FINAL PERFORMANCE REPORT

STATE: Oklahoma PROJECT NUMBER: F11AP00440

GRANT PERIOD: 1 June 2011 – 31 May 2012

GRANT TITLE: Management and Protection for the Ozark Big-eared Bat, Gray Bat, and Stygobitic Fauna in Oklahoma

ABSTRACT:

Unique characteristics common to North American cave-dwelling and subterranean fauna render them vulnerable to anthropogenic activities and underscore the importance of monitoring and protecting sensitive populations. Procedures implemented during this project were intended to 1) maintain the bat population in targeted caves by preventing unnecessary human entry and disturbance to critical roosts, and 2) survey stygobitic fauna in Oklahoma to delineate biologically important subterranean systems. Management procedures, including gate/grill construction and/or repair, were completed at two caves, and population monitoring was conducted at 17 caves that have received past management and protection efforts. Stygobitic surveys were conducted at 7 caves and focused on population counts of Ozark Cavefish and both species of state-endemic cave crayfish (*Cambarus tartarus* and *Cambarus subterraneus*). Management recommendations follow the results of these project activities.

NEED:

Cave ecosystems harbor a variety of unique and sensitive organisms, many of which are cave obligates. Unique characteristics common to North American subterranean fauna render them vulnerable to anthropogenic activities and underscore the importance of monitoring and protecting sensitive populations. Subsurface habitats typically display decreased diversity in community complexity and reduced species abundance relative to above ground ecosystems translating to fewer species and individuals in subterranean habitats than in surface habitats (Holsinger, 1988). Processes that isolate subterranean populations of organisms, and evolutionary adaptation of those species to their environments, can produce extreme patterns of endemism (Barr and Holsinger, 1985; Culver et al, 2000).

Procedures during this project were conducted in eastern Oklahoma in the western limit of the Boston Mountains of the Ozark Plateau. The Plateau covers about 103,000 km^2 (Huffman 1959) in the central United States; elevations are 260–460 m above mean sea level. The Plateau was comprised of alternating layers of limestone, flint (= chert) and sandstone that are conducive to cave formation (Blair and Hubbell 1938). Caves in this region serve as refugia from severe

winters for many cave-dwelling species (Humphrey and Kunz 1976). The vegetation on mountain slopes was predominantly blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), black hickory (*Carya texana*), and winged elm (*Ulmus alata*). Coralberry (*Symphoricarpus orbiculatus)* and sassafras (*Sassafras albidum*) comprised the sparse shrubby understory. Riparian areas were dominated by silver maple (*Acer saccharium*), river birch (*Betula nigra*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), sycamore (*Plantanus occidentalis*), and various oak species (*Quercus* spp.). Sporadic openings of managed grasslands have historically been used for various types of agriculture (Blair and Hubbell 1938, Harvey et al. 1981).

OBJECTIVE:

The purpose of the project is two-fold, 1) to maintain the bat population in targeted caves by preventing unnecessary human entry and disturbance to critical roosts, and 2) survey stygobitic fauna in Oklahoma and delineate biologically important subterranean systems to include historical localities of *Amblyopsis rosae* and species of groundwater crayfish endemic to Oklahoma.

PROCEDURES:

Cave Management— Human disturbance at caves is a persistent problem internationally and has been implicated as a major cause of decline of cave-dependent bats (Barbour and Davis, 1969; Humphrey and Kunz, 1976; Tuttle, 1979; American Society of Mammalogists, 1992). About 18 of the 45 species of North American bats rely substantially on caves throughout the year, and 13 use caves year-round (McCracken, 1989). All North American bats listed as endangered or threatened by the United States Fish and Wildlife Service are cave-dwelling species or subspecies (McCracken, 1989; Harvey et al., 1999; Pierson, 1999). In the central United States, two species, the gray bat (*Myotis grisescens*) and Indiana bat (*Myotis sodalis*), and one subspecies, the Ozark big-eared bat (*Corynorhinus townsendii ingens*), are of particular concern to recovery biologists because each is federally listed as endangered (United States Fish and Wildlife Service 1982, 1983, 1995).

