3.6-16 (9-40)	<120 (<394)	51%-75%	Impaired
Buttercup Creek Cave	16-40 (40-100)	<120 (<394)	0	Low
Cedar Elm Cave	3.6-16 (9-40)	<120 (<394)	1-25%	Impaired
Convoluted Canyon Cave	16-40 (40-100)	<120 (<394)	1-25%	Low
Discovery Well Cave	>40 (>100)	>120 (>394)	0	High
Godzilla Cave	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Good Friday Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Grimace Cave	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Harvestman Cave	<3.6 (<9)	<120 (<394)	51%-75%	Impaired
Hideaway Cave	16-40 (40-100)	<120 (<394)	51%-75%	Impaired
Ilex Cave	16-40 (40-100)	<120 (<394)	1-25%	Low

Cave Cluster or Individual Cave	Open Space Area ha (ac)	Distance of Cave to Nearest Edge m (ft)	Percent of Cave Cricket Foraging Area Impacted	Current Resiliency
Marigold Cave	<3.6 (<9)	<120 (<394)	76%-100%	Impaired
May B A Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Nelson Ranch Cave	16-40 (40-100)	<120 (<394)	26%-50%	Impaired
Pat's Pit Cave	3.6-16 (9-40)	<120 (<394)	51%-75%	Impaired
Pig Snout Cave	<3.6 (<9)	<120 (<394)	51%-75%	Impaired
Primrose Cave	<3.6 (<9)	<120 (<394)	76%-100%	Impaired
Salamander Squeeze Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Stone Well Cave No. 1	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Stone Well Cave No. 2	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
T.W.A.S.A Cave	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Testudo Tube Cave	>40 (>100)	>120 (>394)	0	High
Individual Cave(s)				
Treehouse Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Two Hole Cave	<3.6 (<9)	<120 (<394)	26%-50%	Impaired
Whitestone Pit Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Whitewater Cave	<3.6 (<9)	<120 (<394)	51%-75%	Impaired
Wilcox Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired

The Jollyville Plateau Karst Fauna Region contains four cave clusters occupied by the Tooth Cave ground beetle (Table 4). The largest of the four clusters, Cuevas (Tomen Park) Cave Cluster, experienced a decrease in resiliency, compared to the species' 2018 5-year review, from high to moderate resiliency due to loss of cave cricket foraging habitat. The three remaining cave clusters and five individual caves have maintained their resiliency since 2018.

Table 4. Current resiliency of Tooth Cave ground beetle sites (cave clusters and individual caves) in the Jollyville Plateau Karst Fauna Region.

Cave Cluster or Individual Cave	Open Space Area ha (ac)	Distance of Cave to Nearest Edge m (ft)	Percent of Cave Cricket Foraging Area Impacted	Current Resiliency
Cuevas (Tomen Park) Cave Cluster				**Moderate**
Amber Cave	>40 (>100)	<120 (<394)	26%-50%	Low
Gallifer Cave	>40 (>100)	<120 (<394)	1%-25%	Moderate
Homestead Cave	NA	<120 (<394)	NA	Destroyed
Kretschmarr Cave	>40 (>100)	<120 (<394)	26%-50%	Low
Kretschmarr Double Pit	>40 (>100)	<120 (<394)	26%-50%	Low
Puzzle Pits Cave	NA	<120 (<394)	NA	Destroyed
Root/North Root Cave	>40 (>100)	<120 (<394)	51%-75%	Low
Tardus Hole	>40 (>100)	<120 (<394)	26%-50%	Low
Twisted Elm Cave	3.6-16 (9-40)	<120 (<394)	51%-75%	Impaired
Tooth Cave	>40 (>100)	<120 (<394)	1-25%	Moderate
Two Trunks Cave	>40 (>100)	<120 (<394)	26%-50%	Low
Down Dip Sink and Garden Hoe Caves				**High**
Down Dip Sink	>40 (>100)	>120 (>394)	0	High
Garden Hoe Cave	>40 (>100)	>120 (>394)	0	High
Four Points Cave Cluster				**High**
Disbelievers Cave	>40 (>100)	<120 (<394)	1%-25%	Moderate

Cave Cluster or Individual Cave	Open Space Area ha (ac)	Distance of Cave to Nearest Edge m (ft)	Percent of Cave Cricket Foraging Area Impacted	Current Resiliency
Japygid Cave	>40 (>100)	<120 (<394)	1%-25%	Moderate
Jollyville Plateau Cave	>40 (>100)	<120 (<394)	0	High
MWA Cave	>40 (>100)	<120 (<394)	0	High
Stovepipe Cluster				**Moderate**
Persephone Caverns	16-40 (40-100)	<120 (<394)	1%-25%	Low
Stovepipe Cave	16-40 (40-100)	>120 (>394)	0	Moderate
Individual Cave(s)				
Dies Ranch Treasure Cave	>40 (>100)	<120 (<394)	51%-75%	Low
Geode Cave	>40 (>100)	<120 (<394)	26%-50%	Low
Lamm Cave	3.6-16 (9-40)	<120 (<394)	26%-50%	Impaired
Pond Party Pit	>40 (>100)	>120 (>394)	0	High
Spider Cave	>40 (>100)	>120 (>394)	0	High

2.2.1.7 Other:

No new information.

