Kretschmarr Cave Mold Beetle
(*Texamaurops reddelli*)

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW

Kretschmarr Cave Mold Beetle (*Texamaurops reddelli*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service (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 Endangered Species Act (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 May 31, 2018 (83 FR 25034). This review was conducted by the Austin Ecological Field Services Office using methodology developed for a species status assessment completed for the Bone Cave harvestman (Service 2018, pp. 31-32). We considered both new and previously existing information from federal and state agencies, municipal and county governments, non-governmental organizations, academia, and the general public. Recovery criteria and guidelines from the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, pp. 48-58, 86-88), Bexar County Karst Invertebrates Recovery Plan (Service 2011, pp. 19-22), Karst Preserve Design Recommendations (Service 2012, entire), and Karst Preserve Management and Monitoring Recommendations (Service 2014, entire) informed this 5-year review.

1.3 Background:

The Kretschmarr Cave mold beetle (Coleoptera: Staphylinidae: Pselaphinae: *Texamaurops reddelli* Barr and Steeves 1963) is one of 25 species in the subfamily Pselaphinae associated with caves in Texas (Chandler et al. 2009, p. 126). Prior to 1992, two pselaphine species had been described from the state's caves, *Batrisodes schneiderensis* (Park 1960, pp. 75-76) from Kendall County and *Texamaurops reddelli* (Barr and Steeves 1963, pp. 118-120) from Travis and Williamson counties. The latter species, the Kretschmarr Cave mold beetle, was listed as endangered in 1988 (53 FR 36029). Chandler (1992, entire) reviewed the Pselaphinae of Texas, noting 12 species for the state with descriptions of four new species. In that review, Chandler (1992, p. 247) assigned a specimen of the Kretschmarr Cave mold beetle collected from Coffin Cave in Williamson County to a new species, the Coffin Cave mold beetle (*B. texanus*). In 1993, a technical correction published in the Federal Register acknowledged this taxonomic revision and conferred endangered status to the Coffin Cave mold beetle (58 FR 43818).

The Kretschmarr Cave mold beetle is endemic to a restricted range in the Balcones Canyonlands ecoregion of Texas, specifically western Travis County (Chandler 1992, p. 249; Chandler and Reddell 1999, pp. 127; Chandler et al. 2009, pp. 139). The Balcones Canyonlands form the eastern to southeastern boundary of the Edwards Plateau, where the activity of rivers, springs, and streams has resulted in the formation of an extensive karst landscape of canyons, caves, and sinkholes (Griffith et al. 2007, p. 49). The term "karst" refers to a type of terrain that is formed by the slow dissolution of calcium carbonate from surface and subsurface limestone, and other soluble rock types (e.g., carbonites and evaporates), by mildly acidic groundwater (Holsinger 1988, p. 148; Culver and Pipan 2009, pp. 5-15; Stafford et al. 2014, pp. 4-5). Flow of groundwater through conduits leads to the formation of an interconnected system of subterranean voids that become larger as bedrock is dissolved (Culver and Pipan 2009, pp. 5-8; Stafford et al. 2014, pp. 8-18).

The Kretschmarr Cave mold beetle is one of 14 troglobitic (i.e., species adapted to subterranean habitats that must complete their life-cycle underground) Pselaphinae occurring in Texas (Chandler et al. 2009, pp. 126, 136). These species occur primarily in the dark zone of caves, often in humid microhabitats (e.g., under rocks), and exhibit such troglomorphic traits (i.e., adaptations to subterranean environments) as absent or reduced eyes, elongated antennae and legs, and elongated sensory setae (i.e., hair-like structures) (Chandler 1992, pp. 241, 245, 247; Chandler and Reddell 2001, pp. 115, 123, 127; Chandler et al. 2009, p. 126). Research indicates that cave-dwelling arthropods often display preferences for higher relative humidity and/or relatively narrow temperature regimes underscoring a dependence on subterranean conditions (Bull and Mitchell 1972, pp. 375, 386; Howarth 1980, pp. 397-399; Howarth 1987, pp. 5-7; Weinstein 1994, p. 369-370; Doran et al. 1999, pp. 258-259; Lavoie et al. 2007, pp. 121; Yoder et al. 2011, p. 15; Mammola and Isaia 2014, p. 350; Mammola et al. 2015, pp. 246-247).