As a result, cave gating has been used widely by government and private entities to protect these sensitive ecosystems from pernicious impacts. In northeastern Oklahoma, endangered gray bat and Ozark big-eared bat populations have been protected by gate/grill systems at >34 cave entrances (Martin et al. 2006). The remaining caves are inhabited by populations of big brown bats (*Eptesicus fuscus*), tricolored bats (*Perimyotis subflavus*), northern long-eared bats (*Myotis septentrionalis*), and a single hibernaculum of endangered Indiana bats. Four caves that contain populations of either Ozark cavefish (*Amblyopsis rosae*), Oklahoma cave crayfish (*Cambarus tartarus*) and/or Delaware County cave crayfish (*Cambarus subterraneus*) also are protected from human entry by internal gates. Population estimates of bats at these caves prior to installation of gates beginning in 1981 and post-installation estimates show that each cave continues to be used by stable, or increasing populations of resident bats (Grigsby et al. 1993, Martin et al. 2000, 2003, 2006; Puckette 2000).

Procedures in this project assist in stabilizing and increasing the Ozark big-eared bat and gray bat populations in northeastern Oklahoma. This may ultimately allow for recolonization of previously known caves that were inhabited by these species (Grigsby and Puckette, 1984). Proposed objectives were designed to accomplish task B 1.6 and 1.7 of the 1993 Revised Ozark Big-eared Bat and Virginia Big-eared Bat Recovery Plan, and objectives 1, 1.2, 1.3.1, 3, and 3.2 of the 1982 Gray Bat recovery plan.

The following is a description of caves and management procedures that were involved in the project during the 2011-2012 project year.

Continued Investigation of Cave AD-7

This cave is located in Adair County, OK. The site annually serves as a maternity cave for a colony of gray bats. It is the only maternity colony of gray bats in the state that is not protected from human entry by a gate/grill system. In June 2010 an initial visit to the entrance was conducted in an attempt to identify the location of a potential gate/grill system. A visit was conducted to the site on 22 December 2011 to investigate vehicular and equipment access to the site in such a way that would allow for a gate installation to occur. At present, matters of landownership that can be accurately determined and appropriate permission obtained, are the only deterrents to construction of the gate/grill installation.

Gate Repair: Cave OT-13

A summer population of about 14,000 gray bats have historically used cave OT-13 located in Ottawa County, Oklahoma (Martin et al. 2000). Lactating females and volant young were captured in a harp trap at the cave's entrance in July 1999 indicating use by a maternity colony of gray bats. Installation of an internal gate system to provide protection from human entry was completed in spring 2001. During a monitoring visit in February 2012 it was noted that vandalism had occurred to the grill system and human entry was gained to the roost areas. On a subsequent visit to the cave on 12 April 2012 the breach in the system was repaired and the integrity of the system restored.

Gate Replacement/Relocation: Cave DL-91

This repair project was jointly funded through the Oklahoma Chapter of the Nature Conservancy who is the private landowner. Cave DL-91 is located in Delaware County, OK. The cave has a mapped passage of 803m and has historical records of nine roost sites for gray bats. Prior to 1973, DL-91 historically housed the largest colony of gray bats in Oklahoma estimated to be as many as 113,000 bats. Aquatic pools are produced within the passage of the cave provide documented habitat for the Ozark Cavefish and Ozark Crayfish. An internal gate/grill system was placed inside the cave passage in 1993. A reported breach to the internal gate/grill system was verified during a trip on 24 March, 2011 and subsequent repair of the vandalism occurred

