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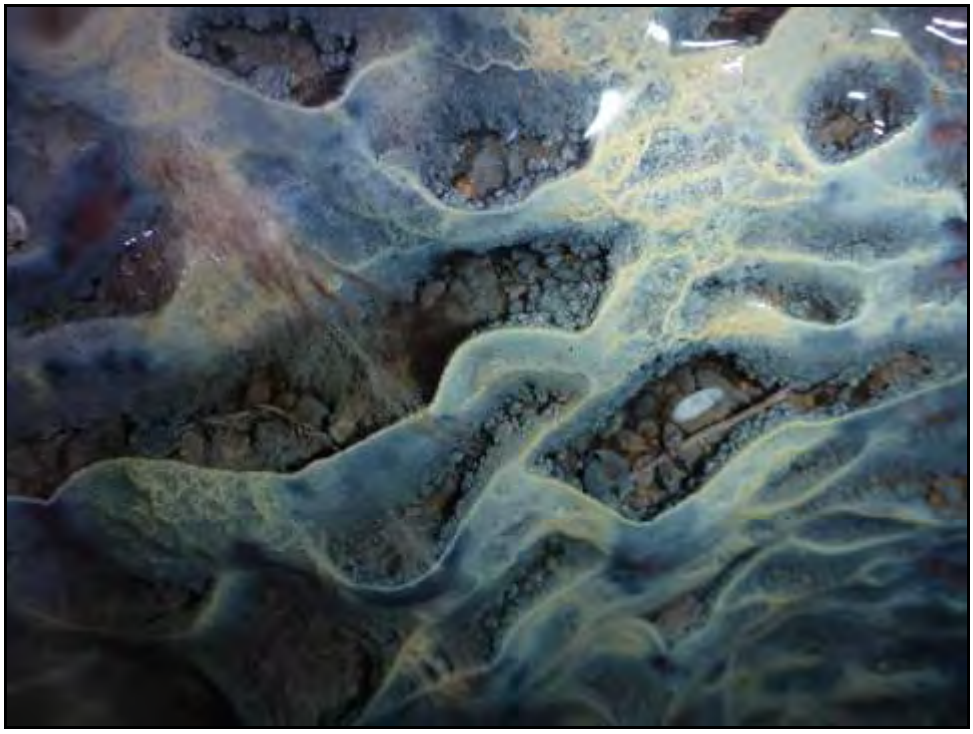
2016 SUMMARY OF CAVE MANAGEMENT ACTIVITIES AT PENNIE'S CAVE, TRAVIS COUNTY, TEXAS



Travertine microgours on flowstone in the lower pit of Pennie's Cave

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Abstract

Pennie's Cave, located on private property in southern Travis County, is one of 62 caves included in the Balcones Canyonlands Conservation Plan, a multi-species regional conservation effort operating under a 10(a) permit issued by the U.S. Fish and Wildlife Service under the Endangered Species Act. Pennie's Cave currently is known to contain two karst invertebrate species covered under the Balcones Canyonlands Conservation Plan: a troglobitic ground beetle (*Rhadine austinica*), troglobitic millipede (*Speodesmus* N.S.), and, although currently unverified, a potential variant of the *Cicurina cueva* complex of troglobitic spiders. Ongoing cave management measures were initiated in 2014. Management activities conducted in 2016 include biological monitoring and red imported fire ant control. Neither the *Rhadine austinica* nor the *Speodesmus* N.S. were observed, but the troglobitic *Cicurina* was recorded. The only other troglobite observed was a *Texoreddellia* silverfish. The numbers of observed and treated red imported fire ant mounds appear to be decreasing over time since first treating at the Pennie's Cave management area in October 2014. However, one red imported fire ant mound was observed for the first time within 10 m of the cave entrance, which is considered an infestation threshold under the *Karst Preserve Management and Monitoring Recommendations* issued by the U.S. Fish and Wildlife Service.

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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 by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act. Ultimately, the permit goal is to set aside 30,428 acres in western Travis County as habitat for two federally listed endangered Neotropical migratory songbirds, six federally listed endangered karst invertebrates, and 27 species of concern. The Balcones Canyonlands Conservation Plan (BCCP) identified 62 caves for acquisition and protection within the BCCP area that are known to contain listed karst species and/or species of concern, most of which occur on the highly karstic Jollyville Plateau (City of Austin and Travis County 1996). Forty-five of these 62 designated caves have some degree of protection in place.

