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POPULATION STATUS OF KARST INVERTEBRATES IN THE BALCONES CANYONLANDS PRESERVE



Rhadine subterranea in Weldon Cave, Travis County, TX.

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Abstract

This project examined the distribution of karst invertebrate in and around the Balcones Canyonlands Preserve (BCP), with particular emphasis on updating occurrence and range records of federally listed karst species through biological surveys of caves and other karst features. Range data of three listed karst invertebrates, the Tooth Cave spider (*Neoleptoneta myopica)*, Tooth Cave pseudoscorpion (*Tartarocreagris texana*) and the Kretschmarr Cave mold beetle (*Texamaurops reddelli*) were of particular interest. New localities for the Tooth Cave spider were documented, although no new localities were found for the other two target species; however, additional localities were recorded for two listed *Texella* harvestmen and a listed *Rhadine* ground beetle.

Introduction

The Balcones Canyonlands Preserve (BCP) is a system of preserved land that exists as a multi-species regional conservation effort operating under a 10(a) permit issued under the Endangered Species Act by the U.S. Fish & Wildlife Service (USFWS). Ultimately, the permit goal is to set aside 30,428 acres in western Travis County as habitat for two endangered Neotropical migratory songbirds, six endangered karst invertebrates, and 27 species of concern. The Balcones Canyonlands Conservation Plan (BCCP) identified 62 caves within the BCP acquisition area that are known to contain listed karst species and/or species of concern, most of which occur on the highly karstic Jollyville Plateau. Currently, 45 of these designated 62 caves have some degree of protection in place.

The project objective was to update species records at sites in and around the BCP, with particular emphasis on finding additional localities for three limited-range listed species: the Tooth Cave spider (*Neoleptoneta myopica)*, Tooth Cave pseudoscorpion (*Tartarocreagris texana*) and the Kretschmarr Cave mold beetle (*Texamaurops reddelli*). These three species were listed as endangered in 1988 based on several threats including habitat loss due to development (USFWS 2009). These are all troglobitic species confined to caves and mesocavernous voids.

Additional caves and karst features located throughout Travis County were identified and, in some cases, excavated during the course of this work. Current listed species records, as reported by the Texas Memorial Museum (TMM), USFWS, Travis County Natural Resources and the City of Austin (COA) Karst Database were also examined and, when feasible, verified and updated in order to provide the most current, up to date species locality data for Travis County karst invertebrates.

Methods

The project consisted of two phases: data compilation and analysis, and field surveys. The two phases are described further below.

Phase I- Data Compilation and Karst Feature Prioritization

Zara personnel gathered karst invertebrate records and localities data from the COA, TMM, and the Texas Speleological Survey (TSS). "Caves of the BCCP" by Elliott (1997) and the USFWS "Five Year Review: Summary and Evaluation" for the three target species (2009) were also reviewed. These data were then combined to

generate a comprehensive list of all known localities of the three target species. Specific areas across the BCP known to have caves and other karst features were examined and initially divided into nine "clusters" that served as target areas for subsequent biological surveys. These clusters were: McDonald, Stovepipe, Tooth, Japygid, Geode, Spider, Beard, Jester, and Stillhouse Hollow; however, two additional clusters, named the Wheless and Robinson clusters, were added as target areas once the project began (**Figure 1**). Although not specifically selected as Karst Fauna Areas (KFAs), which are recovery units specified under the USWFS recovery plan (1994), these clusters could lead to the development of KFAs.

Zara personnel developed a decision matrix in order to prioritize the karst features to be surveyed during Phase II of the project. The purpose of the matrix was to document the decision making process and methodology for prioritizing caves or karst features to be surveyed. The matrix ranked the known karst features or caves in the study area based on the following criteria:

1. ***Number of Target Species Known From Feature Locality-*** *For example, if none of the target species were known from the locality, a score of 3 was assigned. If one of the three targets were known, a score of 2 was given. If two of the three target species were known from the locality, a score of 1 was given.*
2. ***Feature Type-*** *A cave or pit feature was given the highest score of 5. A closed depression or solution cavity was given a score of 1. Shelters or fractures were given a score of 0.*
3. ***Preserve Designation-*** *If feature is within BCP or BCP acquisition boundary, a score of 5 was given. If outside BCP or BCP acquisition boundary, a score of 0 was given.*
4. ***Thoroughness of Previous Biological Inventories-*** *0-5 biological surveys previously completed gave a feature a score of 5. A score of 6-12 previous surveys gave the feature a score of 3. If a feature was previously surveyed more than 12 times, it was automatically excluded from the project.*
5. ***Proximity to features with known listed species-*** *those features in closer proximity to other features with listed species were given a higher score.*

Biological surveys initially focused on those features with highest cumulative scores (and therefore, rank) as identified by the decision matrix. All examined features were located within Travis County karst zones 1-3 (Veni 2007).

Phase II- Field Surveys and Species Identification

Biological surveys were conducted in prioritized features within eleven karst clusters across the BCP preserve and acquisition area in Travis County, TX (**Figure 1**).