Cave-dwelling pselaphines, such as the Kretschmarr Cave mold beetle, likely require subterranean habitats with high humidity and relatively stable temperatures (Hlavác et al. 1999 p. 243; Hlavác and Jalźic 2009, p. 224; Hlavác and Jalźic 2010, p. 116; Carlton 2012, p. 185; Pavićević and Ozimec 2013, pp. 65-66). Intact networks of subterranean voids provide living space and a buffer or refugia from the effects of humidity and temperature extremes (Howarth 1980, pp. 397-398; Howarth 1983, p. 373; Martín and Oromí 1986, p. 384; Holsinger 1988, p. 147; de Freitas and Littlejohn 1987, pp. 559-560; Crouau-Roy et al. 1992, pp. 13-15; Tobin et al. 2013, p. 206; Mammola et al. 2015, pp. 243, 246; Mammola and Isaia 2016, pp. 26-27). Functional surface and subsurface drainage basins supply water that aids in the maintenance of high relative humidity (Hauwert 2009, p. 84; Veni 2003, p. 7).

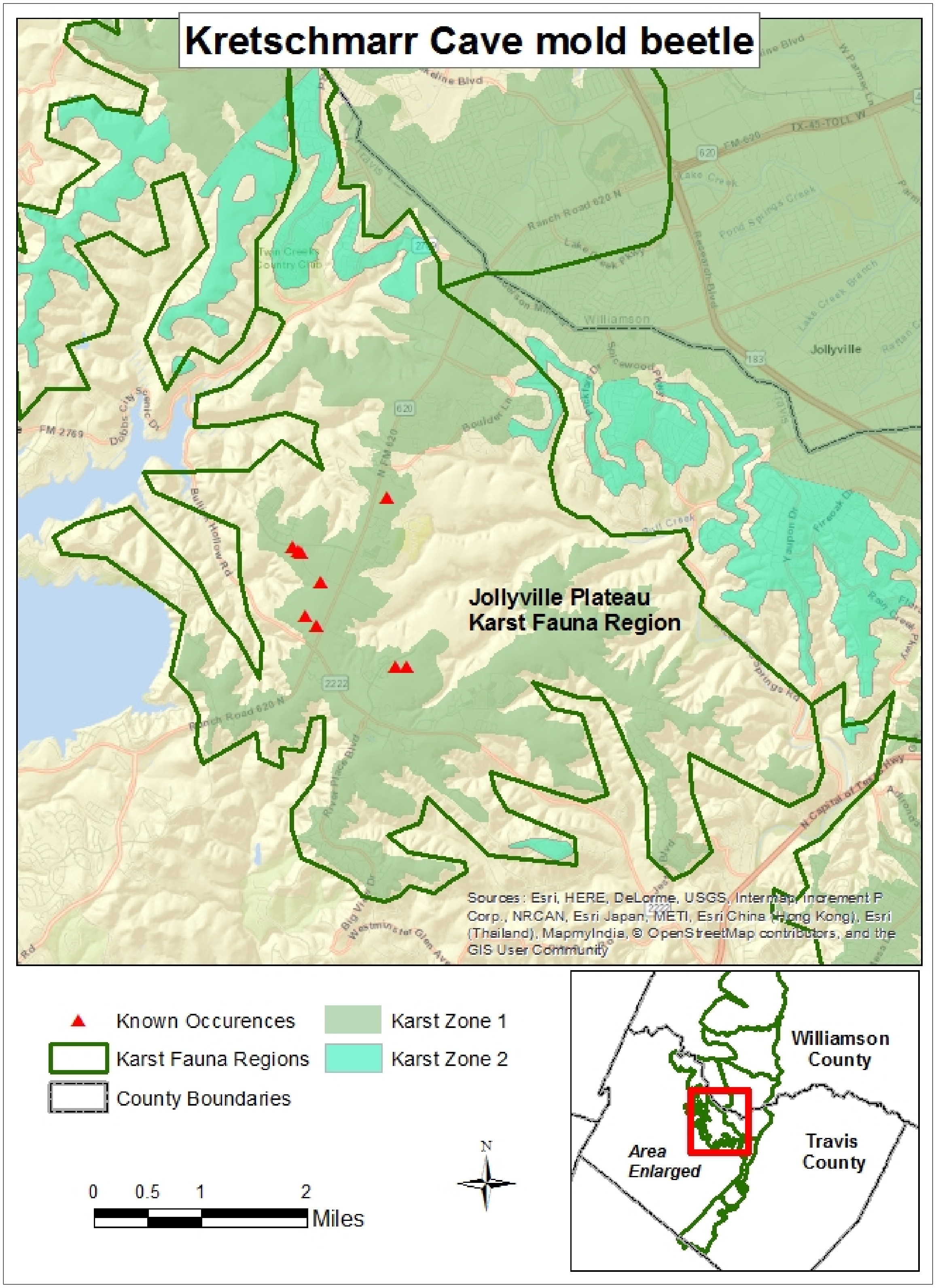
Most pselpahines are predators and the Kretschmarr Cave mold beetle likely requires a source of food in the form of other invertebrates such as mites and springtails (Park 1960, p. 99; Newton and Thayer 1995, p. 303; Taylor et al. 2005, pp. 10, 29; Schomann et al. 2008, pp. 891-906; Ferro and Carlton 2014, p. 8). The majority of nutrients that support subterranean ecosystems originate from surface habitats, specifically the natural communities that overlay these systems (Barr 1968, pp. 47-48; Poulson and White 1969, pp. 971-972; Howarth 1983, p. 376; Culver and Pipan 2009, p. 23). Availability of surface nutrients is an important factor in the maintenance of species richness in caves with greater amounts of nutrients supporting higher species richness (Jaffé et al. 2016, pp. 6, 9, 11; Jiménez-Valverde 2017, pp. 10210-10212).