Pennie's Cave, previously one of the 15 unprotected BCCP caves, is a site located in southern Travis County on private property and is known to contain two karst invertebrate species covered under the BCCP (species of concern [SOCs]: *Rhadine austinica* and *Speodesmus* N.S. (BCP 2016). The cave was first discovered by local cavers in the 1960s and has never been managed for karst species since its discovery. In the 1980s, the landowner completely filled the cave entrance after noticing evidence of unauthorized entry. The entrance was reopened in 2012 as part of an adaptive cave management plan for a development project (Zara Environmental LLC [Zara] 2012). Other components of the management plan that have been completed since the cave's reopening include the establishment of a preserve area, construction of a cave gate, and development of a cave map. Ongoing management activities initiated in 2014 include conducting in-cave biological monitoring for karst invertebrate species, performing red imported fire ant (*Solenopsis invicta*; RIFA) control work, and submitting annual summary reports to the BCP. Since the initiation of in-cave biological monitoring, the only karst invertebrate BCCP SOC detected is the troglobitic millipede, *Speodesmus* N.S. (Zara 2014; Zara 2015). Although currently unconfirmed, it is possible that a variant of the *C. cueva* complex of troglobitic spiders (Paquin and Hedin 2005; Paquin et al. 2008), also SOCs covered under the BCCP, has been collected in Pennie's Cave during biological monitoring (Zara 2014; Zara 2015).

Management activities completed during 2016 include a biological monitoring event, two RIFA control events, and the preparation of this annual report summarizing the completed activities for the year. This annual report details the methodologies, results, and a discussion of activities completed at Pennie's Cave. The discussion includes planned activities for 2017.

Methods

Biological Monitoring

Annual biological monitoring for karst invertebrate species was conducted in effort to append the list of known species and to detect the presence of protected species previously recorded at Pennie's Cave. The cave was delineated previously into five separate biological monitoring zones identified by marked orange flagging tape (Zara 2014). Personnel experienced in invertebrate

biology visually inspected all surfaces in each zone for karst invertebrate species paying particular attention to the undersides of rocks, clumps of dried substrate, decaying skeletons, animal scat, and pools of water. Since there is no need to demonstrate absence of listed species in this study, not all protocols set forth in the USFWS document *Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrate Species* (USFWS 2015) were followed. All fauna encountered were noted on field sheets, and specimens of fauna not previously known from the site were collected to facilitate identification. Unless otherwise directed by USFWS (2016), specimens collected will be deposited in the Texas Natural History Collection, University of Texas at Austin, and the list of known species for this cave will be updated based on the updated specimen records from biomonitoring events.

Microclimate data, including atmospheric pressure, temperature, and relative humidity (RH), were collected during the biological monitoring event. Before entering the cave, measurements were recorded within 5 m of the feature entrance, at ground level and in the shade. During the in-cave surveys, microclimate data were collected in each cave zone. Atmospheric pressure was measured using a digital barometer built into a Garmin GPSmap 60Csx unit or referenced from available hourly climate data (Menne et al. 2012). Temperature data were collected with either a fan-cooled wet and dry bulb psychrometer (Psychro-Dyne®, Industrial Instruments & Supplies, PO Box 416, County Line Industrial Park, Southampton, PA 18966) or a Kestrel® Environmental Meter 5000 with LINK (Nielsen-Kellerman, 21 Creek Circle, Boothwyn, PA 19061). The Kestrel unit provided a direct readout of both temperature and RH data, while the psychrometer provided wet and dry bulb temperatures for calculating RH using atmospheric pressure data and an online calculator (Scanlon 2015).

Red Imported Fire Ant Control

The RIFA control activities were performed in accordance with the USFWS *Karst Preserve Management and Monitoring Recommendations* (USFWS 2014) and set forth in the BCP Land Management Plan (BCP 2016). Fire ants do not maintain their mounds during the summer, making them more difficult to see, but begin rebuilding them as soon as rains and cooler temperatures return (Vinson and Sorensen 1986). In addition, the ants may remain relatively inactive and deep within their mounds during long periods of drought or cold (Vinson and Sorensen 1986), making them more difficult to eradicate. Because of these behavioral characteristics, RIFA control activities were conducted at least once in the spring and at least once in the fall.

Control activities consisted of an ant mound survey and subsequent treatments with hot water to eradicate RIFA colonies inhabiting the identified mounds. The USFWS (2014) recommends a distance of 80 m from the cave entrance for RIFA control activities, resulting in a total area of approximately 20,106 m^2. The circumference based on the 80-m radius was measured using a global positioning system unit and visibly delineated using pin flags. During the survey, all RIFA mounds within the delineated area were located by walking while visually scanning and marking the mounds with pin flags and paying particular attention to likely places for colonies such as clearings, stumps, cracks in rocks, and rotting logs. The survey methods are designed to yield an

accurate account of RIFA mound densities. Any RIFA mounds within a 10-m radius of the cave entrance (an area of approximately 314 m^2) were distinguished from the remaining survey area, as the presence of only one mound within 10 m of the cave entrance is considered an infestation threshold. A density of 80 RIFA mounds within a 50-m radius (7,850 m^2), or one mound per 98.13 m^2, is considered as an infestation threshold for areas beyond 10 m of the cave entrance (USFWS 2014). The exceedance of these infestation thresholds may necessitate an increase in RIFA control frequency (USFWS 2014).

