Robber Baron Cave Meshweaver
(*Cicurina baronia*)

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Robber Baron Cave Meshweaver (*Cicurina baronia*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
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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 Act (Act) to conduct a status review of each listed species once every five 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 Act. 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 provides notice of status reviews via the Federal Register and requests new information on the status of the species (e.g., life history, habitat conditions, and threats). Data for this status review were solicited from interested parties through a Federal Register notice announcing this review on March 19, 2020 (85 FR 15795). The Austin Ecological Services Field Office conducted this review and considered both new and previously existing information from federal and state agencies, municipal and county governments, non-governmental organizations, academia, and the public. Primary sources of information used in this review were recovery criteria and guidelines from the Bexar County Karst Invertebrates Recovery Plan (Service 2011a, pp. 16-26), Karst Preserve Design Recommendations (Service 2012, entire), and Karst Preserve Management and Monitoring Recommendations (Service 2014, entire). Unless otherwise noted, all acreage and distance estimates were calculated using Geographic Information Systems (GIS), 2020 digital aerial photography (Digital Globe 2020), and 2019 Bexar County parcel data (Strategic Mapping Program 2019). These estimates are subject to typical margins of error (about 30 meters (m)

[94.4 feet (ft)]) associated with Global Positioning Systems (GPS) units, GIS, and transferring data from paper sources to digital media.

1.4 Background:

The Robber Baron Cave meshweaver (Arachinida: Araneae: Hahnidae: *Cicurina baronia*) [Gertsch 1992]) is a small, eyeless, troglobitic spider endemic to a restricted range in the karst landscape of northern Bexar County, Texas (Gertsch 1992, p. 109; Cokendolpher 2004, pp. 24, 38; Paquin and Dupérré 2009, pp. 15, 58; Hedin et al. 2018, p. 62). 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). Rising waters (i.e., hypogenic) from depth have also played a role in cave formation in this region (Schindel and Gary 2018, pp. 80, 83-85).

The Robber Baron Cave meshweaver is one of 58 currently recognized species of eyeless Cicurina described within the subgenus *Cicurella*, all but four of which are found in Texas (Gertsch 1992, pp. 97-120; Cokendolpher 2004, pp. 38-56; Paquin and Dupérré 2009, pp. 9-62; Hedin et. al. 2018, p. 50). Nine of the species found in Texas, including the Robber Baron Cave meshweaver, are found only in Bexar County (Gertsch 1992, pp. 101, 103, 109, 111; Cokendolpher 2004, pp. 38-44, 46, 47-48, 51-56; Paquin and Dupérré 2009, pp. 15-17, 27-29, 33-34, 38, 52-53).

The eyeless species of *Cicurina* in Bexar County, including the Robber Baron Cave meshweaver are all troglobites (i.e., species that spend their entire life-cycle underground) and exhibit morphological adaptation to subterranean environments (i.e., troglomorphy) including the lack of eyes, large size, longer appendages, and lighter coloration (Cokendolpher 2004, p. 23). They all inhabit dark, moist areas of caves and other subterranean voids and do not occur at or very near twilight zones (Cokendolpher 2004, p. 20).

Studies indicate that troglobitic arthropods display preferences for higher relative humidity and/or lower air temperatures, underscoring a dependence on deep cave conditions (Bull and Mitchell 1972, pp. 375, 386; Yoder et al. 2011, p. 599; Mammola et al. 2015, pp. 246-247; Mammola and Isaia 2017, p. 3). Thus, the Robber Baron Cave meshweaver likely requires subterranean habitats with high humidity and stable temperatures. 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. 558-560; 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).

Cicurinas are predators, biting and holding their prey with their chelicerae (jaw-like appendages) while the venom acts (Cokendolpher 2004, p. 21). Cricket nymphs and a range of other cavernicolous invertebrates, including *Brackenridgia* isopods, *Texoreddellia* silverfish, *Cambala* and *Speodesmus* millipedes, and *Pseudosinella* springtails found in the dark zone of caves, are potential food for the eyeless *Cicurinas* (Cokendolpher 2004, p. 21).