2.2.1.8 Conservation Measures:

No new information.

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:

The range of the Tooth Cave ground beetle in Travis and Williamson counties, Texas has experienced significant human population growth (Neumann and Bright 2008, pp. 8-11, 13; Potter and Hoque 2014, pp. 2, 5). During the period from 1980 to 2010, the Austin-Round Rock-Georgetown Metropolitan Area was among the fastest growing metropolitan areas in the United States (Frey 2012, p.

4). As of 2022, the Texas contains five of the most populous cites (e.g., Austin, Dallas, Houston, Fort Worth, and San Antonio) in the United States and five of the nation's fastest growing cities (U.S. Census Bureau 2023a, unpaginated). The state's fastest growing cities are suburbs of adjacent major metropolitan areas (e.g., Austin-Round Rock-Georgetown and San Antonio-New Braunfels Metropolitan Areas) [U.S. Census Bureau 2023a, unpaginated).

Between 1980 and 2021, the human population of Travis County grew substantially from 419,573 people to 1,305,154 people (U.S. Census Bureau 1982, p. 10; U.S. Census Bureau 2023b, unpaginated). The county's largest city, the City of Austin, grew from 345,890 people in 1980 to 964,000 people in 2021 (City of Austin 2016; U.S. Census Bureau 2023b, unpaginated). Like Travis County, Williamson County experienced substantial population growth from 1980 to 2021. Over that period, the county grew from 76,521 people to 643,026 people (U.S. Census Bureau 1982, p. 10; U.S. Census Bureau 2023b, unpaginated). The population of the City of Georgetown increased from 9,468 people in 1980 to 75,407 people in 2021 (U.S. Census Bureau 1982, p. 27; U.S. Census Bureau 2023b, unpaginated).

Increased conversion of natural surface habitat to development or infrastructure has accompanied human population growth in Travis County. Based on data from the U.S. Census Bureau (2012, p. 9; 2023b unpaginated), numbers of single and multi-family housing units in Travis County increased more than five-fold from 100,882 units in 1970 to 593,189 units in 2021. In Williamson County, numbers of single and multi-family housing units increased more than 18 times between 1970 to 2021, from 13,216 units to 249,393 units (U.S. Census Bureau 2012, p. 9; U.S. Census Bureau 2023b, unpaginated).

Installation of infrastructure projects and non-residential commercial development can be expected to follow establishment of new housing units further expanding the urban, suburban, and exurban footprint (Cohen 1996 pp. 1051-1053; Brueckner 2000, pp. 166-167; Cowley and Spillette 2001, pp. 8-9; Heimlich and Anderson 2001, pp. 15, 18-19; Scheer 2001, pp. 31-35; Oguz et al. 2008, pp. 11-12; Landis 2009, pp. 157, 165). From 2009-2015, Texas was among states with the greatest annual loss in tree cover (8,413 ha/yr [20,790 ac/yr]) and greatest annual net increase in impervious cover (12,092 ha/yr [29,880 ac/yr]) in urbanized areas (Nowak and Greenfield 2018a, p. 37).

Nowak and Greenfield (2018b, pp. 168-171) developed projections for urbanized land growth in the United States from 2010 to 2060. Texas is projected to gain the second highest amount of urbanized land in the country at 3,004,386 ha (7,424,000 ac) over that 50-year period (Nowak and Greenfield 2018b, p. 169). Percentage of urbanized land in Travis County is projected to increase from 25%-40% in 2010 to 60%-80% in 2060 (Nowak and Greenfield 2018b, p. 170). Williamson County is projected to experience increases in urbanized land from 10%-15% in 2010 to 40%-60% in 2060 (Nowak and Greenfield 2018b, p. 170).

The Tooth Cave ground beetle, and its subterranean habitat, is reliant on functional surface ecological systems. The plant communities that overlay and surround cave systems aid in buffering subterranean ecosystems from stressors, support nutrient flow, and aid in the maintenance of microclimatic conditions (Barr 1968, pp. 47-48; Poulson and White 1969, pp. 971-972; Howarth 1983, p. 376; Culver and Pipan 2009b, p. 23; Simões et al. 2014, p. 168; Pellegrini et al. 2016, pp. 28, 32-34). As a site is developed, native plant communities are often mechanically cleared and replaced with a highly modified urban to exurban landscape (Theobald et al. 1997, p. 26; McKinney 2002, pp. 884, 886; McKinney 2008, p. 168; Zipperer 2011, pp. 188-189).