Eradication treatments were performed immediately following the mound survey during early to mid-morning when the queen(s) and larvae are likely to be near the top of the mound (Vinson and Sorensen 1986). Water was heated in the field either by heating metal buckets on propane-fired burners or using a diesel-fired pressure washer supplied by a 220-gallon water tank (if possible based on site and equipment accessibility). Disturbance to RIFA mounds was minimized before treatment, as this may cause the ants to move the queen(s) and larvae to deeper locations within the mound or to a remote location. Mounds were excavated slowly with a pickaxe to expose the colony chambers and tunnels, and boiling water was then immediately poured on the mound and emerging ants. These steps were repeated layer by layer, until the bottom of the colony was reached and ants ceased emerging from deeper chambers and tunnels. Care was taken to distinguish RIFA mounds from native ant mounds during control activities to avoid treatment of native colonies. Abandoned mounds with no RIFA colonies were not treated.

Results

Biological Monitoring

The biological monitoring event was conducted in Pennie's Cave on 28 January 2016. The biological monitoring event at Pennie's Cave was performed during a total of 100 person minutes. No BCCP species of concern were detected, although the biological monitoring resulted in the detection of eyeless *Cicurina* spiders that may be a variant of the *C. cueva* complex (Paquin and Hedin 2005; Paquin et al. 2008), which are SOCs covered under the BCCP. No federally listed species were observed. New invertebrate records for the cave include an unidentified millipede (Diplopoda) and symphylan (Symphyla), neither of which are troglobitic species. A list of taxa and numbers of individuals observed during 2016 is presented in Table 1. A comprehensive list of all taxa observed by cave zone since the initiation of biomonitoring in 2014 is presented in Table 2.

During the month of January 2016, approximately 0.3 inch of precipitation occurred in the area, which is about 1.92 inches below average for that period (Menne et al. 2012). Conditions in the cave appeared to correlate to these dry conditions; the cave ceilings and walls were noticeably drier than previous surveys and slightly lower RH was recorded in zone 2. The air quality was considerably worse (i.e., inadequate levels of oxygen/high levels of carbon dioxide) that during the previous biological monitoring events performed in February and April of 2015. As such, only zones 1, 2, and 3 were inventoried in 2016 due to these unsafe conditions for the surveyors. Comprehensive microclimate data recorded since 2014 are presented in Table 3.

Table 1. Biological observations and collections at Pennie's Cave on 28 January 2016.

Common Name	Lowest Taxonomic Identification	# Observed	Collected Y/N? (#)
Snails	*Helicodiscus* sp.	2	N
Silverfish	*Texoreddellia* sp.	1	N
Centipedes	Chilopoda	2	N
Symphylans	Symphyla[1]	1	N
Millipedes	Diplopoda[1]	1	N
Springtails	Collembola	37	N
Spiders	*Cicurina* sp. (eyeless) Araneae	2 1	N N
Crickets	*Ceuthophilus secretus* *Ceuthophilus cunicularis* *Ceuthophilus* sp. (Nymph)	12 7 15	N N N
Gnats	*Diptera* sp.	10	N
Frogs	*Lithobates* sp.[2]	1	N
Earthworms	Oligochaeta	4	N
Salamanders	*Plethodon albagula*	2	N

[1] New taxa record for Pennie's Cave

Table 2. Total biological observations and collections by cave zone at Pennie's Cave.

Common Name	Lowest Taxonomic Identification	Biomonitoring Zone
Snails	*Helicodiscus* sp.	1, 2
Earthworms	Oligochaeta	1, 3
Spiders	*Cicurina* sp. (eyeless) Araneae *Eidmanella* sp.	1, 2, 3, 4 1, 2 2
Harvestman	*Leiobunum townsendii*	1
Centipedes	Lithobiomorpha Chilopoda	1, 3 1, 3
Millipedes	*Speodesmus* N.S.[1] Diplopoda[2]	2, 3 1
Symphylans	Symphyla[2]	1
Springtails	Collembola	1, 2, 3, 4
Silverfish	*Texoreddellia* sp.	2, 4
Crickets	*Ceuthophilus secretus* *Ceuthophilus cunicularis* *Ceuthophilus* sp. (Nymph) *Ceuthophilus* sp. (Sub-Adult)	1, 2, 3 1, 2, 3, 4 1, 2, 3, 4, 5 2, 3, 4
Cockroaches	Blattaria	3
Woodlice	*Porcellio* sp. *Armadillidium* sp.	1 1
Gnats	*Diptera* sp.	1, 2, 3, 4
Frogs	*Eleutherodactylus marnockii* *Bufo nebulifer* *Lithobates* sp.[2]	1 2 2
Salamanders	*Plethodon albagula*	1, 2