during a return trip on 30 April, 2011. For some time researchers have been more than somewhat suspect of the ability of the existing internal gate/grill system at this site to sustain long term protection to the sensitive species from potential human entry and vandalism. In question is the strength of the lightweight steel used to construct the current system. As evidence in support of our scrutiny is the fact that we have repaired breeches to the system twice in the past three years and that the cave is the most susceptible to vandalism and subsequent human entry in the region. Several factors contribute to concern for the long-term management and protection of the system: 1) the persistent awareness of locals, both in close proximity and beyond, of the system and its popularity as a recreational opportunity, 2) the critical nature of the cave with respect to inhabitation by sensitive and endangered species, both vertebrates and invertebrates, and 3) an aging construction crews who possess the experience in cave management. Permission was sought and granted to replace the existing ¼" steel 4" x 4" angle iron horizontal bars with the standard 3/8" steel angle iron, and undergirded with 2" x 2" angle iron to prevent spreading and expansion with hydraulic jacks. The existing horizontal bars had no undergirding, and been repeatedly breached using this tactic already. Initial excavation and planning/design was conducted on 20 October, 2011 and was completed on 25 February 2012. A final trip to the cave was made on 23 March, 2012 to complete the removal of the old gate system, and to apply a coat of industrial primer to the new gate/grill structure. It was evident from scattered guano on the new structure that some bat use had already occurred. An inspection of the caverns and roosting areas close to the gate/grill indicated that some gray bats were already using the cave, and moving through the new grill system.

Colony/Species Monitoring:

An important aspect of the long-term E-22 project is monitoring caves that have received past management and protection efforts. These monitoring visits establish continued use by target species, verify the integrity of installed structures intended to eliminate human entry, and are conducted at non-gated caves to determine a ranking hierarchy for need of future consideration of management procedures. Monitoring at hibernacula was conducted between December 2011 through January 2012. Summer roost monitoring visits were conducted from May through July to selected caves to determine use patterns and if possible, population estimates (Table 1). Guano measurements at gray bat maternity caves are conducted biennially after the colonies have vacated caves in Oklahoma to their respective hibernacula in Missouri and Arkansas. Using standardized measuring methods for the past 40 years allows appropriate comparative estimates to monitor population fluctuations in respective maternity colonies of gray bats (Grigsby et al. 1993).

Table 1. Population estimates and species richness at select caves in eastern Oklahoma during the 2011-2012 project year.

Date	County	Cave Number	Historical Bat Use	Gated	Monitoring Method/Results
6-Jun-11	Delaware	DL-4	Multiple Species	Yes	NA
6-Jun-11	Delaware	DL-8	Multiple Species	Yes	NA
6-Jun-11	Delaware	DL-21	Multiple Species	No	98 *Perimyotis subflavus*
21-Jun-11	Delaware	DL-1	Gray Bat	Yes	Emergence/9,615
21-Jun-11	Delaware	DL-91	Gray Bat	Yes	Emergence/0
5-Jul-11	Cherokee	CZ-9	Gray Bat	Yes	Emergence/9,864
20-Jul-11	Adair	AD-220	Gray Bat (Past)	Yes	14 *Perimyotis subflavus*
20-Jul-11	Adair	AD-137	Gray Bat (Past)	No	0
5-Aug-11	Delaware	DL-1	Gray Bat	No	Emergence/0
5-Aug-11	Delaware	DL-91	Gray Bat	Yes	Emergence/12,784
21-Nov-11	Delaware	AD-8	Gray Bat	Yes	Guano/15,538
22-Dec-11	Adair	AD-7	Gray Bat	No	Guano/16,324
27-Dec-11	Delaware	DL-92	Gray Bat	Yes	NA
27-Dec-11	Delaware	DL-1	Gray Bat	Yes	Guano/10,401
28-Dec-11	Adair	AD-29	Multiple Species	Yes	7 PESU
28-Dec-11	Adair	AD-30	Multiple Species	Yes	23 *Perimyotis subflavus*
28-Dec-11	Adair	AD-54	Multiple Species	Yes	31 *Perimyotis subflavus*
28-Dec-11	Adair	AD-201	Multiple Species	Yes	4 *Perimyotis subflavus*
28-Dec-11	Adair	AD-221	Multiple Species	Yes	80 *P. subflavus*; 2 *C. t. ingens*
12-Feb-12	Delaware	DL-91	Gray Bat	Yes	Guano/26,734
20-Feb-12	Ottawa	OT-13	Gray Bat	Yes	Guano/14,276