Construction activities may also modify cave entrances and other openings to the surface (Watson et al. 1997, p. 11; Veni et al. 1999, p. 55; Waltham and Lu 2007, p. 17; Frumkin 2013, pp. 61-62; Hunt et al. 2013, p. 97) which could affect climatic conditions within the cave as well as water infiltration (Pugsley 1984, pp. 403-404; Elliott and Reddell 1989, p. 7; Culver and Pipan 2009b, p. 202). The abundance and species richness of native animals may decline due to decreased foraging or sheltering habitat, increased predation, competition with non-native species, or lack of connectivity among populations (Rebele 1994, p. 177; McKinney 2002, pp. 885-886; Taylor et al 2007, pp. 2, 37, 41-44; Pellegrini et al. 2016, pp. 28, 34). Direct and collateral impacts to surface and subsurface habitat from urbanization have the potential to reduce Tooth Cave ground beetle population viability and the species' long-term persistence. Given population and urbanized land growth projections (Texas Demographic Center 2014; Nowak and Greenfield 2018b, p. 170), it is likely that remaining surface and subsurface habitats will be impacted in the absence of management and protection.

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

No new information.

2.2.2.3 Disease or predation:

No new information.

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

The Tooth Cave ground beetle occurs at seven cave clusters and 12 individual caves in Travis and Williamson counties, Texas. The East Cedar Park Karst Fauna Region contains only two high resiliency individual caves. All remaining sites in that region are impaired or destroyed. The West Cedar Park Karst Fauna Region contains a single high resiliency cave cluster. All individual caves in that region are impaired. The Jollyville Plateau Karst Region contains two high and two moderate resiliency cave clusters and two high resiliency individual caves. Rapid human population growth and urban, suburban, and exurban development are the primary contributors to the degradation and destruction of Tooth Cave ground beetle habitat. Natural open space has been reduced or eliminated at low resiliency and impaired sites with tracts fragmented and isolated from one another. These sites may be unable to support viable populations of the Tooth Cave ground beetle over the long-term.

There are five cave clusters and four individual caves of high to moderate resiliency with potential to support viable Tooth Cave ground beetle populations over the long-term. Larger tracts of open space with natural vegetation surround these caves, providing higher quality cave cricket foraging habitat and greater potential for connectivity among karst features to support cricket populations. Persistence of Tooth Cave ground beetle populations at these sites is dependent upon management and perpetual protection that maintains adequate open space, sufficient buffering from edge effects, intact foraging areas for cave crickets, and sufficient quantity and quality of water from intact drainage basins.

Recovery criterion (1) in Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, pp. 86-88; Service 2019, pp. 6-7) states that three karst fauna areas within each karst fauna region should be protected if a species occupies more than one region. If a species only occurs within a single karst fauna region, six karst fauna regions should be protected. Protection is defined as an area sufficiently large to maintain the integrity of the karst ecosystem on which the species depends. These areas must also provide protection from threats such as habitat destruction, red-imported fire ants, and contaminants. Recovery criterion (2) requires at least five consecutive years of a cave meeting karst fauna area status and that perpetual protection of these areas is in place.

Four cave clusters and three individual caves in the Jollyville plateau Karst Fauna Region receive some level of protection through the Balcones Canyonlands Preserve. These sites have not been formally recognized as karst fauna areas, however. In the East Cedar Park Karst Fauna Region, two individual caves receive some level of protection through the City of Austin and two caves within the Buttercup Cave Cluster are a sufficient distance from an edge and on large enough open space that they could contribute to a potential karst fauna area provided the other criteria could be met. Additional information is needed to determine if these sites meet karst fauna area criteria and guidelines.

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):

No change is needed.

Brief Rationale:

The majority of sites occupied by the Tooth Cave ground beetle are of low resiliency or impaired. Only a few sites hosting the beetle are of sufficient resiliency (i.e., high or moderate) to support long-term persistence of the species. At present, recovery criteria for the Tooth Cave ground beetle have not been achieved. No karst fauna areas exist for this species in any occupied karst fauna region. In Travis and Williamson counties, threats from increasing development due to rapidly growing human populations are projected to continue. At this time, we do not recommend a change in listing status for the Tooth Cave ground beetle given the lack of protected karst fauna areas.

3.3 Listing and Reclassification Priority Number, if reclassification is recommended (see 48 FR 43098):

Reclassification (from Threatened to Endangered) Priority Number: Not applicable
Reclassification (from Endangered to Threatened) Priority Number: Not applicable
Delisting (Removal from list regardless of current classification) Priority Number: Not applicable

Brief Rationale:

Not applicable

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Obtain information for high and moderate resiliency sites within the Balcones Canyonlands Preserve to include surface and subsurface drainage basins, potential development impacts, tract acreage, management, and perpetual protection mechanisms among others. Review information to determine the potential for the site to be recognized as a karst fauna area.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Tooth Cave ground beetle (*Rhadine persephone*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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, Austin, Texas

Approve KAREN MYERS Digitally signed by KAREN MYERS Date: 2023.08.11 09:03:51 -05'00' ____