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; Jasinska et al. 1996, p. 518). 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; 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). 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).

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; 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; Lavoie et al 2007, p. 131). 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).

Known from one cave at the time, the Robber Baron Cave meshweaver was listed as endangered on December 26, 2000, due to its restricted distribution and threats from urban development (65 FR 81419). The stressors that most influence the Robber Baron Cave meshweaver viability are habitat destruction, degradation, and fragmentation that results from urban development.

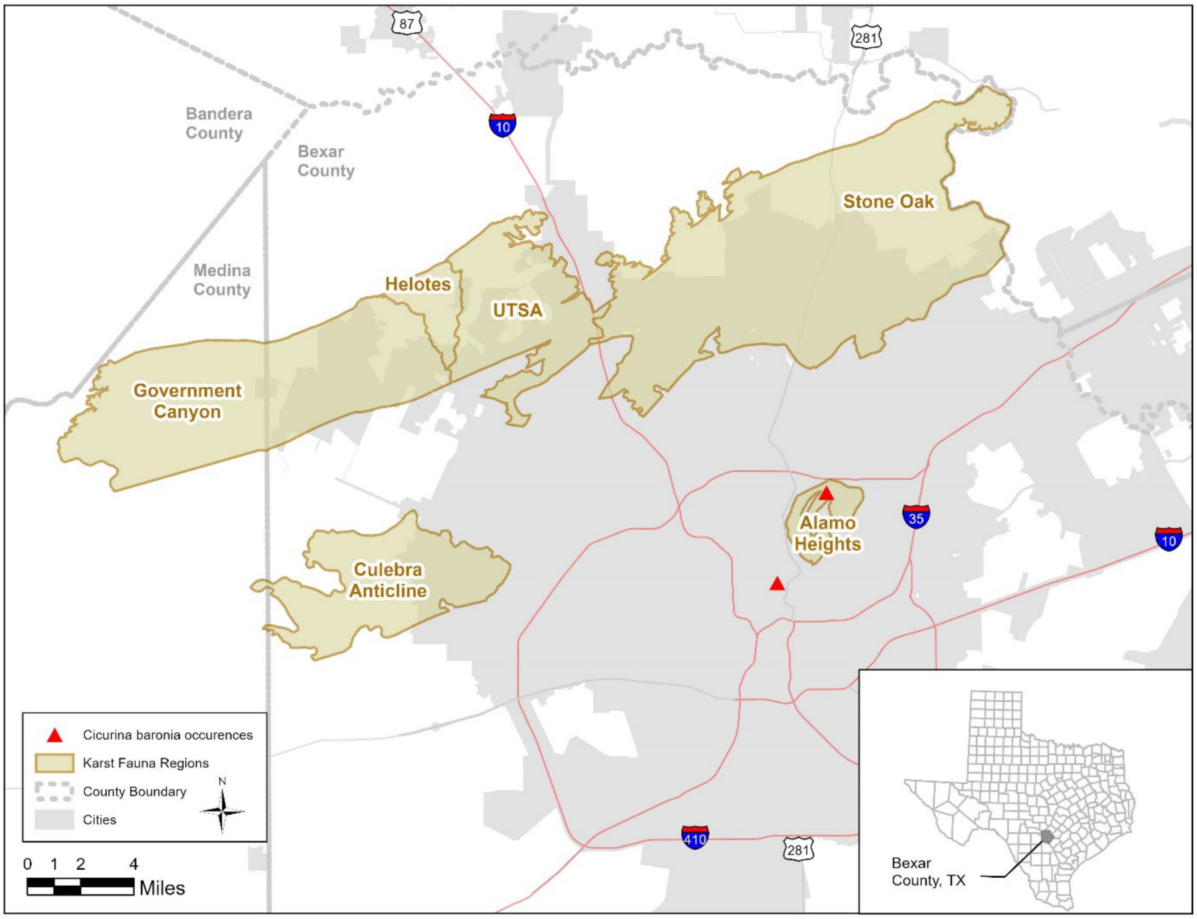

Figure 1. Current distribution of the Robber Baron Cave meshweaver in Bexar County, Texas