Management of Stygobytic Fauna—Anthropogenic activities threaten groundwater quality and quantity to the communities of organisms living in groundwater habitats. The combined ranges of over 50% of the described species and subspecies of groundwater dwelling fauna (stygobites) in the continental United States are estimated to constitute less than 1% of the total surface area of that region (Culver et al, 2000). These phenomena render groundwater species vulnerable to anthropogenic activities and necessitate monitoring of vulnerable species and populations.

Agricultural pollution and industrial runoff pose serious risks to groundwater quality (Crunkilton, 1984; Culver et al, 2000). From a wildlife management perspective, groundwater contamination is a serious problem. Because so many groundwater species are found in single aquifer systems, a contamination event can pose an extinction threat. Because an aquifer is the entire available habitat for groundwater fauna, any change in water quality, and especially contamination of it, poisons the environment without places of refuge (Crunkilton, 1984).

The Ozarks are no exception to the generalities of subterranean communities mentioned above and the vulnerabilities to anthropogenic activities. Commercial and residential development in recharge zones, groundwater extraction issues, and contamination of groundwater are all potential threats to subterranean fauna of the Ozarks (Crunkilton, 1984; Margat, 1994; Fels,

1997; Graening and Brown, 2003; Mace et al., 2006). Of particular concern is the Ozark Blind Cave Fish that is endemic to the Ozark Plateaus Ecoregion and is a federally listed endangered species. Additionally, both species of groundwater crayfish endemic to Oklahoma, *C. subterraneus* and *C. tartraus*, have exceptionally small ranges and are vulnerable to human activities; they are listed as endangered and critically endangered by the IUCN respectively and both are listed by NatureServe as critical (Graening and Fenolio, 2005; Graening et al., 2006).

Stygobitic surveys conducted in this project—in particular, regular counts of habitats containing populations of Ozark Cavefish and both state endemic cave crayfish, have been a focus of these surveys. Examining caves where old records of Ozark Cavefish exist, but where they have not been seen in recent years, is a goal. Trapping in caves with old reports of cave crayfish, and where the identity of those species has not been determined, has also been a focus. Of note on these surveys are other important subterranean species such as the Ozark Blind Cave Salamander (*Eurycea spelaea*), groundwater amphipods (*Stygobromus* ssp.), and range limited groundwater isopods such as Mackin's Cave Isopod (*Caecidotea mackini*).

The 2012 surveys were planned for the spring. April and May can be wet months so rain plans included back up caves that are not likely to flood, such as Twin Cave in Delaware County. We included a survey of cave DL-148 in our plans even though the water in that cave is often times too high to enter the cave mouth. The site has the record high survey count for Ozark Cavefish in Oklahoma (19) observed in 1999 (Graening et al., 2010). Data collected from these surveys has always been provided to the Subterranean Biodiversity Project database, maintained by Dr. G.O. Graening. A formal final report of that 13 year project has now been published through the University of Oklahoma Press, "*The Subterranean Fauna of Oklahoma and Arkansas*" by Graening, Fenolio, and Slay.
The following is a description of caves and management procedures that were involved in the project during the 2011-2012 project year.

27 April – 2 May 2012: DL-64 and Cave DL-21 Delaware Co.

Cave DL-64 has records from the 1980s and early 1990s of a cave crayfish inhabiting the cave stream (Subterranean Biodiversity Project database records). No identification has ever been made of the species inhabiting the site. Englebrecht Cave has records from the same time frame of both a cave crayfish and Ozark Cavefish sightings; although no recent sightings have been made in either system. The last sighting of an Ozark Cavefish in cave DL-21 was made in 1987 (Graening et al, 2010). The landowners of cave DL-64 live in the house on the right hand side of the road where you park to walk to the cave. The landowners are friendly and have allowed access to the cave since I have started visiting it in the early 2000s. Ownership/management of cave DL-21 is far less clear; the mobile home that used to sit across the road from the cave is now gone but the last property manager gave me "unrestricted permission to access the system with my survey work." We put baited minnow traps out in both caves for 5 days. The fence at cave DL-21 has been damaged by a number of fallen trees. Additionally, someone bent the edge of the chain link gait up so that they could pass beneath it and gain access the cave. The gate is seriously damaged.