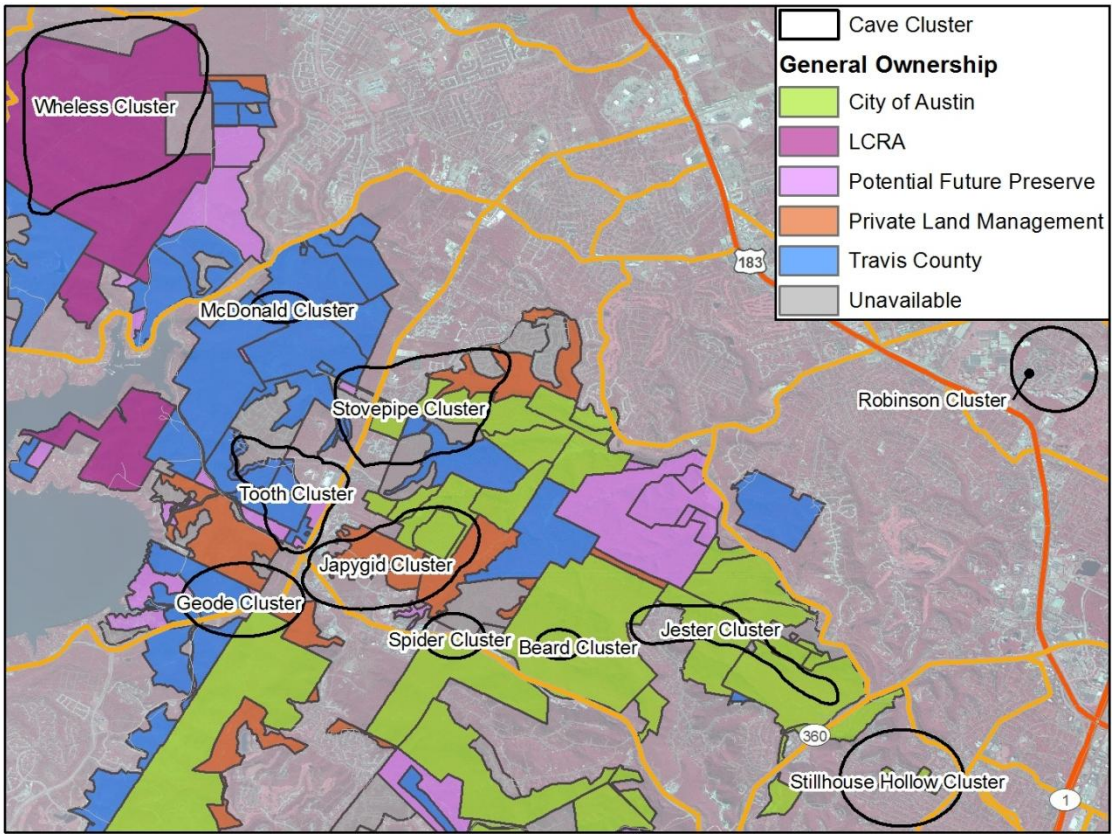


Figure 1. Eleven karst clusters targeted for karst feature investigations and biological surveys.

Surveys were conducted from August 2009 to December 2010. At each feature surveyed, positional data were recorded using a hand held Magellan Explorist Global Positioning System (GPS) receiver when the estimated position error (EPE) was ten meters or less. All surveyed features were also photographed. One to four surveys were conducted in each site, depending on results of previous surveys and also in consideration of rank and whether or not the feature was an excavation site.

Surveys were conducted with a minimum of two persons. Temperature and relative humidity (RH) were measured using a fan-cooled wet and dry bulb psychrometer (Psychro-Dyne®, Industrial Instruments & Supplies, PO Box 416, County Line Industrial Park, Southampton, PA 18966) and O_2 levels were measured for safety considerations using a GasBadge® Plus Oxygen Monitor, Industrial Scientific. In caves with delineated zones, temperature and humidity were recorded in each zone, as well as total survey effort time.

Visual, timed searches for organisms were performed by thoroughly inspecting all surfaces, including the walls, floor, and examining the insides of any cracks and crevices using a headlamp. The undersides of loose rocks were inspected with the naked eye, occasionally aided by the use of a jeweler's loupe for magnification. The floor substrate, including substrate underneath rocks, was also thoroughly examined. All species and number of individuals encountered were recorded and collected organisms were placed in plastic collection bottles containing 95% ethyl alcohol for subsequent identification. Collected specimens were taken back to the Zara Environmental lab for examination and taxonomic evaluation. All collections

were assigned a collection number, placed in glass vials with permanent labels, and entered into the Zara Microsoft Access database. Species requiring taxonomic confirmation were sent to various taxonomists and identified based on morphological characteristics or DNA sequencing (**Appendix A**). The following taxonomists were utilized based on their area of expertise:

Pseudoscorpions:	Dr. James Cokendolpher- Texas Tech University Dr. Mark Harvey- Western Australian Museum
Mold Beetles:	Dr. Don Chandler- University of New Hampshire
Ground Beetles:	Dr. James Reddell – Texas Memorial Museum, University of Texas
Harvestmen:	Dr. Darrell Ubick- California Academy of Sciences, San Francisco
Neoleptonetid Spiders:	Dr. Joel Ledford- University of California, Berkeley

These and all other collected specimens were ultimately delivered to Dr. James Reddell of the Texas Memorial Museum (TMM) for curation. All collected species data were also recorded in a Microsoft 2007 Excel spreadsheet for delivery to and inclusion in the City of Austin's BCCP karst database. Features visited, number of surveyors, survey effort, climate data and O_2 levels, as well as species information was also recorded in the spreadsheet, per request by the City of Austin.

Species occurrence records from the TMM database, *TexBio* (*Vers. April 28, 2009*), updated and maintained at the Texas Memorial Museum, Austin, Texas were reviewed and incorporated into an Excel spreadsheet for delivery to the City of Austin for integration into the BCP Karst Database.

Excavation Efforts

Excavations were conducted on four BCP properties: Ribelin, Ivanhoe, Wheless and Vireo Ridge (**Figure 2**). All excavations were conducted with a minimum of three persons using hand tools. When feasible, faunal surveys were conducted during the excavation. Excavations followed protocol outlined in the USFWS karst invertebrate survey requirements (USFWS 2006). Positional data for all excavated features were recorded using a hand-held Magellan GPS unit (EPE less than six meters). Coordinates for these features are reported in feature visit log (**Appendix B**) and are also included in the EXCEL spreadsheet for COA data integration.

Baited Traps

Glue traps were used to sample in features that were humanly inaccessible and some newly excavated features. Tomcat® glue traps (**Figure 3**) were baited with peanut butter or meat and checked five days after placement in the feature. Glue traps were not used in features known to contain listed karst invertebrates.