[1] BCCP species of concern
[2] New taxa record for Pennie's Cave

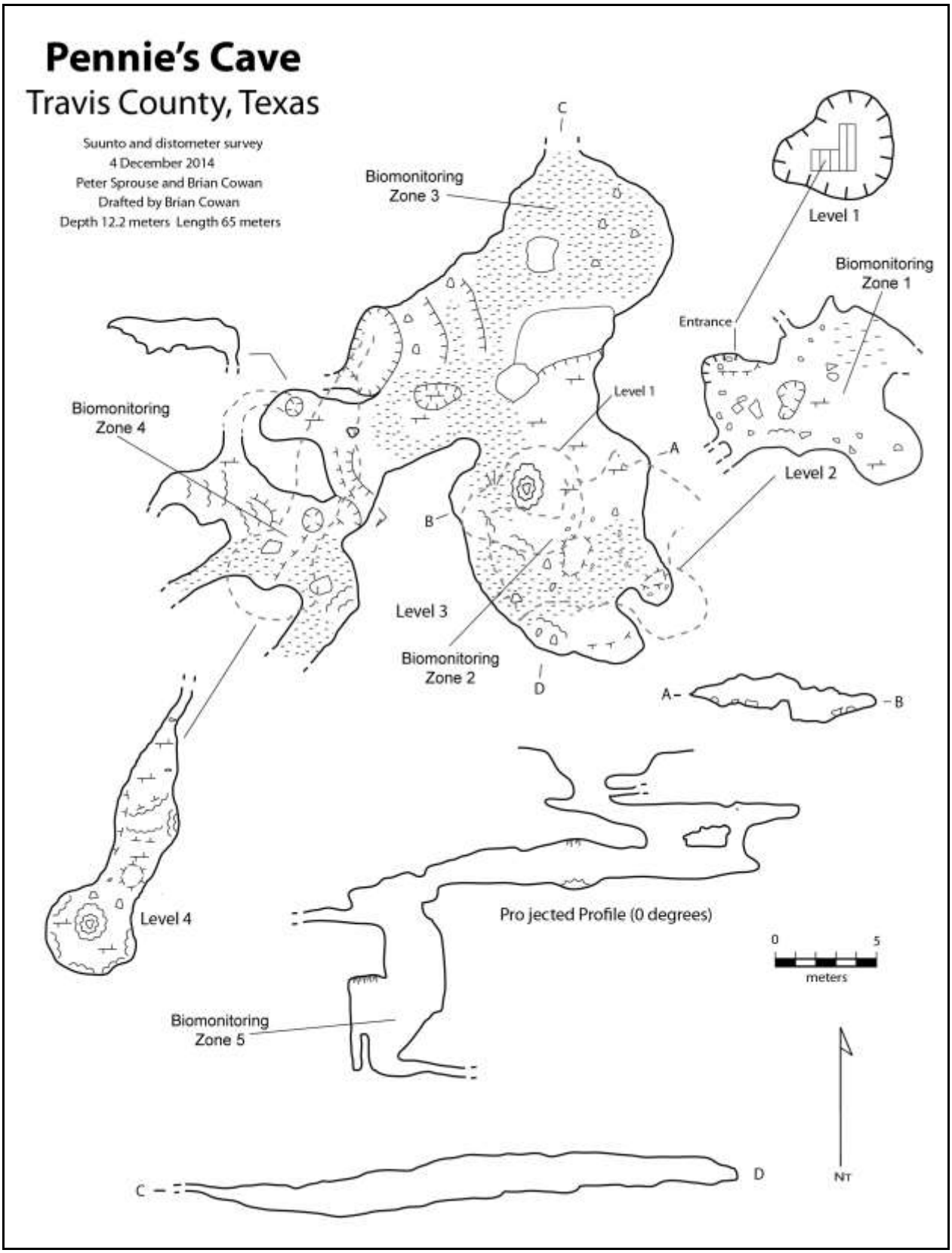

Figure 1. Map of Pennie's Cave including biomonitoring zones.