1.4.1 FR Notice citation announcing initiation of this review:

85 FR 15795, March 19, 2020

1.4.2 Listing history

Original Listing
FR notice: 65 FR 81419
Date listed: December 26, 2000
Entity listed: Robber Baron Cave meshweaver (*Cicurina baronia*)
Classification: Endangered

1.4.3 Associated rulemakings:

Critical habitat was designated for seven of the nine listed Bexar County karst invertebrates, including the Robber Baron Cave meshweaver, as announced in an April 8, 2003, Federal Register notice (68 FR 17156). In this critical habitat designation, the Service began using the new common names for six of the listed Bexar County invertebrates, due to changes in the common names of these species as a result of a meeting of the Committee on Common Names of Arachnids of the American Arachnological Society in 2000 (Breene et al. 2001, pp. 10, 12, 14, 15). Accordingly, we changed the common name of the Robber Baron Cave spider to the Robber Baron Cave meshweaver (Breene et al. 2001, p. 15).

On February 22, 2011, the Service proposed a revision of the previous critical habitat designations (68 FR 17156) and proposed critical habitat for the Government Canyon Bat Cave spider (*Tayshaneta* [=*Neoleptoneta*] *myopica*) and the Government Canyon Bat Cave meshweaver (*Cicurina vespera*) (76 FR 9872). A notice extending the comment period on the proposed revisions was published on August 2, 2011 (76 FR 46234), and the final notice announcing the revised designated critical habitat was published on February 14, 2012 (76 FR 8540).

1.4.4 Review history:

Status reviews for the Robber Baron Cave meshweaver were conducted in 2000 for the final listing of the species (65 FR 81419) and 2011 in a 5-year review (Service 2011b, entire). The 2011 5-year review recommended no change in classification of endangered (Service 2011b, p. 19).

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

5C

1.4.6 Recovery Plan or Outline

Name of plan or outline: Bexar County Karst Invertebrates Recovery Plan
Date issued: September 2011

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.

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:

Goal - The goal of the recovery plan is to reduce or remove threats to the species such that their long-term survival is secured in the wild, the species are no longer endangered or threatened, and can be delisted.

Objective 1 - Perpetually preserve a sufficient amount and configuration of habitat areas (karst fauna areas or KFAs) to preserve populations that span the range and provide representation of the genetic diversity of the species. This will help conserve their adaptive capabilities and will help protect the species survival in the event of catastrophic or other stochastic influences. When preserved, ensure these areas have a high probability of the species survival in perpetuity.

Objective 2 - Manage these areas to remove threats to the species' survival.

The following criteria were developed to measure our successes at accomplishing the objectives and reaching the goal above.

Criterion 1 (downlisting) - The location and configuration of at least the minimum quality and number of KFAs in each karst fauna region (KFR) for each species are preserved. Also, legally binding commitments are in place for perpetual protection and management of these KFAs. Overarching criteria that are applied per species include:

(1) at least one high quality protected KFA per KFR;
(2) at least three total medium or high quality protected KFAs per KFR;
(3) a minimum of six protected KFAs rangewide per species;
(4) a minimum of three high quality KFAs;
(5) all KFAs at least medium or high quality.

Criterion 2 - (delisting) - In addition to the downlisting criterion, monitoring and research have been completed to conclude with a high degree of certainty that KFA sizes, quality, configurations, and management are adequate to provide a high probability of the species survival (greater than 90 percent over 100 years). To assess adequacy, results should be measured over a long enough time that cause and effect can be inferred with a high degree of certainty.