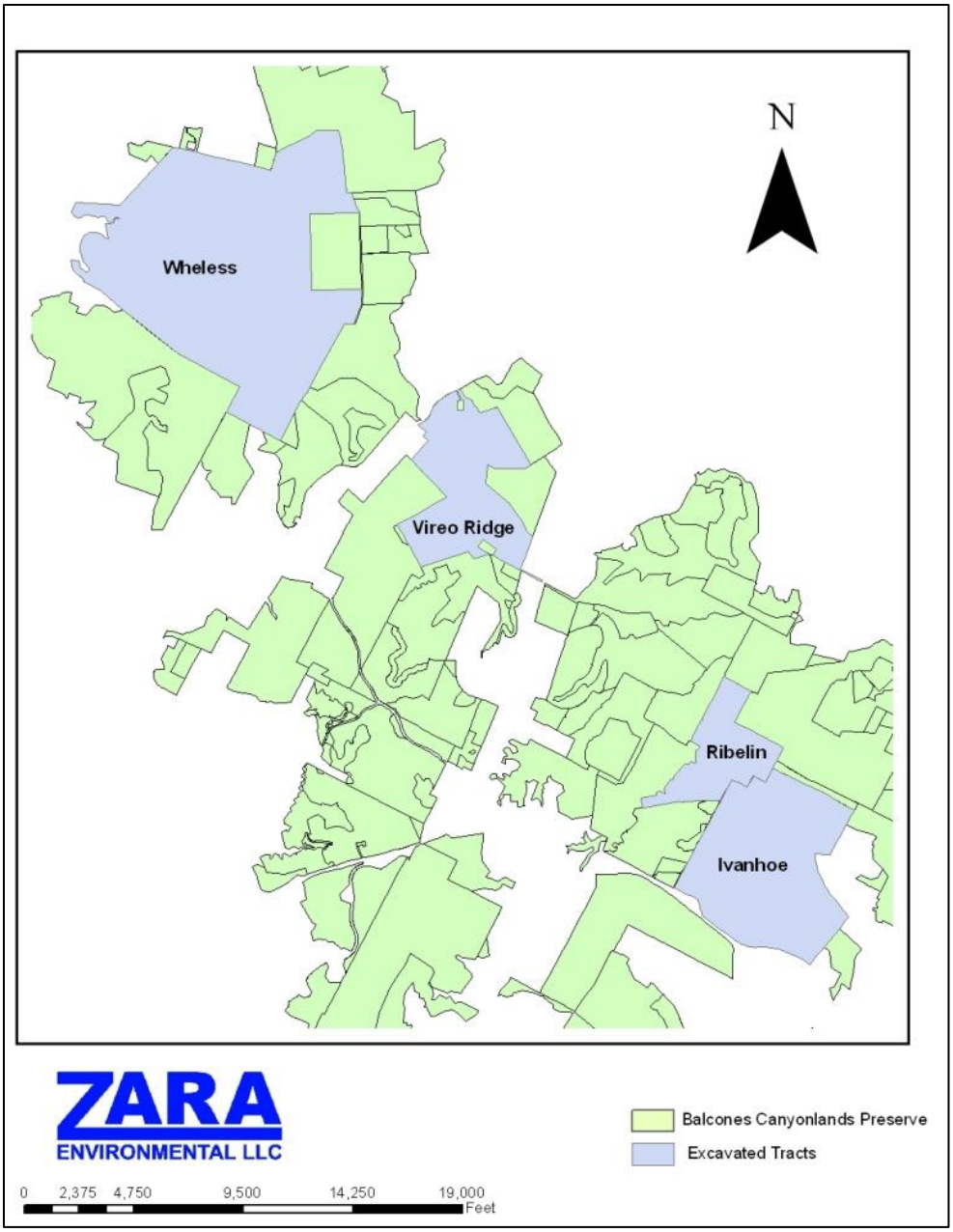


Figure 2. Tracts within the Balcones Canyonlands Preserve where excavations were conducted.



Figure 3. Glue traps after being pulled from Smurf Cave on Canyon Vista Tract, Travis County. The left trap contains *Ceuthophilus* cricket parts. The right trap contains *Calosoma* beetles.

Results

From August 2009 to December 2010, a total of 97 visits, including excavations and biological survey efforts, were made to 63 sites. A log of caves and karst features visited and number of visits to each is provided in **Appendix B**.

Of the three listed species targeted, new locality data was limited to the Tooth Cave Spider (*Neoleptoneta myopica*) (**Table 1**).

Table 1. Specimens sent for taxonomic identification with species determination.

Specimen sent:	Cave:	Cave Cluster:	Taxonomic Identification:	Taxonomist:
Neoleptoneta sp.	Jester Estates Cave	Jester	Confirmed as *N. myopica*	Dr. Joel Ledford
Neoleptoneta sp.	Stovepipe Cave	Stovepipe	Confirmed as *N. devia*	Dr. Joel Ledford
Neoleptoneta sp.	Cortana Cave	Geode	Confirmed as *N. myopica*	Dr. Joel Ledford
Neoleptoneta sp.	*Steiner Cave	Geode	Confirmed as *N. myopica*	Dr. Joel Ledford
Neoleptoneta sp.	Tight Pit Cave	Tooth	Confirmed as *N. myopica*	Dr. Joel Ledford

Specimen sent:	Cave:	Cave Cluster:	Taxonomic Identification:	Taxonomist:
Neoleptoneta sp.	Brewpot Sink	Tooth	Confirmed as *N. devia*	Dr. Joel Ledford
Neoleptoneta sp.	McNeil Bat Cave	Robinson	Confirmed as *N. myopica*	Dr. Joel Ledford
Neoleptoneta sp.	Millipede Annex Cave	Robinson	*Neoleptoneta* sp. (unable to determine species)	Dr. Joel Ledford
Pseudoscorpion	Fossil Garden Cave	Robinson	*Tartarocreagris sp. (unable to determine species)*	Dr. James Cokendolpher
Pseudoscorpion	Cotterel Cave	Stillhouse Hollow	Confirmed as *Tartarocreagris infernalis*	Dr. James Cokendolpher; Dr. Mark Harvey
Pseudoscorpion	Pond Party Pit	Beard	Confirmed as *Tartarocreagris infernalis*	Dr. James Cokendolpher
Pseudoscorpion	Weldon Cave	Robinson	Confirmed as *Aphrastochthonius* N.S.	Dr. James Cokendolpher
Pseudoscorpion	Millipede Cave	Robinson	Confirmed as *Tartarocreagris domina*	Dr. James Cokendolpher
Texella sp.	Pond Party Pit	Beard	Confirmed as *Texella reyesi*	Dr. Darrell Ubick
Texella sp.	Pilfer Cave	McDonald	Confirmed as *Texella grubbsi*	Dr. Darrell Ubick
Texella sp.	Merkin Hole	Spider	*Tentatively confirmed as Texella reddelli*	Dr. Darrell Ubick
Texella sp.	IV-3	Spider	*Tentatively confirmed as Texella reyesi*	Dr. Darrell Ubick
Texella sp.	RI-1	**	*Confirmed as Texella reddelli*	Dr. Darrell Ubick
Texella sp.	Millipede Annex Cave	Robinson	*Confirmed as Texella reyesi*	Dr. Darrell Ubick
Mold Beetle	Forest Garden Cave	Robinson	Confirmed as *Batrisodes uncicornis*	Dr. Don Chandler
Mold Beetle	Cold Cave	Robinson	Confirmed as *Batrisodes uncicornis*	Dr. Don Chandler
Mold Beetle	Geode Cave	Geode	Confirmed as *Batrisodes uncicornis*	Dr. Don Chandler
Ground Beetle	***Amber Cave	Tooth	Confirmed as *Rhadine persephone*	Dr. James Reddell

***based on previously collected species; ID verified during course of this study**
**** not within any of eleven designated clusters**
*****based on collection made during quarterly survey efforts; ID verified during course of this study**

New locality data for two listed *Texella* harvestmen, the Bone Cave harvestman and the Bee Creek Cave harvestman, were found in three of 14 excavated features (**Table 2**). These specimens were collected at a depth range of 0.5 – 3 meters. A new locality for the Bone Cave harvestman was also found at Pond Party Pit, a feature located on the COA's Ivanhoe tract in the Beard Cluster (**Table 1**).