Table 3. Dates of biological monitoring events, surface and void temperatures, and humidity calculations at Pennie's Cave.

Date	Time	Location	Temperature (°C)			Pressure (mb)	Relative humidity (%)	
			Wet Bulb[1]	Dry Bulb[1]	Direct Read[2]		Calculated[1]	Direct Read[2]
7 August 2014	14:32	Surface	25.7	37.6	--	1,012	38.2	--
7 August 2014	14:45	Zone 1	23.2	26.0	--	1,012	78.9	--
7 August 2014	14:58	Zone 2	21.2	24.2	--	1,012	76.5	--
7 August 2014	15:20	Zone 3	20.6	21.6	--	1,012	91.4	--
7 August 2014	15:25	Zone 4	20.7	22.0	--	1,012	89.0	--
7 August 2014	NM	Zone 5	NM	NM	--	NM	NM	--
4 December 2014	13:45	Surface	17.8	18.3	--	1,019	95.3	--
4 December 2014	13:55	Zone 1	29.0	29.5	--	1,019	96.3	--
4 December 2014	14:10	Zone 2	20.0	20.2	--	1,019	98.2	--
4 December 2014	14:27	Zone 3	21.5	21.7	--	1,019	98.3	--
4 December 2014	14:50	Zone 4	20.8	21.2	--	1,018	96.5	--
4 December 2014	15:55	Zone 5	NM	NM	--	1,018	NM	--
18 February 2015	09:59	Surface	9.5	13.5	--	1,029	59.0	--
18 February 2015	10:25	Zone 1	14.0	14.5	--	1,029	94.7	--
18 February 2015	10:53	Zone 2	25.5	26.0	--	1,028	96.0	--
18 February 2015	11:21	Zone 3	16.0	16.25	--	1,028	97.5	--
18 February 2015	11:50	Zone 4	18.0	18.5	--	1,027	95.3	--
18 February 2015	12:20	Zone 5	19.5	20.0	--	1,027	95.5	--
21 April 2015	11:10	Surface	16.5	22.5	--	1,016	53.8	--
21 April 2015	11:17	Zone 1	18.9	20.8	--	1,016	83.6	--
21 April 2015	11:42	Zone 2	18.25	19.2	--	1,016	91.3	--
21 April 2015	12:05	Zone 3	17.5	18.0	--	1,015	95.2	--
21 April 2015	12:27	Zone 4	18.5	19.0	--	1,015	95.4	--
21 April 2015	13:23	Zone 5	19.9	21.25	--	1,015	93.9	--
28 January 2016	10:50	Surface	--	--	17.5	1,024	--	30.5
28 January 2016	NM	Zone 1	--	--	NM	NM	--	NM
28 January 2016	11:22	Zone 2	--	--	17.0	1,023	--	89.7
28 January 2016	NM	Zone 3	--	--	NM	NM	--	NM
28 January 2016	12:08	Zone 4	--	--	19.3	1,022	--	95.2
28 January 2016	NM	Zone 5	--	--	NM	NM	--	NM
NM = not measured								

Red Imported Fire Ant Control

Red imported fire ant control activities were performed on 05 May 2016 and 17 November 2016. Both RIFA treatments were performed during a period of cooler, wetter weather, thus facilitating the identification of RIFA activity (i.e., mound rebuilding). The 80-m RIFA control radius extended beyond the boundary of an adjacent, inaccessible property, resulting in a net total of approximately 14,245 m^2 that was surveyed and treated out of the intended 20,105-m^2 control area (Figure 2).