Nutrients may take the form of animal or plant material washed in by water, blown by wind, or transported by animals (Barr 1968, pp. 51, 53; Howarth 1983, pp. 376-377; Holsinger 1988, p. 147; Jasinska et al. 1996, p. 518; Culver and Pipan 2009, pp. 24, 27-39). Deposited organic matter provides a resource base for bacteria, fungi, and invertebrates that serve as prey for other invertebrates as well as vertebrates in caves (Barr 1968, pp. 53-60; Kane and Poulson 1976, pp. 799-800; Longley 1981, pp. 126-127; Howarth 1983, pp. 378-379; Ferreira et al. 2000, pp. 108-109).

Cave crickets are contributors of nutrients in some subterranean ecosystems, including those of the Edwards Plateau (Barr 1968, pp. 51, 53; Peck 1976, p. 315; Veni et al. 1999, pp. 45-46; Sharrat et al. 2000, p. 123; Reddell and Cokendolpher 2001, pp. 132-133; Taylor et al. 2004, pp. 9, 28, 31; Lavoie et al. 2007, p. 131; Peck and Wynne 2013, p. 314). Cave crickets roost in caves during the day, leaving at night to forage on animal and/or plant matter in the surrounding plant communities (Taylor et al. 2004, pp. 37-38; Taylor et al. 2005, p. 105). Nutrients obtained during foraging are transferred into the cave through defecation (i.e., guano), laying of eggs, predation of living crickets, and carcasses of dead crickets (Barr 1968, p. 53; Mitchell 1971, p. 259; Elliott 1994, p. 16; Poulson et al. 1995, pp. 226, 229; Taylor et al. 2003, p. 47; Lavoie et al 2007, p. 131). The natural foraging habitat surrounding a cave is vital to the maintenance of cave cricket populations (Taylor et al. 2007, pp. 2, 37, 43). Declines in cave cricket populations can potentially lead to decreased abundances for other karst invertebrates (Taylor et al 2007, pp. 2, 37, 41-44).

The stressors that most influence Kretschmarr Cave mold beetle viability are habitat destruction, degradation, and fragmentation that results from urban development. The species' range in Travis County has experienced substantial human population growth and development (Theobald 2005, pp. 15, 22; Berube et al. 2006, p. 12; Neumann and Bright 2008, pp. 8-11, 13; Torrens 2008, pp. 8-9, 16, 33; Frey 2012, pp. 4, 14; Potter and Hoque 2014, pp. 2, 5; Urban Land Institute 2016, p. 9). In Travis County, the human population increased between 1980 and 2017, from 419,573 people to 1,226,698 people (U.S. Census Bureau 1982, p. 10; U.S. Census Bureau 2018b). Expansion of urban, suburban, and exurban developments has led to loss and fragmentation of natural habitat in this county. Numbers of single and multi-family housing units in Travis County increased by 394% over a 46-year period, from 100,882 units in 1970 to 499,062 units in 2016 (U.S. Census Bureau 2012, p. 9; U.S. Census Bureau 2018a).