Table 2. Biological inventory for caves DL-64 and DL-21 Delaware County, Oklahoma

Location	Biological Inventory		No.
DL-64	Cave Cricket	*Ceuthophilus*	12
DL-64	Ringed Crayfish	*Orconectes neglectus*	6
DL-64	Tricolored Bat	*Perimyotis subflavus*	1
DL-21	Hothouse Millipede	*Oxidus gracilis*	6
DL-21	Ringed Crayfish	*Orconectes neglectus*	1
DL-21	Pickerel Frog	*Lithobates palustris*	2
DL-21	Carolina Sculpin	*Cottus carolinae*	1
DL-21	Northern Long eared Bat	*Myotis septentrionalis*	>30

28 April 2012: DL-74 Delaware Co.

Visited with the landowners, Mr. and Mrs. Caroll, prior to entering the cave. They were very friendly and supportive of the cave survey on their property. They asked that we take a disposable camera in the cave with us to take some images – we did that. They also would like images of the focal species that have been observed in their cave. The cave has changed with regard to the crawl early off in the cave. The bedding plane that was used to get to the rear area of the cave is now filled with chert from heavy water flow in the system. The only way to access the rear portions of the cave and follow the cave stream involves negotiation of a narrow slot to the left of the entrance. The crawl is very narrow and only two of the smallest surveyors on the team could fit through the slot…belly crawling in the water and removing their helmets to fit through the passage. A coyote (*Canis latrans*) had died in the cave stream and its skeleton was visible in the first pool after slipping through the slot.

Table 3. Biological Inventory for cave DL-74 in Delaware County, Oklahoma

Biological Inventory		No.
Cave Cricket	*Ceuthophilus sp.*	10
Cave Dung Flies	*Spelobia sp.*	50+
Hothouse Millipede	*Oxidus gracilis*	4

Delaware County Cave Crayfish	*Cambarus subterraneus*	1
Banded Sculpin	*Cottus carolinae*	2
Cave Salamander	*Eurycea lucifuga*	2
Tricolored Bat	*Perimyotis subflavus*	1

29 April 2012: Cave DL-39

We observed 6 dead bats and 1 sick bat around the Moonshine Room, all were in the water. The bats were collected and stored at the Ozark Plateau National Wildlife Refuge headquarters (Mary Loony Unit). The bats were a mix of Northern Long Ear Bats and Tricolor Bats. A number of Gray Bats had arrived to the cave and were flying around but I suspect the numbers were 1/10th the size of the colony there in the summer. We examined all Tricolor Bats closely and saw no signs of WNS. The dead bats did not have any apparent signs of WNS but the corpses had been in the water. A single bat was collected for testing but negatively tested for rabies. We noted a large guano pile toward the back of the cave that had not been seen on prior surveys. The pile was approximately 2 feet in diameter and 1.5 to 2 feet in height. The guano looked to be last year's material. There were no bats roosting above the pile when observed. The pile is well beyond the rasp and on the right bank of the stream, prior to the canyon slot at the back of the cave.

The Oklahoma Cave Crayfish count is a record count for cave DL-39 at 43 individuals (last year {2011} was the previous high count at 37). The greatest count made for the species during a survey was on 31 August 2001 in cave DL-148 at 63 (Graening et al. 2006). Last year's count for this site included a number of YOY "young of the year" individuals, two were observed this season. This is a good indication of recruitment in consecutive years. Morphometric data were collected for 34 individuals on this survey. Surveyor's pushed the upper crawling lead in the back of the cave and at the end of the "canyon slot." They crawled through a low bedding plane for approximately 500 feet and passed into much larger walking passage. They described a stream that had plunge pools and waterfalls. Owing to time constraints, they did not follow the passage and turned around but there is apparently at least another quarter to half mile of passage beyond anything included on the one map for the system.