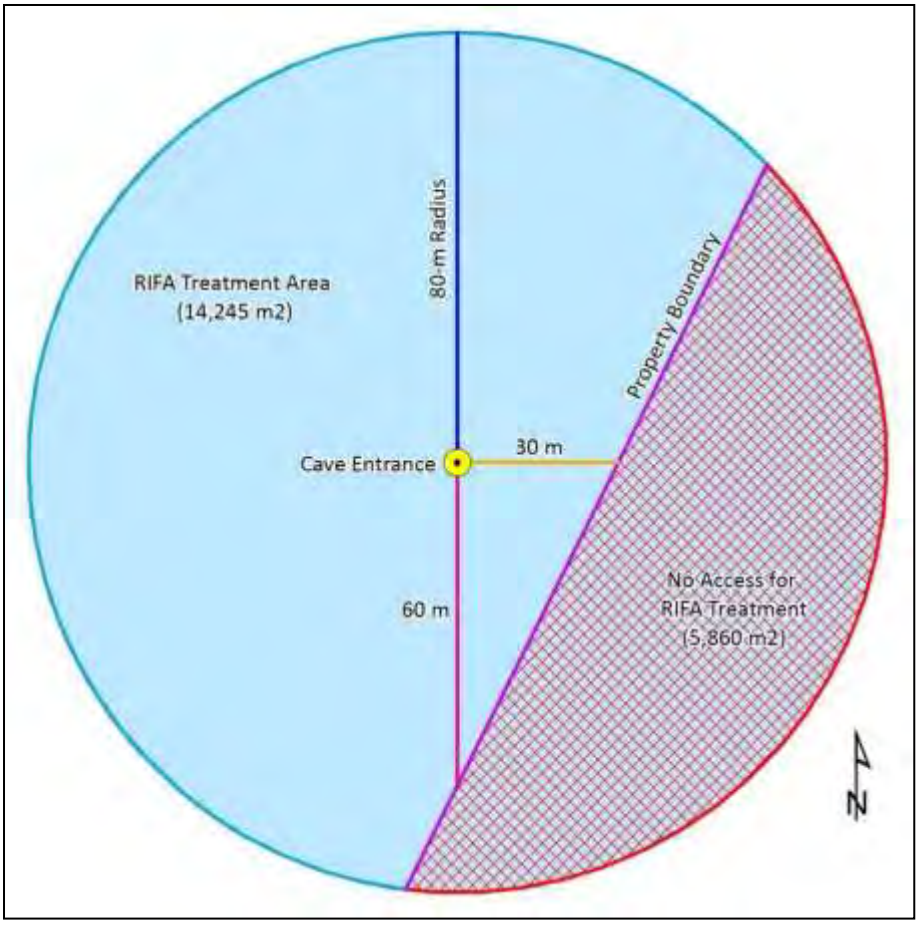

Figure 2. Diagram illustrating the entrance to Pennie's Cave, 80-m radius from the cave entrance, adjacent property boundary, RIFA treatment area, and inaccessible area located at the adjacent property.

A total of 75 active RIFA mounds, 40 in May and 35 in November, were identified and treated during the two control events in 2016. Fourteen abandoned mounds were also identified (six in May and eight in November). The resulting density of active RIFA mounds equates to one mound per 356.1 m^2 for the May treatment event and one mound per 407.0 m^2 for the November event. One active RIFA mound was identified within the 10-m infestation threshold radius during the May treatment event. Native ant colonies were not identified within the treatment area during either of the 2016 RIFA control events.

The number of counted RIFA mounds, approximate colony sizes, and the approximate volume of hot water used to date during control activities are presented in Table 4. The comprehensive RIFA treatment results are also presented in Figure 3 and Figure 4. Photographs of equipment and treatment activities are presented as Figure 5 and Figure 6.

Table 4. Dates of control activities, number of RIFA mounds and approximate colony sizes counted by radius distance, and approximate volume of hot water used during control activities.

RIFA Control Date	Surveyed RIFA Mounds by Approximate Colony Size					RIFA Mounds by Distance from Cave Entrance (m)		Total RIFA Mounds Surveyed	Total RIFA Mounds Treated	Volume of Hot Water Used (gal)
	Abandoned (No ants)	<100	<500	<1,000	<5,000	<10	<80			
18 October 2014	21	44	12	3	0	0	80	80	59	150
29 April 2015	13	8	20	12	10	0	63	63	50	115
13 November 2015	0	4	3	1	2	0	63	10	10	10
05 May 2016	6	15	15	7	2	1	39	46	40	50
17 November 2016	8	16	14	5	0	0	35	43	35	40