Figure 1. Distribution of the Kretschmarr Cave mold beetle in Travis County, Texas.



1.3.1 FR Notice citation announcing initiation of this review:

83 FR 25034, May 31, 2018

1.3.2 Listing history

Original Listing
FR notice: 53 FR 36029
Date listed: September 16, 1988
Entity listed: Kretschmarr Cave mold beetle (*Texamaurops reddelli*)
Classification: Endangered

1.3.3 Associated rulemakings:

Not applicable.

1.3.4 Review history:

Status reviews for the Kretschmarr Cave mold 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 for a 5-year review (Service 2009, entire).

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

2C

1.3.6 Recovery Plan or Outline

Name of plan or outline: Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas
Date issued: 1994

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

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

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes. The recovery plan identifies downlisting criteria; however, no delisting criteria were identified in the recovery plan.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No. After the recovery plan was completed, additional work on other karst invertebrates lead to the development of delisting criteria which may be applicable to this species as well.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

Yes.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

The Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, pp. 86-88) only provides criteria for downlisting from endangered to threatened. The Kretschmarr Cave mold beetle will be considered for reclassification from endangered to threatened when:

> (1) Three karst fauna areas (if at least three exist) within each karst fauna region in each species' range are protected in perpetuity. If fewer than three karst fauna areas exist within a given karst fauna region, then all karst fauna areas within that region should be protected. If the entire range of a given species contains less than three karst fauna areas, then they should all be protected for that species to be considered for downlisting.
>
> (2) Criterion (1) has been maintained for at least five consecutive years with assurances that these areas will remain protected in perpetuity.

Karst geologic areas were established for Travis and Williamson counties by Veni and Associates (1992, p. 52) and incorporated as karst fauna regions into the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, pp. 28-34). Geologic continuity, hydrology, and the distribution of rare karst invertebrates informed delineation of these regions (Service 1994, p. 76). The Kretschmarr Cave mold beetle occurs in one of the eight karst fauna regions demarcated for Travis and Williamson counties, the Jollyville Plateau Karst Fauna Region (Figure 1).

A karst fauna area is a geographic area known to support one or more locations of an endangered karst invertebrate species (Service 1994, p. 87). A karst fauna area is distinct in that it acts as a system separated from other karst fauna areas by geologic and hydrologic features and/or processes or distances that create barriers to movement of water, contaminants, and troglobitic invertebrate fauna. Karst fauna areas should be far enough apart that a catastrophic event (e.g., contaminants from a spill, pipeline leak, or flooding, etc.) that may kill karst invertebrates or destroy habitat in one karst fauna area would be unlikely to affect karst invertebrates or habitat in other karst fauna areas. Within each karst fauna region, an established karst preserve may be considered a karst fauna area if it meets recovery criteria.

Brief summary of preserve design principles:

Much of the conservation and recovery of the Kretschmarr Cave mold beetle depends upon the long-term protection of surface and subsurface habitat. The study of troglobitic invertebrates is complicated by their cryptic nature, low observed abundances, and difficulty in accessing and adequately surveying subterranean habitats (Park 1960, p. 90; Veni et al. 1999, p. 28; Sharratt et al. 2000, pp. 119-121; Culver et al. 2004, p. 1223; Schneider and Culver 2004, pp. 42-43; Krejca and Weckerly 2007, pp. 8-10; Mosely 2009, pp. 50-51; Paquin and Dupérré 2009, pp. 6, 64; Schneider 2009, pp. 125-128; Wakefield and Zigler 2012, p. 25; Wynne 2013, p. 53; De Ázara and Ferreira 2014, p. 272; Pape and O'Connor 2014, p. 785; Stoev et al. 2015, p. 108; Souza and Ferreira 2016, p. 257; Trajano et al. 2016, p. 1822; Bichuette et al. 2017, pp. 82-83; Jiménez-Valverde et al. 2017, p. 10213; Sendra et al. 2017a, p. 101; Sendra et al. 2017b, p. 49; Nae et al. 2018, p. 22). Therefore, conservation strategies for the Kretschmarr Cave mold beetle focus on the delineation, protection, and management of occupied karst fauna areas.

The Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas provides guidelines on habitat conditions that are important to karst invertebrates, including maintaining stable humidity and temperatures, nutrient input from surface plant communities, preventing surface and subsurface contamination, controlling the invasion of non-native species (i.e., red-imported fire ants), and allowing for potential nutrient and karst invertebrate movement through subterranean interstitial spaces (Service 1994, pp. 48-58). Scientific information and additional karst preserve guidelines are further detailed in the Bexar County Karst Invertebrates Recovery Plan (Service 2011, pp. 19-22), Karst Preserve Design Recommendations (Service 2012, entire), and the Karst Preserve Management and Monitoring Recommendations (Service 2014, entire). According to the Karst Preserve Design Recommendations, karst fauna areas should meet the following objectives (Service 2012, p. 1):

- Provide adequate quality and quantity of moisture to karst ecosystems
- Maintain stable in-cave temperatures
- Reduce or remove red-imported fire ant predation/competition
- Provide adequate nutrient input to karst ecosystems
- Protect mesocaverns to support karst invertebrate population needs, including adequate gene flow and population dynamics

- Ensure resiliency of karst invertebrate populations by establishing preserves large enough to withstand random or catastrophic events
- Provide a high probability of viable karst invertebrate population persistence in each preserve
- Minimize the amount of active management needed for each preserve

For a karst fauna area to count toward meeting recovery criteria that area must be of a certain quality (i.e., high or medium). A legally binding mechanism must also assure management and perpetual protection of the area. The quality of a preserve is an indicator of how likely species are to survive for the long-term. Details regarding preserve quality are as follows (Service 2012, p. 3):

I. High Quality Preserve:

High quality preserves have a higher probability of long-term survival of karst invertebrates. A high quality preserve is at least 40 hectares (ha) (100 acres [ac]) and includes the following components:

- The entire surface and subsurface drainage basin of caves and karst features
- The native surface plant and animal communities
- The cave or karst feature footprint, which should be over 105 meters (m) [345 feet (ft)] from the preserve edge

II. Medium Quality Preserve:

A medium quality preserve is 16 to 40 ha (40 to 99 ac) and includes the following components:

- The entire surface and subsurface drainage basin of caves and karst features
- The native surface plant and animal communities
- The cave or karst feature footprint, which should be over 105 m (345 ft) from the preserve edge

III. Low Quality Preserve:

A low quality preserve is less than 16 ha (40 ac). Low quality preserves should only be established in areas where conditions for high or medium quality preserves do not exist. While these preserves will not contribute to meeting the recovery criteria set forth for endangered karst invertebrate species, they help increase their probability of overall survival beyond what it would be without them; so they do have some value.

***Analysis regarding whether downlisting criteria have been met*:**

At the time of the 2009 5-year review for the Kretschmarr Cave mold beetle, no karst fauna areas had been established for this species (Service 2009, p. 5). The 5-year review identified three sites (i.e., Gallifer, Stovepipe, and Tooth Caves) in the Jollyville Plateau Karst Fauna Region that had the potential to meet karst fauna area criteria (Service 2009, pp. 5-12). However, insufficient information was available regarding subsurface drainage basin delineations, tract acreage, and management and perpetual protection mechanisms to determine if those sites met qualifying criteria.

As of 2018, no karst fauna areas have been recognized for the Kretschmarr Cave mold beetle (Table 1). Nine caves occupied by the species receive some level of protection within the Balcones Canyonlands Preserve (Balcones Canyonlands Preserve 2016, pp. 6-8). Ownership of these tracts varies from City of Austin, Travis County, to private holdings (Table 2). Per our methodology described in sections 2.3.1.5 and 2.3.1.6 below, eight caves were grouped into two cave clusters (i.e., Cuevas (Tomen Park) and Four Points Cave Clusters) based on proximity. The remaining site represents an individual cave (i.e., Stovepipe Cave). All three sites have potential as karst fauna areas. To receive that recognition, we would need additional information to determine if these sites meet qualifying criteria including surface and subsurface drainage basin delineations, cave location(s), confirmation of Kretschmarr Cave mold beetle presence, tract acreage, management and perpetual protection mechanisms, among others. Recovery criteria for the Kretschmarr Cave mold beetle have not been achieved in the Jollyville Plateua Karst Fauna Region.