Table 4. Biological Inventory for cave DL-39 in Delaware County, Oklahoma

Biological Inventory		No.
Cave Isopods	*Caecidotea sp.*	4
Cave Amphipod	*Stygobromus sp.*	1
Hothouse Millipedes	*Oxidus gracilis*	12

Edaphic Centipede		1
Mosquitoes	Culicidae	50+
Cave Beetles	*Platynus sp.*	10
Cave Beetles	*Ptomaphagus sp.*	5
Crane Fly	Tipulidae	4
Cave Crickets	*Ceuthophilus sp.*	25
Oklahoma Cave Crayfish	*Cambarus tartarus*	43
Ringed Crayfish	*Orconectes neglectus*	10
Ozark Blind Cave Salamander	*Eurycea spelea*	3 adult; 7 larvae
Cave Salamander	*Eurycea lucifuga*	3 adult; 1 larvae
Banded Sculpin	*Cottus carolinae*	2
Tricolored Bat	*Perimyotis subflavus*	50+
Gray Bat	*Myotis grisescens*	100+

1 May 2012: DL-91 Delaware County

Cave DL-91 is a regular cave for survey on these trips owing to the presence of the Delaware County Cave Crayfish and older sightings of Ozark Cave Fish (early 2000s, Graening et al., 2010). The high count for Delaware County Cave Crayfish in this cave is comprised of two counts, each of 17 individuals, on 28 October 1989 and again on 5 March 2001 (Graening and Fenolio, 2005). Our count on this visit is nearly 3 times greater than the previous high counts, at 48 individuals. What is important to tease out of the high count is the fact that 12 of the individuals observed were either young of last year or young of this year. All were less than 3cm total length. This is a good sign of recruitment and is suggestive of a healthy population. Perhaps the largest individual observed in this system was captured and measured on this survey. An old and large female measured 70.1mm total length, 44.6mm chaela length, 10.6mm chaela width, 17.4mm carapace width, and 36.4mm carapace length (Fig. 7). No Ozark Cavefish were observed.

Table 5. Biological Inventory for cave DL-91 in Delaware County, Oklahoma

Biological Inventory		No.
Cave Isopods	*Caecidotea sp.*	3
Webworms	*Macrocera noblis*	2
Hothouse Millipede	*Oxidus gracilis*	12+
Cave Millipede	*Causyella sp/Trigenotyla sp*	2
Edaphic centipede		1

Heleomyzid Fly		25+
Cave Beetle	*Platynus sp.*	24+
Cave Beetle	*Ptomaphagus sp.*	3
Meshweaver Spider	*Cicurina sp.*	2
Ozark Blind Cave Salamander	*Eurycea spelea*	1 adult; 4 larvae
Delaware County Cave Crayfish	*Cambarus subterraneus*	48
Slimy Salamander	*Plethodon albagula*	1 adult; 1 juvinile
Tricolored Bat	*Perimyotis subflavus*	12
Gray Bat	*Myotis grisescens*	100+

4 May 2012: DL-148

Surveyors were able to make it back roughly 300 meters into the system before the water level and the ceiling closed to less than 6 inches of air space. The Ozark Cavefish observed in the system was a juvenile and apparently in good condition. The 2 Oklahoma Cave Crayfish observed were smaller individuals (4–5cm total length) and possibly second or third year animals. We searched the tree roots that come through the ceiling and sides of the cave and then extend down into the water but didn't see any juvenile Ozark Cavefish. On a survey in the early 2000s, a baby Ozark Cavefish was observed in this root microhabitat, measuring less than 8mm (unpublished, personal observation).