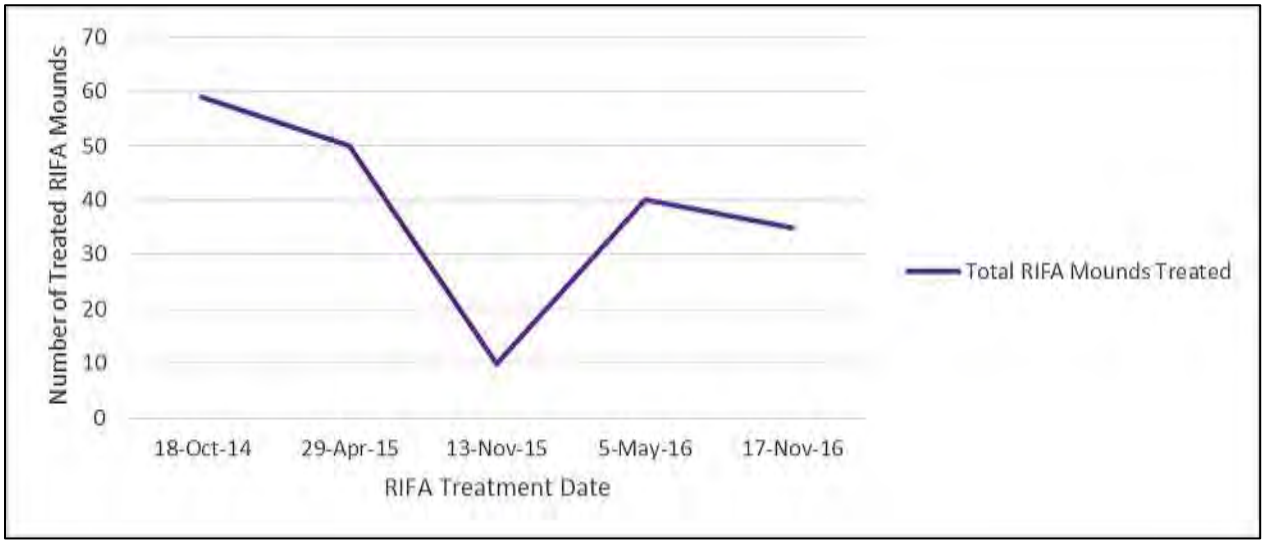

Figure 3. Total number of treated RIFA mounds by treatment date.

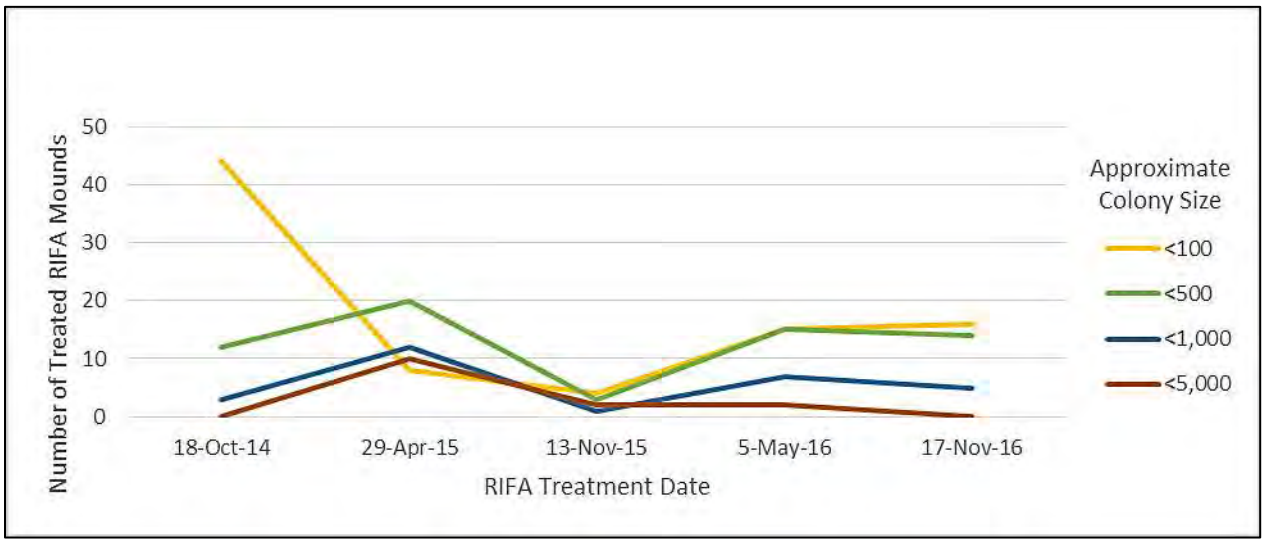

Figure 4. Number of treated RIFA mounds by treatment date and approximate colony size.



Figure 5. Equipment used to boil water for RIFA treatments.



Figure 6. Field crew treating a RIFA colony underneath a boulder using boiled water.

Discussion

Overall, lower numbers of karst invertebrates (i.e., number of taxa as well as individuals) were encountered during the 2016 biological monitoring compared to previous events, and only two troglobitic species were detected, *Cicurina* spiders a *Texoreddellia* silverfish. Neither of the documented BCCP species of concern, the *Speodesmus* N.S. millipede and *Rhadine austinica* ground beetle, were observed. The eyeless *Cicurina* spider observed during the 2016 biological monitoring may be a species protected under the BCCP as documented by Zara (2014; 2015), although additional studies would be needed for confirmation. No federally listed karst species were encountered at Pennie's Cave. Considering the low quality of air encountered in the cave, the difficult conditions limited the amount of survey time and number of cave zones the surveyors could visit, which likely contributed to the low numbers of observed karst invertebrate taxa and individuals. In addition, the low numbers of observed taxa and individuals could be attributed in part to the relatively drier conditions observed in the cave.