Table 1. Potential, proposed, and protected karst fauna areas by karst fauna region.

Karst Fauna Region	Potential Karst Fauna Area(s)	Proposed Karst Fauna Area(s)	Protected Karst Fauna Area(s)
Jollyville Plateau	3	0	0

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

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

No new information.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

No new information.

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

No new information.

2.3.1.4 Taxonomic classification or changes in nomenclature:

Newton and Thayer (1995, pp. 302-303) reduced the family Pselaphidae to a subfamily (i.e., Pselaphinae) within the family Staphylinidae (Bouchard et al. 2011, p. 31).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The 2009 5-year review for the Kretschmarr Cave mold beetle listed eight caves with records of that species (Service 2009, pp. 2, 7). This review documented nine caves with records of the beetle. Confirmation of the species from Kretschmarr Double Pit Cave accounts for the single cave increase since 2009.

An important consideration for this 5-year review was whether occupied caves warranted consolidation into single populations based on geographic proximity (Service 2018, pp. 24, 49-50). Although there are no data specific to the Kretschmarr Cave mold 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*=*Neoleptoneta*) 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 other 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*=*Neoleptoneta 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 (e.g., 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 m (958 ft).

For our assessment, we assumed that populations of the Kretschmarr Cave mold 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 Kretschmarr Cave mold beetle dispersal distances may be greater or less than that value. Genetic analyses would be necessary to provide more certainty regarding actual dispersal distances.

For each cave occupied by the Kretschmarr Cave mold 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 Kretschmarr Cave mold 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 occurrences into a total of two cave clusters and one individual cave (Table 2).

Table 2. Kretschmarr Cave mold beetle cave clusters and individual caves.

Karst Fauna Region	County	Ownership
Jollyville Plateau		
Cave Cluster(s)		
Cuevas (Tomen Park) Cave Cluster	Travis	Travis County
Four Points Cave Cluster	Travis	Private
Individual Cave(s)		
Stovepipe Cave	Travis	City of Austin

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

The population needs of the Kretschmarr Cave mold 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 Kretschmarr Cave mold 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 (2018, 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 2016 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 2018, 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 2018, p. 52). We also 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 Kretschmarr Cave mold beetle populations and the associated karst ecosystem. However, a sites' 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 Kretschmarr Cave mold beetles over the long-term.

Impacts to a cave’s surface or subsurface drainage basin can be a significant source of stressors for Kretschmarr Cave mold 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 Kretschmarr Cave mold beetle persistence.

Based on our review, two cave clusters and an individual cave are currently of high to moderate resiliency with potential to support Kretschmarr Cave mold beetle populations over the long-term (Table 3). For the most part, these sites are located in larger tracts of open space, have relatively unaltered cave cricket foraging areas, and are afforded some level of protection through the Balcones Canyonlands Preserve. The high resiliency Cuevas (Tomen Park) Cave Cluster contains six caves occupied by the species and is owned and managed by Travis County. The privately owned Four Points Cave Cluster, another high resiliency sites, contains two caves occupied by the Kretschmarr Cave mold beetle. This area was set aside as mitigation for a 10(a)(1)(B) permit and Habitat Conservation Plan. The moderate resiliency Stovepipe Cave is located on the City of Austin’s Canyon Creek Preserve. Although this tract protects the cave’s cave cricket foraging area and surface drainage basin, portions of the subsurface drainage basin likely extend off the preserve. Additional information is needed to determine if these sites meet karst fauna area criteria and guidelines.

Currently, there are two high resiliency cave clusters and a moderate resiliency individual cave in the Jollyville Plateau Karst Fauna region. Additional information is needed to determine if resiliency can be maintained over the long-term given rapid human population growth and increasing development pressures.

Table 3. Current resiliency of Kretschmarr Cave mold beetle sites (cave clusters and individual caves).