The high count for Oklahoma Cave Crayfish in the DL-148 and DL-119 system is 63, observed from cave DL-148 on 31 August 2001 (Graening et al., 2006). From previous surveys, typically more *C. tartarus* had been observed in cave DL-148 than in DL119. However, this year cave DL-119 had 7 individuals and DL-148 had 2. Similarly, the Ozark Cavefish are usually more abundant in DL-148 than in DL-119 but this year's survey indicated a record 9 Ozark Cavefish in DL-119 and only 1 in DL-148. Last year, cave DL-148 was sumped and could not be surveyed, but in cave DL-119, 5 Ozark Cavefish were observed. With the exception of one individual, all of the fish observed this year were the young of last year's reproductive cycle (YOY – young of the year) based on the small size of the fish. This is a good indication of recruitment two years in a row. Likewise, three of the *C. tartarus* observed in cave DL-19 were less than 3cm and were likely YOY from last year. The aquatic isopod identification (*Caecidotea mackini*) is based on the description of an endemic isopod to the system (Lewis et al., 2006 and from Graening et al., 2007).

Table 6. Biological Inventory for cave DL-148 in Delaware County, Oklahoma

Biological Inventory		No.
Mackin's Cave Isopod	*Caecidotea mackini*	2
Cave Dung Flies	*Spelobia sp.*	100+
Oklahoma Cave Crayfish	*Cambarus tartarus*	2

Ringed Crayfish	*Orconectes neglectus*	1
Cave Salamander	*Eurycea lucifuga*	2
Ozark Cave Fish	*Amblyopsis rosae*	1 juvenile

4 May 2012: DL-119

The record count for Ozark Cavefish in cave DL-119 was made in 1990 when 6 fish were observed (Graening et al., 2010). Last year, our surveyors observed 5 individuals (1 adult and 4 juveniles). This year's record count for the cave (9 fish – 8 juveniles and one adult) is encouraging and is indicative of recruitment (Fig. 9). As an important note, future surveyors should not step onto the chert pile at the beginning of the cave pool as we observed several juvenile Ozark Cavefish swimming into and out of the microhabitat. To enter the pool for a survey, walk along the limestone ledges and step onto the silt bottom of the pool, bypassing the chert pile.

Table 7. Biological Inventory for cave DL-119 in Delaware County, Oklahoma

Biological Inventory		No.
Mosquitoes	Culicidae	100+
Heleomyzid Fly		10+
Oklahoma Cave Crayfish	*Cambarus tartarus*	7
Ozark Blind Cave Salamander	*Eurycea spelea*	7 larval
Cave Salamander	*Eurycea lucifuga*	3 larval
Ozark Cave Fish	*Amblyopsis rosae*	1 adult; 8 juveniles

MANAGEMENT RECOMMENDATIONS:

1. Cave AD-7 in Delaware County is the last known maternity colony of gray bats in Oklahoma that is currently unprotected from human entry and disturbance. Verifying landownership of the cave's two entrances and securing access across private properties is a crucial step in providing long-term protection to the critical bat roosts inside the cave. Once these are established, planning needs to begin in an expeditious manner to install gate/grill systems inside the cave's respective entrance's and passages.

2. The gate and fence surrounding cave DL-21 requires repair. In addition, establishing accurate landownership will assist in future management efforts and access at the site.

3. Annual monitoring of caves that have received past management and protection efforts. These monitoring visits establish continued use by target species, verify the integrity of installed structures intended to eliminate human entry, and are conducted at non-gated caves to determine a ranking hierarchy for need of future consideration of management procedures.

4. Future surveyors of cave DL-74 need to be smaller individuals. The pathway to the back of the cave is a narrow slot that requires a small individual and removal of one's helmet to pass through the hole and to larger passageway.

5. The limestone bluff line west of the opening to cave DL-74 has several small karst windows. They have groundwater that can be seen from the surface. They should be investigated for *C. subterraneus* when surveys are performed.