Despite the fluctuation in observed RIFA colonies over time (November 2015), the total numbers of observed RIFA mounds generally are decreasing (Figure 3). The distribution of colony size has remained somewhat consistent over time, with the exception of November 2015 and the initial treatment in October 2014 when a higher number of smaller colonies (less than 100 ants) were observed (Figure 4). Future RIFA control activities will help determine whether mound densities will continue to remain below the infestation threshold density and whether the number of mounds continues to decrease. In May 2016, one active RIFA mound was identified within the 10-m infestation threshold radius. Despite the recent occurrence of RIFA within 10 m of the entrance, no ants have been observed inside the cave since biological monitoring began in 2014.

Cave management activities planned for 2017 at Pennie's Cave include the continuation of annual biological monitoring. The next planned biological monitoring likely will occur in early 2017 in the winter due to the presence of potentially hazardous air in the cave during the warmer months. In addition, bi-annual RIFA control activities are planned for the spring and fall of the upcoming year. The results of the RIFA control activities will be reviewed after each year of treatments to determine whether continued control activities should continue on a bi-annual basis. Finally, an annual report summarizing the activities performed in 2017 will be prepared and submitted to the Travis County Transportation and Natural Resources Department for inclusion in the BCCP annual report for the year.

Literature Cited

Balcones Canyonlands Preserve (BCP). 2016. BCP land management plan, Tier II-A, Chapter IX, Karst species management. 70 pp.

City of Austin and Travis County. 1996. Habitat conservation plan and final environmental impact statement. U.S. Fish and Wildlife Service (USFWS) Ecological Services Field Office, Austin, Texas.

Menne, M.J., I. Durre, B. Korzeniewski, S. McNeal, K. Thomas, X. Yin, S. Anthony, R. Ray, R.S. Vose, B.E.Gleason, and T.G. Houston. 2012. Global Historical Climatology Network - Daily (GHCN-Daily), Version 3. [Station IDs: US1TXTV0164 and USW00013958]. NOAA National Climatic Data Center. doi:10.7289/V5D21VHZ. Available at https://www.ncdc.noaa.gov/data-access. Accessed 17 November 2016.

Paquin, P. and M. Hedin. 2005. Genetic and morphological analysis of species limits in *Cicurina* spiders (Araneae, Dictynidae) from southern Travis and northern Hays counties (Texas), with emphasis on *Cicurina cueva* Gertsch and relatives. Report to USFWS. Austin, Texas. 21 pp.

Paquin, P., N. Dupérré, J.C. Cokendolpher, K. White, and M. Hedin. 2008. Fundamental importance of taxonomy in conservation biology: the case of the case of the eyeless spider *Cicurina bandida* (Araneae: Dictynidae) of Central Texas, including new synonyms and the description of the male of the species. Invertebrate Systematics, 22. 11 pp.

Scanlon, S. 2015. Relative humidity calculator webpage. Available at http://www.ringbell.co.uk/info/humid.htm. Accessed 17 November 2016.

USFWS. 2016. Endangered karst invertebrate taxonomy of central Texas, revised October 17, 2016. USFWS Ecological Services Field Office, Austin, Texas. 24 pp. Available at: http://www.fws.gov/southwest/es/Documents/R2ES/AUES_KarstInverts_Taxonomy.pdf. Accessed 6 December 2016.

_____. 2015. Section 10(a)(1)(A) Scientific permit requirements for conducting presence/absence surveys for endangered karst invertebrate species, revised May 21, 2015. USFWS Ecological Services Field Office, Austin, Texas. 24 pp. Available at: https://www.fws.gov/southwest/es/Documents/R2ES/Karst_Survey_Procedures_20150528.pdf. Accessed 5 December 2016.

_____. 2014. Karst preserve management and monitoring recommendations, revised April 8, 2014. USFWS Ecological Services Field Office, Austin, Texas. 12 pp. Available at: https://www.fws.gov/southwest/es/Documents/R2ES/TX_Karst_Preserve_Mgmt_module.pdf. Accessed 5 December 2016.

Vinson, S.B. and A.A. Sorenson. 1986. Imported fire ants: life history and impact. Texas Department of Agriculture. Austin, Texas. 28 pp.

Zara Environmental LLC (Zara). 2012. Management plan for Pennie's Cave, Travis County, Texas. Manchaca, Texas. 3pp.

_____. 2014. 2014 Summary of cave management activities at Pennie's Cave, Travis County, Texas. Manchaca, Texas. 12 pp.

_____. 2015. 2015 Summary of cave management activities at Pennie's Cave, Travis County, Texas. Manchaca, Texas. 14 pp.