Table 2. Features excavated on BCP properties and listed species collected.

Tract Name	Feature Name	Cluster	Listed Species Collected
Ribelin	RI-1	-	*Texella reddelli*
Ribelin	RI-6	-	
Ribelin	RI-3	-	
Ribelin	RI-8	-	
Ivanhoe	Merkin Hole	Spider	*Texella reddelli*
Ivanhoe	IV-1	Spider	
Ivanhoe	IV-2	Spider	
Ivanhoe	IV-3	Spider	*Texella reyesi*
Ivanhoe	IV-4	Spider	
Vireo Ridge	Lonnie Moore Cave	McDonald	
Vireo Ridge	BCP-01	McDonald	
Wheless	WF-22 (Neo Cave)	Wheless	
Wheless	WF-27 (Bufo Cave)	Wheless	
Wheless	WF-7	Wheless	

Tooth Cave Spider (Neoleptoneta myopica)

Four new localities were found for the Tooth Cave spider (*Neoleptoneta myopica*), including one new record from the McNeil/Round Rock karst fauna region (KFR). These data extend the range of the Tooth Cave Spider north of the Jollyville Plateau. The Five Year Status Review for the Tooth Cave spider (USFWS 2009) lists six known localities for this species across the Jollyville Plateau and Central Austin KFRs (Table 3). Our results, based on the confirmation of new localities and also on the dissertation work (to be completed in December 2010) of Dr. Joel Ledford at the University of California, Berkeley, reports 10 localities across the Jollyville Plateau and McNeil Round Rock KFRs (Table 3).

The USFWS five year status review (2009) lists two localities for the Tooth Cave Spider that may be erroneous. These inaccurate localities are: Stovepipe Cave and Moonmilk Cave. Species found in these two sites have been identified as *Neoleptoneta devia*, a species of concern under the BCCP (Joel Ledford, pers. comm. 2010). Furthermore, attempts to locate Moonmilk Cave were unsuccessful and the cave has most likely been destroyed.

Table 3. Currently known localities for Tooth Cave Spider (*Neoleptoneta myopica*) in Travis County, TX.

Karst Feature	Karst Fauna Region	Cluster
Gallifer Cave	Jollyville	Tooth
Tooth Cave	Jollyville	Tooth
Root Cave	Jollyville	Tooth
Tight Pit Cave	Jollyville	Tooth
Geode Cave	Jollyville	Geode
New Comanche Trail Cave	Jollyville	Geode

Jester Estates Cave	Jollyville	Jester
McNeil Bat Cave	McNeil/Round Rock	Robinson
Cortana Cave	Jollyville	Geode
Steiner Ranch Cave	Jollyville	Geode

Tooth Cave Pseudoscorpion (Tartarocreagris texana)

No new locality data was found for the Tooth Cave pseudoscorpion during the course of this project. However, a specimen collected from Weldon Cave in the Robinson cluster is an undescribed troglobitic species of the genus *Aphrastochthonius* and may be a species of concern, as identified in the BCCP. The first record of this genus in Texas came from Stovepipe Cave in the Jollyville KFR. It has since been found in nine other caves located in Williamson County (Elliott 1997). *Tartarocreagris domina* was originally known only from No Rent Cave in the McNeil/Round Rock KFR. At least one other cave in this cluster, Millipede Cave, is now known to contain this species and a *Tartarocreagris* pseudoscorpion that is most likely *T. domina* was collected from another cave in this cluster, Fossil Garden Cave; however, this was unable to be confirmed morphologically because it was an immature specimen (**Table 1**).

Elliott (1997) reports two inaccurate localities for the Tooth Cave pseudoscorpion. These are Stovepipe Cave and M.W.A. Cave (both located on the Jollyville KFR). The pseudoscorpion from Stovepipe Cave is *Tartarocreagris attenuata* (Muchmore 1992 and *TexBio Vers. April 28, 2009*), and the specimen reported from M.W.A. Cave was never confirmed (Cyndee Watson pers. comm. 2010) Neither M.W. A. Cave nor Stovepipe Cave is listed as a locality for the Tooth Cave pseudoscorpion in the Five Year Review (USFWS 2009).

Kretschmarr Cave Mold Beetle (Texamaurops reddelli)

No new locality data were found for the Kretschmarr Cave mold beetle. Species distribution is currently known only from the Jollyville karst fauna region and is documented in eight caves (USFWS 2009), although two of these, M.W.A Cave and Japygid Cave, are not confirmed localities. This is addressed further in the Discussion section of this report.

One new locality was confirmed for the federally listed Tooth Cave ground beetle, *Rhadine persephone*. Although not initially targeted as part of this study, a specimen was collected during quarterly monitoring efforts for Amber Cave of the Tooth cluster and identification was confirmed and included as a part of this study.

City of Austin (COA) Karst Database Review

Some of the listed species localities, as reported in the COA Karst Database, were found to be erroneous and are summarized in Table 4. Species records were verified through review of Texas Speleological Survey (TSS) data and also through review of *TexBio (Vers. April 28, 2009)*, a species database managed by James Reddell. The following data are also provided in the Excel spreadsheet delivered to COA staff.

Table 4. Inaccurate listed species/SOC data in COA karst database.

Species	Cave Reported from	Correction/Comment
Neoleptoneta myopica	McDonald Cave	Not accurate locality; Species is *N. devia*
Neoleptoneta myopica	Moonmilk Cave	Not accurate locality; Species is *N. devia*
Tartarocreagris texana	McDonald Cave	Not accurate locality; Species is *T. reddelli*
Tartarocreagris texana	Stovepipe Cave	Not accurate locality; Species is *T. attenuata*
Tartarocreagris texana	M.W.A. Cave	Tentative ID; Species not confirmed from this locality
Texamaurops reddelli	M.W.A. Cave	Tentative ID; Species not confirmed from this locality
Texamaurops reddelli	Japygid Cave	Tentative ID; Species not confirmed from this locality
Texella reyesi	Kretschmarr Double Pit Cave	Not accurate locality; Species is *T. grubbsi*
Rhadine persephone	Testudo Tube	Not listed as locality in COA karst database
Rhadine persephone	Garden Hoe Cave	Not listed as locality in COA karst database
Rhadine persephone	Down Dip Cave	Not listed as locality in COA karst database
Rhadine persephone	Two Trunks Cave	Not listed as locality in COA karst database
Texella reyesi	Cave Y	Not accurate locality; Species is *T. grubbsi*

* Data does not include new locality data found during course of this study and provided in this report.