For the purposes of the recovery program, a KFA is an area known to support one or more locations of a listed species. A KFA is distinct in that it acts as a system that is separated from other KFAs by geologic and hydrologic features and/or processes that create barriers to the movement of water, contaminants, and troglobitic fauna. Karst fauna areas should be far enough apart so that if a catastrophic event (for example, contamination of the water supply, flooding, disease) were to destroy one of the areas, that event would not likely destroy any other area occupied by that species.

To be considered adequate to contribute to meeting the recovery criteria, a KFA must be sufficiently large to maintain the integrity of the karst ecosystem on which the species depend(s). In addition, to be considered "protected" these areas must provide protection in perpetuity from threats such as red-imported fire ants, habitat destruction, and contaminants.

There are six KFRs in Bexar County that contain listed species. These regions are delineated based on geologic continuity, hydrology, and the distribution of rare troglobites (Veni 1994, entire). These six KFRs were used in the final rule to define the ranges of the listed species and are as follows: Stone Oak, University of Texas at San Antonio (UTSA), Helotes, Government Canyon, Culebra Anticline, and Alamo Heights (Figure 2).

Based on current information, the Robber Baron Cave meshweaver occurs in the Alamo Heights KFR. In order to meet Criterion 1 (downlisting), there would need to be at least six protected KFAs in this KFR, with at least three of those meeting the criteria for a high quality KFA.

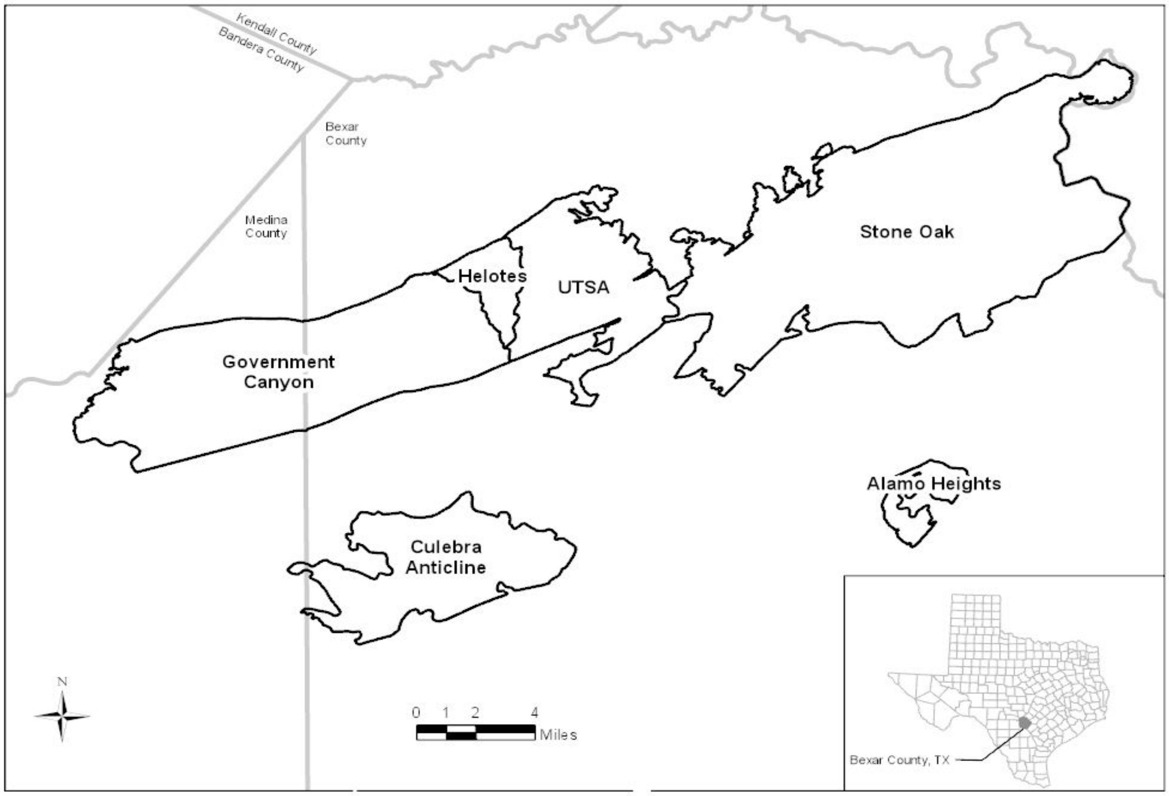

Figure 2. Karst Fauna Regions of Bexar County, Texas.