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
Jollyville Plateau Karst Fauna Region				
Cave Cluster(s)				
Cuevas (Tomen Park) Cave Cluster				**High**
Amber Cave	>40 (>100)	<120 (<394)	25-50%	Low
Gallifer Cave	>40 (>100)	>120 (>395)	0%	High
Tardus Hole	>40 (>100)	<120 (<395)	25-50%	Low
Tooth Cave	>40 (>100)	<120 (<395)	0-25%	Moderate
Kretschmarr Cave	>40 (>100)	<120 (<395)	25-50%	Low
Kretschmarr Double Pit	>40 (>100)	<120 (<395)	25-50%	Low
Four Points Cave Cluster				**High**
Japygid Cave	>40 (>100)	<120 (<394)	50%-75%	Moderate
M.W.A. Cave	>40 (>100)	>120 (>394)	25-50%	High
Individual Cave(s)				
Stovepipe Cave	16-40 (40-100)	>120 (>394)	75-100%	Moderate

2.3.1.7 Other:

No new information.

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

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The range of the Kretschmarr Cave mold beetle in Travis County 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 area was among the fastest growing metropolitan areas in the United States (Frey 2012, p. 4). In 2018, the U.S. Census Bureau

(2018a) rated the Austin-Round Rock area as the ninth fastest growing metropolitan area in the United States.

In Travis County, the human population grew substantially between 1980 and 2010, from 419,573 people to 1,024,266 people (144% increase over 30 years; U.S. Census Bureau 1982, p. 10; U.S. Census Bureau 2012, p. 9). The county's largest city, the City of Austin, grew from 345,890 people in 1980 to a projected 949,587 people in 2017 (174% increase over 37 years; City of Austin 2018). From 2010 to 2017, the population of Travis County increased to 1,226,698 people (U.S. Census Bureau 2018b), an increase of 192% since 1980.

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), numbers of single and multi-family housing units in Travis County more than tripled over a forty-year period from 1970 to 2010, from 100,882 units to 441,240 units. From 2010 to 2016, number of housing units increased to 499,062 units (U.S. Census Bureau 2018a), an increase of 394% since 1970.

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).

Population projections for Travis County indicate substantial increases will continue over the next several decades (i.e., through 2050). Projections from the Texas Demographic Center (2014) estimate that Travis County will increase in population from 1,099,512 people in 2017 to either 1,612,674 people (One-half 2000-2010 Migration (0.5) Scenario) or 2,011,009 people (2000-2010 Migration (1.0) Scenario) in 2050, a 47% or 83% increase over 33 years, respectively. The City of Austin's population is expected to reach 1,361,464 people by 2050 (City of Austin 2018), an increase of 43% over 33 years.

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 25.1%-40% in 2010 to 60.1%-80% in 2060 (Nowak and Greenfield 2018b, p. 170).

The Kretschmarr Cave mold 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 Kretschmarr Cave mold 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), there is a potential that remaining surface and subsurface habitats will could be impacted in the absence of management and protection specifically tailored to the needs of the Kretschmarr Cave mold beetle.

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

No new information.

2.3.2.3 Disease or predation:

Recent research underscores the importance of human disturbance to red-imported fire ant invasion. Although habitat disturbance facilitates red-imported fire ant establishment in affected natural communities (LeBrun et al. 2012, pp. 891-893; King and Tschinkel 2013, p. 73), the absence of disturbance does not preclude invasion of undisturbed areas. In southern Texas, LeBrun et al. (2012, pp. 891-892) noted that red-imported fire ants were able to establish colonies in undisturbed grassland and achieve abundances comparable to dominant native ant species. The prevalence of this non-native ant in those grasslands, however, was lower than in disturbed grasslands (LeBrun et al. 2012, p. 888). Red-imported fire ant prevalence can decline following the cessation of disturbance but several decades may be required before populations reach the lower levels observed in undisturbed habitats (LeBrun et al. 2012, p. 892).

Since the 2009 5-year review, a new non-native invasive ant species has established colonies at sites in Travis County. The tawny crazy ant (*Nylanderia fulva*), native to South America, was documented in Texas in 2002 and has established populations along the state's Gulf Coast and some central Texas counties (Wang et al. 2016, p. 4). This ant has exhibited a potential to affect native animal and plant communities (LeBrun et al. 2013, p. 2439; Wang et al. 2016, p. 5).