Discussion

M.W.A. Cave and Japygid Cave

Both M.W.A. and Japygid Caves are reported as localities for the Kretschmarr Cave mold beetle and the Tooth Cave pseudoscorpion by the TMM database *TexBio (Vers. April 28, 2009)*. However, metadata in the TSS database associated with M.W.A. Cave states the following:

*"The Tooth Cave ground beetle and the Bone Cave harvestman have been collected from the cave, and what is most likely the Tooth Cave pseudoscorpion and the Kretschmarr Cave mold beetle has been **observed** in the cave."*

"The Caves of the BCCP" (Elliott 1997), under the species list for M.W.A. Cave, lists both species as: "probably Tooth Cave pseudoscorpion" and "probably Krestchmarr cave mold beetle".

For Japygid Cave, metadata from TSS database states:

*"The Tooth Cave ground beetle has been collected from this cave, and what is likely the Kretschmarr Cave mold beetle has been **observed** in the cave".*

Again, "The Caves of the BCCP" (Elliott 1997), under the species list for Japygid Cave, lists this species as "probably Krestchmarr Cave mold beetle".

Since no specimens have been collected and identified by a qualified taxonomist from either of these caves, it would be inaccurate to state that these localities are confirmed for either of these species.

Both of these caves are located in the Four Points area off of RR 2222. This privately-owned and managed tract is considered part of the BCP and is managed by ACI Consulting. Several requests were made to ACI Consulting staff to access these caves. These were ignored and access was never granted.

Stovepipe Cave and Moonmilk Cave

Stovepipe Cave was reported as a locality for the Tooth Cave pseudoscorpion by Elliott (1997). Muchmore (1992) reports that this species is actually *Tartarocreagris attenuata*, as does the *TexBio (Vers. April 28, 2009*) database. Additionally, the Tooth Cave spider is reported from Stovepipe Cave by both *TexBio* and Elliott (1997). Elliott's listing is reported as tentative, and Dr. Joel Ledford has confirmed that this species is actually *Neoleptoneta devia*, a BCCP species of concern (pers. comm. 2010).

Summary of number of known localities for the three target species:

The USFWS Five Year Review of the three listed species targeted for this project states the following number of localities for each of these species (2009):

-Tooth Cave Spider (*Neoleptoneta myopica*) - six caves
-Tooth Cave Pseudoscorpion (*Tartarocreagris texana*) - four caves
-Krestchmarr Cave Mold Beetle (*Texamaurops reddelli*) - eight caves

Investigations conducted during the course of this study, suggest the following number of localities for each of these species:

-Tooth Cave Spider *(Neoleptoneta myopica*) – 10 caves
-Tooth Cave Pseudoscorpion (*Tartarocreagris texana*) - four caves
-Kretschmarr Cave Mold Beetle (*Texamaurops reddelli*) - six caves

An additional locality may exist for the Tooth Cave spider in the Robinson Cluster. Specimens collected from Millipede Annex Cave were sent to Dr. Joel Ledford, who determined they were *Neoleptoneta* sp., but he was unable to classify them further, as all individuals sent were either female or juvenile males. DNA sequencing would be needed for further classification. Given their location, other species possibilities include *Neoleptoneta devia* and *Neoleptoneta concinna*.

Project Issues

Zara personnel were unsuccessful at finding several features. These were Moonmilk Cave, Vailview Cave, Snake Trail Cave, Indian Head Cave (all four from the Stillhouse Cluster) and Four Points Talus Cave from the Jollyville Cluster.
It was determined that one feature from the Spider Cluster, New Ivanhoe Trail Cave, did not exist.

Gaining access to several features, particularly those known from the Four Points area, was challenging. ACI Consulting was contacted several times for access permission to these important caves. Attempts were unsuccessful and USFWS was eventually contacted in the hope that they could provide assistance with access permission. Permission to access Pickle Pit was also pursued but was unsuccessful. Access was pursued to another site called Hidden Forest Cave, located in the Robinson Cluster and underneath McNeil High School. According to TSS metadata,

" This profusely decorated Hidden Forest Cave was discovered while expanding the McNeil High School building. Core drilling for the foundations encountered this cave and it was sealed despite a concerted effort to save the cave as an educational exhibit for the school. The drill hole opens into the main room of the cave well decorated and in some areas of walking height" (**Appendix C**).

Collecting the most up to date species lists from the TMM database, *TexBio*, proved to be challenging. Dr. James Reddell is currently updating species lists, however, the most current version is over a year old.

One mold beetle specimen collected from Broken Arrow Cave in the Cedar Park KFR (north of McDonald Cluster) was lost during the course of the study. Attempts to collect another specimen on subsequent visits were unsuccessful.

Recommendations

Collaboration with USFWS in order to gain access to caves located in the Four Points area is warranted. As previously stated, two caves on this property are listed as tentative localities for two listed species, and confirmation of their presence is needed.

Further excavation/investigation of features located in the Cedar Park and McNeil/Round Rock KFRs should also be pursued.

Millipede Annex Cave should be revisited and adult male *Neoleptoneta* specimens should be collected for taxonomic clarification. The collection of mature, male pseudoscorpions from Fossil Garden Cave should also be pursued.

While there is no federally-listed eyeless *Cicurina* sp. in the range of this study, there are at least seven congeners that are species of concern in Travis County (*C. bandida, C. cueva, C. elliotti, C. reyesi, C. travisae* and *C. wartoni*), including one that is a candidate for listing, *Cicurina wartoni* (71 FR 53755-53835). Also, there may be some taxonomic clarification needed with these species. According to Dr. Pierre Paquin, those species located north of the Colorado River (*C. travisae, C. elliotti, C. reddelli* and *C.* wartoni) are all synonymous with *Cicurina buwata* (pers. comm. 2009). A detailed examination of these taxa in Travis and Williamson Counties is warranted in order to assist land managers with conservation planning for this candidate species.

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Personnel

Kathleen O'Connor: Ecologist. Kathleen has worked on Central Texas endangered species for seven years. She earned her M.S. in Wildlife Ecology from Texas State University in 2003, and subsequently worked as a Natural Resources Specialist on Travis County's Balcones Canyonlands Preserve where she was the lead biologist on Travis County's karst management program. She holds a U.S. Fish and Wildlife Service scientific research permit (TE-227505) for listed karst invertebrates in Williamson, Travis, and Bexar counties, Texas.