Brief summary of preserve design principles:

Much of the conservation and recovery of the Robber Baron Cave meshweaver 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 (Veni et al. 1999, p. 28; Culver et al. 2004, pp. 1222-1223; Schneider and Culver 2004, pp. 42-43; Krejca and Weckerly 2007, pp. 8-10; Moseley 2009, pp. 50-51; Schneider 2009, pp. 125-128; Wakefield and Zigler 2012, p. 25; Wynne 2013, p. 53; 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, p. 83; Jiménez-Valverde et al. 2017, p. 10213; Sendra et al. 2017a, p. 101; Sendra et al. 2017b, p. 49). Therefore, conservation strategies for the Robber Baron Cave meshweaver focus on the delineation, protection, and management of occupied karst fauna areas.

The Bexar County Karst Invertebrate Recovery Plan provides guidelines on habitat conditions that are important to karst invertebrates (Service 2011a, pp. 6-8). Scientific information and additional karst preserve guidelines are further detailed in the 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 m (345 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 2011 5-year review for the Robber Baron Cave meshweaver, no karst fauna areas had been established for this species (Service 2011b, p. 7). No new locations have been discovered since that time. The only two known caves supporting the species, Robber Baron Cave and OB3, occur under a residential neighborhood and a former sports field in a highly urbanized area of San Antonio.

Robber Baron Cave occurs beneath a densely urbanized section of San Antonio and has approximately 1.6 kilometer (km) (1.0 mile [mi]) of mapped passages (Veni and Associates 1991, p. 4; TCMA 2020). It currently occupies a roughly square area of approximately 100 m (328 ft) on a side, although it may have at one time extended at least 600m (1969 ft) southwest and 100 m (328 ft) east of its current boundaries (Veni and Associates 1997, p. 28).

The cave's entrance occurs at the bottom of a large sinkhole on a 0.37 ac (0.15 ha) lot owned and managed by the Texas Cave Management Association (Mitchell and Palit 2009, p. 1191). Over the years, work has been conducted to remove trash and sediment from the sinkhole and stabilize its edges, as well as to clean the interior of the cave and to gate and stabilize its entrance (Veni and Associates 1991, p. 4; Mitchell and Palit 2009, p. 1191; TCMA 2020). The surface of the property is open to visitors, but the cave is closed to the general public. At times, however, certain portions of the cave are open for general exploration, such as during open houses or for guided tours (TCMA 2020).

The interior of the cave has been highly impacted by human visitation, with floors being leveled with fill material during a period of commercial cave tours and passages being opened or blasted closed at various times (Veni 1988, pp. 199-210; TCMA 2020). Road building, trenching for utility lines, and other construction related to urbanization has also led to collapse of some passages (Veni and Associates, 1997, p. 28). The surface area above the cave and its subsurface drainage basin, which potentially extends 1.2 km (0.7 mi) southwest of the cave, has also been highly modified by residential and commercial development (Veni 2003, pp. 12, 19; Digital Globe 2020). The surface drainage basin of the cave has been modified by berms to prevent and deflect possible overflow from a sanitary sewer and to prevent contaminated runoff from surrounding streets from entering the sinkhole (Veni 2003, p. 19; Mitchell and Palit 2009, p. 1194).

OB3 occurs on a roughly seven-acre open field that was once part of sports complex (Zara 2009, p. 2; StratMap 2019). The cave was discovered when the top layer of the Austin Chalk was removed during cleanup of unauthorized fill material on the site (Zara 2009, p. 2). The currently mapped surface and subsurface drainage basins for this feature occur within the open field but portions of the cave cricket foraging area are covered by residential and commercial development.