Tawny crazy ant colonies are often polygynous and can form dense infestations that dominate the local ant community (LeBrun et al. 2013, p. 2433). Arthropod species richness and abundance may decline in areas infested by tawny crazy ants (LeBrun et al. 2013, pp. 2434-2435; Wang et al. 2016, pp. 5, 7). Tawny crazy ants also appear capable of eliminating red-imported fire ants from areas where the species co-occur (LeBrun et al. 2013, pp. 2436-2437). Unlike red-imported fire ants that generally prefer open-habitat types, the tawny crazy ant can reach high densities in forested habitats along with grasslands and other open-habitat types (LeBrun et al. 2013, pp. 2439-2440). Sites with dense canopies, therefore, would be afforded some decreased susceptibility to red-imported fire ants but not the tawny crazy ant.

Tawny crazy ants have established populations at Whirlpool and No Rent Caves in Travis County (LeBrun 2017, p. 3). LeBrun (2017, entire) assessed the effects of tawny crazy ants at these caves. Based on observations at these two sites, use of caves by ants was tied to surface temperatures and moisture with tawny crazy ants most prevalent in caves during hot, dry summer conditions (LeBrun 2017, p. 35). Tawny crazy ants preyed on cave crickets and other karst invertebrates with one species, the spider *Cicurina varians*, experiencing decreased abundance associated with that ant's presence (LeBrun 2017, pp. 21-22, 35-36). No declines were noted for other karst invertebrates examined, though sample size was small (LeBrun 2017, pp. 22, 35). Additional research is needed to determine the potential for the tawny crazy ant to affect karst invertebrates.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

No new information.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

No new information.

2.4 Synthesis

There are currently two cave clusters and one individual cave of high to moderate resiliency with potential to support Kretschmarr Cave mold 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

Kretshmarr Cave mold beetle populations at these sites are 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.

Projections indicate that the combined human population of Travis County will grow from 1,599,419 people in 2017 to between 2,605,488 and 3,987,967 people in 2050, an increase of 63%-149% over 33 years (Texas Demographic Center 2014). Such significant human population growth is projected to result in increased conversion of natural surface habitat to urban land uses through 2060 (Nowak and Greenfield 2018b, p. 170). If adequate protections are not enacted and maintained, land clearing, residential and commercial construction, and installation of infrastructure will accompany this growth and degrade the resiliency of high and moderate resiliency sites over time.

Recovery criterion (1) in Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994, pp. 86-88) states that three karst fauna areas within each karst fauna region 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.

The Balcones Canyonlands Preserve contributes to the current resiliency of Cuevas (Tomen Park) Cave Cluster, Four Points Cave Cluster, and Stovepipe Cave. These sites are located in areas of Travis County that have experienced substantial urban development. The protections provided by the preserve system have maintained large amounts of open space surrounding most of these caves and the integrity of cave cricket foraging habitat. Additional information is needed to determine if these sites meet karst fauna area criteria and guidelines. At present, recovery criteria for the Kretschmarr Cave mold beetle have not been achieved. In Travis County, 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 Kretschmarr Cave mold beetle given the lack of recognized karst fauna areas.

3.0 RESULTS

3.1 Recommended Classification:

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist (*Indicate reasons for delisting per 50 CFR 424.11):***
 ____ *Extinction*
 ____ *Recovery*
 ____ *Original data for classification in error*
__X__ **No change is needed**

3.2 New Recovery Priority Number: No change (2C)

Brief Rationale: A Recovery Priority Number of 2C is indicative of a taxon with a high degree of threat, a high recovery potential, and the taxonomic standing of a species. The C indicates that the species' recovery conflicts with water demands, development projects, or other forms of economic activity. The Kretschmarr Cave mold beetle continues to be threatened by a high degree of habitat destruction, disturbance, and degradation across its range. However, we consider this species' potential for recovery to be feasible through the concerted efforts of Service personnel and our partners to restore, enhance, and protect habitat.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

I. Obtain information for 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 sites to be recognized as karst fauna areas.

II. Draft quantitative delisting criteria for the Kretschmarr Cave mold beetle and other listed karst invertebrates in Travis and Williamson counties, Texas.

III. Reassess the current karst fauna regions of Travis and Williamson counties, Texas using current data and revise regions as necessary to better inform recovery efforts.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Kretschmarr Cave mold Beetle (*Texamaurops reddelli*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Review Conducted By: Michael Warriner and Jenny Wilson, Austin Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ______________________________ Date July 6, 2018