Peter Sprouse: Karst specialist. Peter has been exploring and studying caves since 1970, having led the exploration of Sistema Purificación in Mexico, one of the longest and deepest caves in the world. He began collecting cave fauna for study by taxonomists in 1977, and has nine species named in his honor. He attended the University of Texas at Austin as a geology major, and since 1991 he has worked professionally in the fields of cave biology, land management, and cartography. He holds US Fish and Wildlife Service endangered species permit number TE014168-0 (covering endangered karst invertebrates in Texas) and Texas Dept. of Agriculture Pest Control License number 0362274. He has extensive experience in conducting karst surveys for invertebrate cave fauna habitat and biological inventories in caves and wells. He is a director of the Texas Speleological Survey and serves on the Balcones Canyonlands Preserve Scientific Advisory Committee Karst Subcommittee. The National Speleological Society has given him the prestigious Lew Bicking Award, named him an NSS Fellow, and he was the medal winner in the 1980 and 1986 NSS Cartographic Salons.

Sarah J. "Saj" Zappitello is a hydrogeologist specializing in karst and groundwater systems. She earned a B.S. in hydrogeology and environmental geology from the University of Texas, where as a research assistant she published on the isotopic constraints and research applications of isotope ratios in aquifer studies. After graduating, Saj worked as a technician for the USGS, then became a hydrogeologist with INTERA Inc. She is currently a hydrogeologist with Zara Environmental LLC where her projects include aquifer dye traces, hydrogeological studies, and karst feature surveys and assessments. In addition to her education and professional background, Saj gains valuable experience recreationally caving and volunteering for non-profit institutions like the Texas Cave Management Association and Proyecto Espeleológico Purificación. Previous efforts with these groups involved exploring and surveying new caves, searching for and mapping karst features, and leading beginner trips to expose the public to karst hydrogeology. She holds a USFWS endangered species permit (TE208531-0) covering geologic research in central Texas caves.

Krista McDermid: Ecologist. Krista holds a Master's degree in Wildlife Ecology from Texas State University in San Marcos, where she studied the Common Musk Turtle, *Sternotherus odoratus*. She also holds a bachelor's degree in Evolution, Ecology and Behavior from The University of Texas at Austin, where she worked on behavioral and genetic development of the zebra fish, *Danio rerio.* Krista has worked as a biologist for Texas Parks & Wildlife Department monitoring white-winged dove migration and population, and the City of Austin assisting with a mark-recapture study on the Jollyville Plateau Salamander, *Eurycea tonkawae*.
Krista is a GIS technician; she received her certification in ArcView 3.x in 2005, and completed the postbaccalaureate certification program in geographic information systems through Penn State University in 2010. She has worked with Zara since

2007 and in that time has participated in numerous habitat surveys for listed karst invertebrates, cave fauna surveys, karst feature surveys, presence/absence surveys and biological monitoring for listed karst invertebrates. She has also conducted aquatic macro-invertebrate habitat and presence/absence surveys for aquifer species in Hays, Bexar, Uvalde and Medina Counties. She holds Texas Parks and Wildlife Scientific Research Permit SPR-0608-082 (expires 5 June 2011) to collect and study aquifer fauna and U.S. Fish and Wildlife Service Permit TE192229-0 (expires 30 October 2011) to collect and study federally listed endangered Texas karst invertebrate species.

Bill Larsen: Karst Specialist. Bill began exploring and studying caves in 1986 and has since discovered over 300 caves in central Texas. He began working as a karst technician in 1990, subcontracting to George Veni and Associates. In 2009 he became an employee of Zara Environmental. Much of his work has been in the San Antonio to Austin area and has included grid searches for karst features, excavation of caves and karst features, collection of invertebrate karst species for study, biomonitoring caves, and well sampling for fauna. Bill holds a USFWS Endangered Species Permit.

Jeanette Larsen: Biologist. Jeanette has a Bachelor's degree in aquatic biology, with a minor in chemistry. She began studying caves in 1995. She has worked as a karst technician since 2000. Much of her work has been in the San Antonio to Austin area, and has included grid-searches for karst features, excavation of caves and karst features, collection of invertebrate karst species for study, and biomonitoring caves. She has also participated in several dye traces where she collected and analyzed samples. She holds USFWS Endangered Species Permit TE00294A-0.

Appendix A. Taxonomy Log

Specimen	Locality	Sent To:	Taxon ID:	Confirmed by:
Araneae	Tight Pit	J. Ledford	*Neoleptoneta myopica*	DNA sequencing
Araneae	Brewpot Sink	J. Ledford	*Neoleptoneta devia*	DNA sequencing
Pseudoscorpion	Cotterel Cave	Cokendolpher	*Tartarocreagris infernalis*	morphology
Pseudoscorpion	Pond Party Pit	Cokendolpher	*Tartarocreagris infernalis*	morphology
Mold beetle	Fossil Garden Cave	D. Chandler	*Batrisodes uncicornis*	morphology
Harvestman	Pilfer Cave	D. Ubick	*Texella grubbsi*	morphology
Pseudoscorpion	Pond Party Pit	M. Harvey	*Tartarocreagris infernalis*	morphology
Pseudoscorpion	Cotterel Cave	M. Harvey	*Tartarocreagris infernalis*	morphology
Pseudoscorpion	Stovepipe Cave	M. Harvey	*Tartarocreagris attenuata*	morphology
Harvestman	RI-1 (Ribelin)	D. Ubick	*Texella reddelli*	morphology
Harvestman	Coffin Cave	D. Ubick	*Texella reyesi*	morphology
Harvestman	Merkin Hole	D. Ubick	*Texella reddelli*	morphology
Harvestman	Millipede Annex	D. Ubick	*Texella reyesi*	morphology
Harvestman	IV-3 (Ivanhoe)	D. Ubick	*Texella reyesi*	morphology
Araneae	Millipede Annex Cave	J. Ledford	*Neoleptoneta* sp.	morphology
Araneae	Spider Cave	J. Ledford	*Eidmanella* sp.	morphology
Araneae	Millipede Annex Cave	J. Ledford	*Neoleptoneta* sp.	morphology
Araneae	Kickback Cave	J. Ledford	*Eidmanella* sp.	morphology
Araneae	County Line Bat Cave	J. Ledford	*Eidmanella* sp.	morphology
Araneae	Millipede Cave	J. Ledford	Eidmanella sp.	morphology
Araneae	Hole in the Road Cave	J. Ledford	*Anapistula* sp.	morphology
Araneae	McDonald Cave	J. Ledford	Gnaphosidae; *Eidmanella rostrata*	morphology
Pseudoscorpion	Millipede Cave	Cokendolpher	*Tartarocreagris domina*	morphology
Pseudoscorpion	Weldon Cave	Cokendolpher	*Aphrastochthonius* N.S.	morphology; undescribed species
Pseudoscorpion	Fossil Garden Cave	Cokendolpher	*Tartarocreagris* sp.	Morphology
Araneae	Cortana Cave	J. Ledford	*Neoleptoneta myopica*	Morphology
Araneae	Stovepipe Cave	J. Ledford	*Anapistula* sp.	Morphology
Carabidae	Amber Cave	J. Reddell	*Rhadine persephone*	Morphology