Due to the highly urbanized settings surrounding both features containing the Robber Baron Cave meshweaver, no areas containing this species meet the criteria for either a high or medium KFA in the Alamo Heights KFR. Thus, downlisting criteria have not been achieved for this species.

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.):

Hedin (2015, entire) developed an integrative approach to species delimitation questions for troglobitic *Cicurina* including comparisons of multiple independent lines of evidence (e.g. mtDNA data, nuclear data, and morphology) for selected species in Travis and Williamson counties. This included next-generation sequencing methods, such as sequence capture of ultra-conserved elements. Hedin et al. (2018, entire) extended theses sequencing methods with some success to ethanol preserved spider museum specimens as well while utilizing this integrative approach to address species delimitation questions in Bexar County.

2.3.1.4 Taxonomic classification or changes in nomenclature:

Garrison et al. (2016, entire) conducted a phylogenomic analysis of spider relationship using a transcriptome-based data set comprising 70 ingroup spider taxa. In this analysis, *Cicurina* represented the Dictynidae family which was placed as a sister group to Hahiindae (Garrison et al. 2016, p. 25). Wheeler et al. (2017, entire), however, conducted a phylogenetic analysis of spiders using a dataset of 932 spider species, representing 115 families. Using six markers from the mitochondrial and nuclear genomes analyzed by multiple methods, *Cicurina* was moved from Dictynidae to Hahniidae (Wheeler et al. 2017, p. 598). The placement of *Cicurina* in Hahnidae was accepted by the World Spider Catalog (World Spider Catalog 2019).

The Robber Baron Cave meshweaver was originally described in 1992 from a female specimen found in Robber Baron Cave in 1969 (Gertsch 1992, p. 109). One of only four cave-dwelling spiders of the genus *Cicurina* described from Bexar County at the time (Gertsch 1992, p. 98), it was differentiated from other *Cicurina* based on geographic location and specific morphological characters of the female epigyna (Gertsch 1992, p. 109).

Spider taxonomy in general relies largely on genitalic differences in adult specimens using a combination of male and female morphology to delimit species (Paquin and Hedin, 2004, p. 3240; Paquin et al. 2008, p. 139; Paquin and Dupérré

2009, p. 5; Hedin 2015, p. 347). Delimiting trogolobitic *Cicurina* species based on morphology is particularly difficult not only because of the inaccessibility of their habitat for gathering adequate samples (Moseley 2009, pp. 47-48; Paquin and Dupérré 2009, p. 4) but because most collections return immature specimens (Gertsch 1992, p. 80; Cokendolpher 2004, p. 15; Paquin and Hedin, 2004, p. 3240; Paquin et al. 2008, p. 140; Paquin and Dupérré 2009, pp. 5, 64). In addition, the few adults that are collected are disproportionately female (Cokendolpher 2004, pp. 14, 15, 17-18; Paquin and Dupérré 2009, pp. 5, 64; Hedin 2015, p. 347). As females of troglobitic Cicurina exhibit variability in genitalic characters within and between caves, this makes it difficult to determine whether an individual represents a distinct species or intraspecific variation based on morphology alone (Cokendolpher 2004, pp. 30-32; Paquin and Dupérré 2009, pp. 5-6; Paquin et al. 2008, pp. 140, 143, 147; Paquin and Dupérré 2009, pp.4-6, 63-64).

Problems with species delimitation in *Cicurinas* utilizing genetic methods can also arise, such as extreme population genetic structuring found with constrained gene flow in cave restricted species and rare to non-existent cases of sympatry, making it difficult to test reproductive isolation, among others (Hedin 2015, p. 347). In order to address difficulties in species delimitation of troglobitic *Cicurinas*, Hedin et al. (2018, entire) combined morphological, mitochondrial, and nuclear phylogenomic data to address phylogenetic and species delimitation questions with particular focus on the four listed Bexar County species including the Robber Baron Cave meshweaver.

Nuclear phylogenomic analyses recovered two primary eyeless clades corresponding to previously described morphological groups based on the shape of the spermathecum in adult females (Hedin et al. 2018, pp. 55, 61). These include mostly elongate (ME) and rounded (R) spermathecae groups with the exception of two species represented by large even-sized rounded spermathecum (Cokendolpher 2004, pp. 23-24, Paquin and Dupérré 2009, p. 9, Hedin et al. 2018, p. 55). Consistent with previous studies, measurements of degree of troglomorphy, as measured by a ratio of leg length to body length, also supported the ME and R clade lineages with the ME clade having a higher troglomorphic index than the R clade (Cokendolpher 2004, p. 18; Hedin et al. 2018, pp. 63-64).

Although nuclear phylogenomic results agree with the primary eyeless clades, they do not recover the internal groupings described in Cokendolpher 2004 (p. 24) based on female morphological differences within the R clade, of which the Robber Baron Cave meshweaver is a member (Hedin et al. 2018, p. 61). One area of uncertainty within the R clade is the relationships between the Robber Baron Cave meshweaver and species from a *C. bullis* and *C. neovespera* clade (Hedin et al. 2018, pp. 62, 67). Species status and phylogenetic placement of specimens from several caves, including Green Mountain Road Cave, which sometimes placed in a clade with the Robber Baron Cave meshweaver, was uncertain due to different placements across nuclear and mitochondrial analyses (Hedin 2018, pp. 56-58, 67). Both nuclear and mitochondrial results, however, confirmed the Robber Baron Cave meshweaver occurrence in OB3 (Hedin et al. 2018, pp. 61, 67).

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.):

No new information.

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

No specific studies have been conducted to determine the effects of changes in the surface and subsurface drainage basins have had on the hydrology of Robber Baron Cave; however, anecdotal observations between the 1970s and 1990 in noted a decline in moisture throughout the cave (Veni and Associates 1997, p. 29). More recent observations have noted that some areas may also be receiving additional moisture (George Veni, personal communication, April 12, 2020).

2.3.1.7 Other:

No new information.

2.3.1.8 Conservation Measures:

As OB3 did not have a surface expression prior to it being exposed during work on the site, a concrete cap with a removable cover was constructed over OB3 in 2015 in order to stabilize the internal climate of the feature and to facilitate future monitoring (SWCA 2017 p. 1). Two years of monitoring between 2015 and 2017 found that the cap was maintaining the relative humidity of the feature and the temperature was varying much less than the surface (SWCA 2017, p. 5).

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:

No new information.

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 2011 5-year review, a new non-native invasive ant species has established colonies at sites in Bexar 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, pp. 2430, 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.

LeBrun (2017, entire) assessed the effects of tawny crazy ants at two caves in Travis County, Texas. 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, although results may be limited by the small sample size (LeBrun 2017, pp. 22, 35). Additional research is needed to determine the potential for the tawny crazy ant to affect Robber Baron Cave meshweaver populations.

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:

A National Oceanic and Atmospheric Administration (NOAA) report assessing the effect of climate change on Texas asserts that, by the end of the 21st century even under lower emissions scenarios (e.g., RCP 4.5), the coldest years will feel like the warmest years today, and the warmest years will be about 6 degrees (Fahrenheit) warmer than the hottest year from the historical record (Runkle et al. 2017, p. 1). Warming under a higher emissions scenario (RCP 8.5) would lead to higher temperatures (Runkle et al. 2017, p. 1).

Model projections of future climate in southwestern North America also show a transition to a more arid climate that began in the late 20th and early 21st centuries (Seager et al. 2007, pp. 1,183). Milly et al. (2005, p. 349) projected a 10% to 30% decrease in stream flow in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

Based on downscaling global models of climate change, Texas is expected to receive up to 20 percent less precipitation in winters and up to 10 percent more precipitation in summers (Jiang and Yang 2012, p. 238). However, most regions in Texas are predicted to become drier as temperatures increase (Jiang and Yang 2012, pp. 240–242).