Appendix B. Karst Feature Visit Log

No.	Feature Name	Cluster	Visit #1	Visit #2	Visit #3	Visit #4
1	*Amber Cave	Tooth	12/7/2010			
2	Adobe Springs Cave		12/18/2009			
3	Beard Ranch Cave	Beard	8/31/2009	1/14/2010		
4	Brewpot Sink	Tooth	10/19/2009			
5	Bomb Shelter Cave		10/29/2010			
6	Broken Arrow Cave		11/5/2009	1/28/2010	6/30/2010	
7	Bulldozer Cavern	Geode	9/29/2009			
8	Cactus Pit	Tooth	10/19/2009			
9	Canopy Joint Sink	Japygid	4/30/2010			
10	Canyon Head Cave	Spider	10/21/2009			
11	Cold Cave	McNeil	9/22/2010			
12	Cortana Cave	Geode	10/14/2009			
13	Cotterel Cave	Stillhouse Hollow	1/28/2010			
14	CV-1 (Canyon Vista Feature)		10/6/2010	10/20/2010		
15	Deer Stand Cave	Tooth	9/29/2009			
16	Down Dip Sink	Japygid	4/30/2010			
17	Fossil Garden Cave	McNeil	6/4/2010	9/22/2010		
18	Gallifer Cave		12/8/2009			
19	Garden Hoe Sink	Japygid	4/30/2010			
20	Geode Cave	Geode	9/29/2009	10/15/2010		
21	Helen's Cave	McDonald	12/11/2009			
22	Hole in the Road	McNeil	9/22/2010			
23	Jest John Cave	Jester	9/18/2009			
24	Jester Estates Cave	Jester	9/18/2009	8/12/2010		
25	Jester Pit	Jester	7/6/2010			
26	Kickback Cave (most likely)		12/14/2009			
27	Krestchmarr Cave		12/15/2009			
28	Lamm Cave	Tooth	10/14/2009	1/14/2010	10/15/2010	
29	Lonnie Moore Cave	McDonald	4/29/2010	5/18/2010	6/24/2010	9/23/2010
30	McNeil Bat Cave	McNeil	6/4/2010			
31	Millipede Cave	McNeil	7/26/2010	8/19/2010		
32	Millipede Annex Cave	McNeil	7/26/2010	8/19/2010		
33	New Comanche Trail Cave	Geode	12/20/2009			
34	No Rent Cave	McNeil	7/22/2010	8/19/2010		
35	North Root Cave	Tooth	11/12/2009			
36	Oxalis Cave (Ribelin Feature)		9/9/2010			

No.	Feature Name	Cluster	Visit #1	Visit #2	Visit #3	Visit #4
37	Pilfer Cave (Formerly known as Nootsie Cave)	McDonald	3/26/2010	4/7/2010	4/29/2010	9/23/2010
38	Paul's Cave	McDonald	3/26/2010	9/23/2010		
39	Pond Party Pit	Beard	8/31/2009	12/18/2009	8/12/2010	
40	RI-1 (Ribelin Feature)		9/1/2010	9/9/2010		
41	RI-3 (Ribelin Feature)		9/9/2010			
42	RI-6 (Ribelin Feature)		9/9/2010			
43	RI-8 (Ribelin Feature)		9/9/2010			
44	Rolling Rock Cave		12/26/2009			
45	SAS Salamander Cave		8/24/2010			
46	Smurf Cave		10/6/2010	10/20/2010		
47	Spider Cave	Spider	12/27/2009	1/2/2010		
48	Stovepipe Cave	Stovepipe	9/18/2009			
49	Tardus Hole		12/8/2010			
50	Tight Pit (C-9 sink)	Tooth	12/30/2009			
51	Two Trunks Cave	Tooth	12/31/2009	3/26/2010		
52	Volente Cave		1/1/2010			
53	Weldon Cave		7/22/2010	8/19/2010		
54	Wooden Derrick Sink	Spider	1/2/2010	8/12/2010		
55	BCP-01*	McDonald	6/29/2010	7/1/2010		
56	Merkin Hole (Ivanhoe Feature)	Beard	7/20/2010	9/30/2010	10/4/2010	
57	IV-1 (Ivanhoe feature)	Beard	7/20/2010	9/30/2010		
58	IV-2 (Ivanhoe Feature)	Beard	7/20/2010	9/30/2010		
59	IV-3 (Ivanhoe feature)	Beard	7/20/2010	9/30/2010		
60	IV-4 (Ivanhoe feature)	Beard	7/20/2010	9/30/2010		
61	WF 27 (Bufo Cave)	Wheless	8/12/2010	8/26/2010	9/23/2010	
62	WF 22 (Neo Cave)	Wheless	8/12/2010			
63	WF-70	Wheless	8/12/2010			

*Not initially targeted for this study, but a specimen collected during quarterly monitoring efforts was identified as a part of this study and included in this report.

Appendix C. Photos from the Field



Blind *Cicurina* sp. in Millipede Annex Cave, Robinson Cluster.

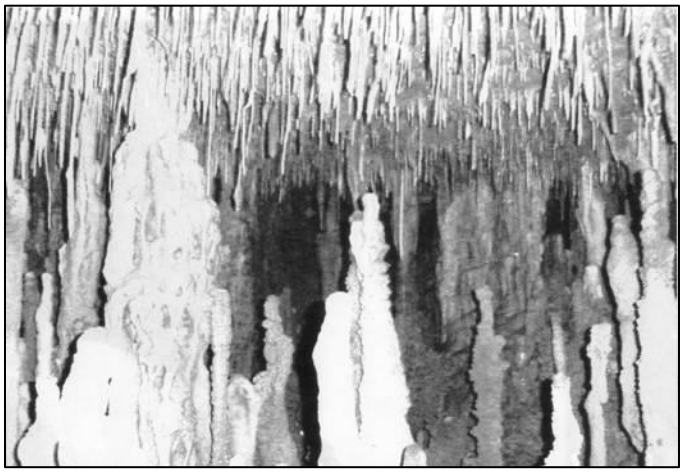


Entrance to Millipede Annex Cave in McNeil High School Courtyard, Robinson Cluster.