Extreme droughts in Texas are now much more probable than they were 40 to 50 years ago (Rupp et al. 2012, pp. 1,053–1,054). In both moderate and high greenhouse gas emissions scenarios, Cook et al. (2015, pp. 5-6) predicted that the Central Plains and Southwest regions of the United States will experience a drought in the second half of the 21st century (2050-2099) more severe than any other in the past 1,000 years.

The climatic conditions of caves, while relatively stable compared to surface habitats, are subject to variation in prevailing relative humidity and air temperature (Culver 1982, p. 9; Culver and Pipan 2009, pp. 3-4). Cave morphology (e.g., size, shape, and volume), number and size of entrances, seasonal changes in airflow, and annual range of surface temperatures among other factors interact to influence subterranean climates (Tuttle and Stevenson 1978, pp. 110-120; de Freitas and Littlejohn 1987, p. 568). Troglobitic arthropods, such as the Robber Baron Cave meshweaver, may respond to seasonal shifts by moving to microclimates with higher humidity (i.e., mesocaverns) during dry conditions or into larger subterranean voids (i.e., macrocaverns) during wet periods (Park 1960, p. 99; Howarth 1983, p. 373; Crouau-Roy et al. 1992, p. 17; Mammola et al. 2015, p. 246); however, the exact limits of its temperature and humidity physiological tolerance for this species are unknown.

With increasing distance into the cave, climatic conditions stabilize within a narrow range of humidity and temperature (Poulson and White 1969, p. 972; Howarth 1980, p. 398; Howarth 1993, p. 69; Prous et al. 2004, pp. 377-378; Tobin et al. 2013, p. 206). These temperatures, however, are affected by the average local temperature of the area within which the cave occurs (Badino 2010,

p. 429; Covington and Perne 2015, p. 365; Mammola et al. 2017, p. 7-EV). Thus, as average annual surface temperatures increase, it is reasonable to predict that increases in temperatures in caves will follow. However, the length of the lag time for this correlation under climate change scenarios, as well as the detailed mechanistic relationship between climate change and changes in temperatures for individual caves is not easy to predict. If surface temperature increases and longer dry periods and reduced soil moisture lead to changes in the climate of the deep cave zones, this could reduce or eliminate available habitat within occupied caves, thus affecting the Robber Baron Cave meshweaver.

2.4 Synthesis

Recovery criterion (1) in the Bexar County Karst Invertebrates Recovery Plan (Service 2011a, p. 25) recommends that at least six KFAs in the Alamo Heights KFR be protected, with at least three being high quality in order to ensure the species' long-term survival in the wild is secure. 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) recommends conducting sufficient research to conclude that these areas provide a high probability of species long-term survival.

Currently, there are no areas occupied by the Robber Baron Cave meshweaver that have the potential to meet either a high or medium quality KFA and the only two known locations occupied by this species occur within a highly urbanized area. At present, recovery criteria for the Robber Baron Cave meshweaver have not been achieved and we do not recommend a change in listing status for the Robber Baron Cave meshweaver at this time.

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 (5C)

Brief Rationale: A Recovery Priority Number of 5C is indicative of a taxon with a high degree of threat, a low 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. This recovery priority number remains appropriate because the likelihood that we can recover them is low considering that the species is known from only two locations and occurs in a highly urbanized area.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

I. Conduct a status survey for the species in Robber Baron Cave.

II. Determine whether any additional areas exist within the Alamo Heights KFR that may support populations.

III. Resolve the species status and phylogenetic placement of specimens from Green Mountain Road Cave.

IV. Reassess the current karst fauna regions of Bexar County, 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 Robber Baron Cave meshweaver (*Cicurina baronia*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Review Conducted By: Jenny Wilson, Austin Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ADAM ZERRENNER Digitally signed by ADAM ZERRENNER Date: 2020.09.09 11:47:46 -05'00' ________________