Appendix C continued



Entrance to Hidden Forest Cave inside McNeil High School, Robinson Cluster.



Picture of formations inside Hidden Forest

Cave taken before entrance was closed.
Appendix C continued



Entrance to No Rent Cave, Robinson Cluster.



***Texella reyesi* in Millipede Annex Cave, Robinson Cluster.**

Appendix C continued

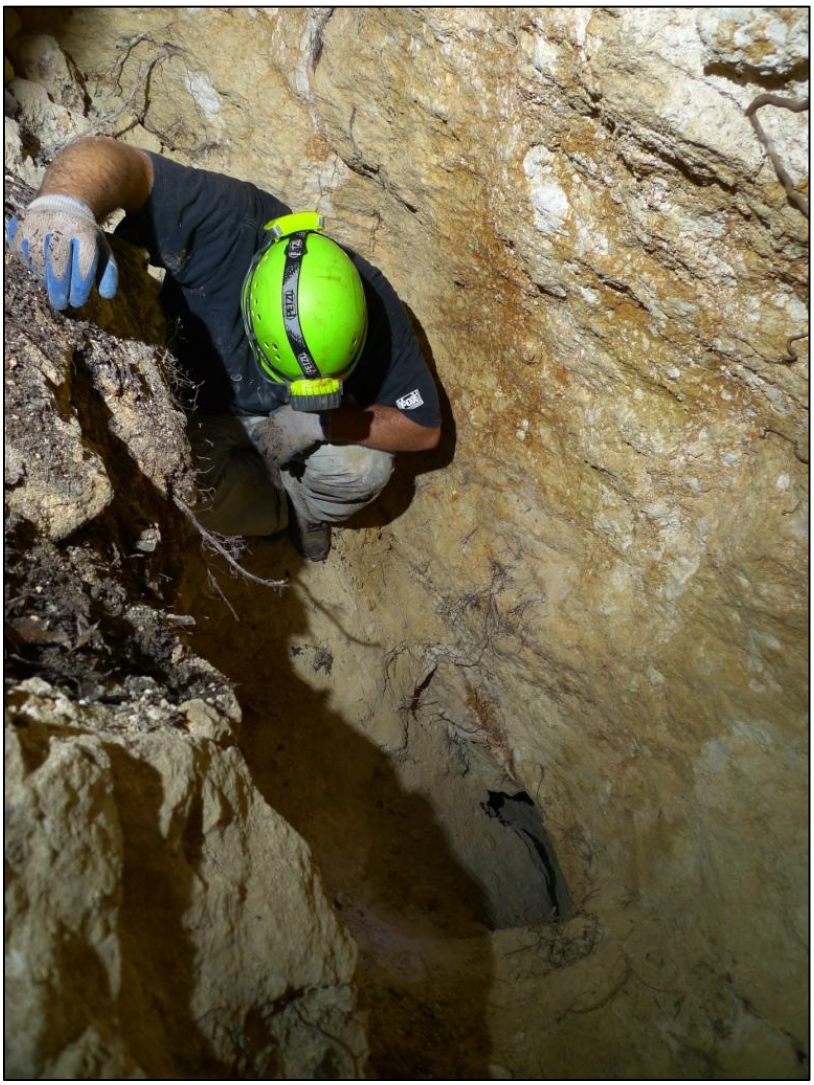


Goat in Weldon Cave, Robinson Cluster.



Merkin Hole excavation, Ivanhoe Tract, Beard Cluster.

Appendix C continued



Pilfer Cave Excavation, Vireo Ridge Tract- McDonald Cluster.

Appendix C continued



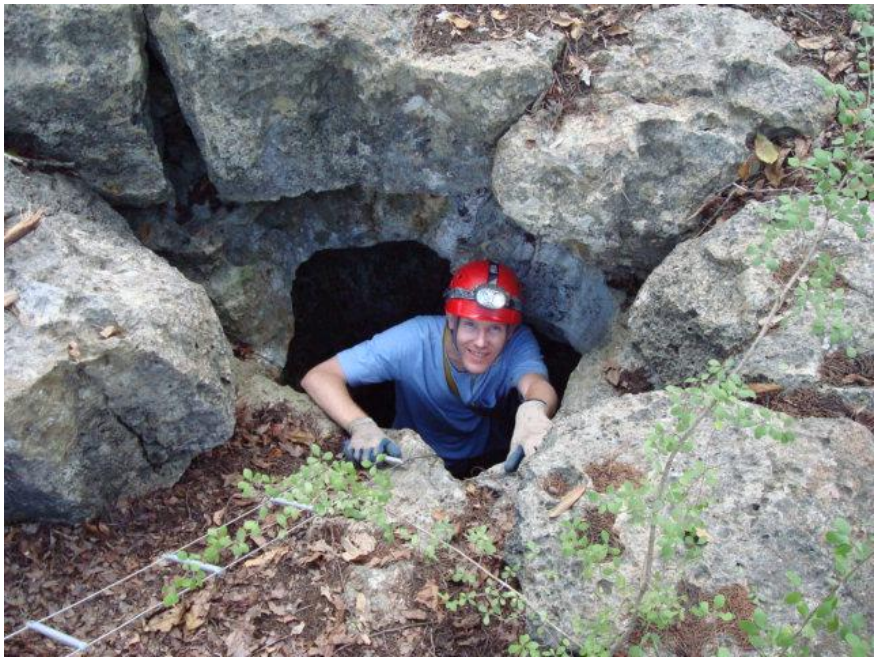
Wheless Tract excavation, LCRA-owned property.



Surveying Pond Party Pit, Ivanhoe Tract- Beard Cluster.
Appendix C continued

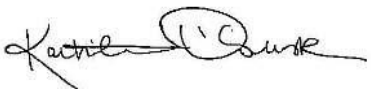


Western Hognose snake (*Heterodon nasicus*) in Lamm Cave, Stovepipe Cluster.



Cactus Pit Cave, Cuevas Tract, Tooth Cluster.

This report is true and complete to the best of my knowledge.



Kathleen O'Connor 8 November 2010
USFWS Permit No. TE227505