6. In an effort to maintain productive landowner relationship at cave DL-74, images of the cave fauna should be provided to the Carroll Family. Prints will be made and sent to the U.S.F.W Service to deliver to them at a later date.

7. A mapping survey of cave DL-39 is suggested. An accurate map of the system would help with biological surveys and with reporting.
8. Care should be taken by anyone working in McGee's Cave not to step on the chert pile at the front of the pool owing to juvenile Ozark Cavefish utilizing the rocky microhabitat and its interstitial spaces.

9. Much removal of timber has been conducted around caves DL-148 and McGee's Caves. Observing the progression of the habitat alteration closely is suggested as the activities could impact the systems.

COOPERATOR: Rogers State University, Claremore, Oklahoma

PROJECT INVESTIGATORS:

Keith W. Martin, Ph.D.
Dean, Associate Professor of Biology
School of Mathematics, Science, Health Science
Rogers State University
Claremore, Oklahoma 74017
918-343-7706

W.L. Puckette
Instructor of Biology
Poteau Public Schools
Poteau, Okla. 74953
918-647-3911

Danté Fenolio, Ph.D.
Atlanta Botanical Garden
Department of Conservation Research
1345 Piedmont Ave, N.E.

Atlanta, GA 30309
404-591-1719

SIGNIFICANT DEVIATIONS:

None

PREPARED BY: Dr. Keith W. Martin, Dean, Professor of Biology
Rogers State University, Claremore, Oklahoma

DATE: 6 August 2012

APPROVED BY: _____
Wildlife Division Administration
Oklahoma Department of Wildlife Conservation

_____
John D. Stafford, Federal Aid Coordinator
Oklahoma Department of Wildlife Conservation

LITERATURE CITED:

American Society of Mammalogists. 1992. Guidelines for the protection of bat roosts. Journal of Mammalogy 73:707-710.

Barbour, R.W. and W.H. Davis. 1969. Bats of America. University of Kentucky Press, Lexington, KY 286 pp.

Barr, T. C. and J. R. Holsinger. 1985. Speciation in cave faunas. Annual Review of Ecology and Systematics 16: 313–337.

Blair, W. F., and T. H. Hubbell. 1938. The biotic districts of Oklahoma. American Midland Naturalist 20: 425–454.

Crunkilton, R. 1984. Subterranean contamination of Meramac Spring by ammonia nitrate and urea fertilizer and its implication on rare cave biota. From – Proceedings of the 1984 National Cave Management Symposium, Journal of the Missouri Speleological Society 25: 151–158.

Culver, D. C., L. L. Master, M. C. Christman, and H. H. Hobbs III. 2000. Obligate cave fauna of the 48 contiguous United States. Conservation Biology 14: 386–401.

Fels, J. B. 1997. Source identification investigation of petroleum contaminated groundwater in the Missouri Ozarks. From Beck, B.F., B.J. Stephenson, and J.G. Herring (eds.). The engeneering geology and hydrogeology of Karst terranes. Balkema. pp 199-205.

Graening, G. O. and Brown, A. V. 2003. Ecosystem dynamics and pollution effects in an Ozark cave stream. Journal of the American Water Resources Association 39: 1497-1507.

Graening, G.O. and D.B. Fenolio. 2005. Status update of the Delaware County Cave Crayfish, *Cambarus subterraneus* (Decapoda: Cambaridae). Proceedings of the Oklahoma Academy of Sciences, 85:85–89.

Graening, G.O., D.B. Fenolio, H.H. Hobbs, S. Jones, M.E. Slay, S.R. McGinnis, and J.F. Stout. 2006. Range extension and status update for the Oklahoma Cave Crayfish, *Cambarus tartarus* (Decapoda: Cambaridae). The Southwestern Naturalist 51: 94–99.

Graening, G.O., M.E. Slay, D.B. Fenolio, and H.W. Robison. 2007. Annotated checklist of the isopoda (Subphylum Crustacea; Class Malacostraca) of Arkansas and Oklahoma, with an emphasis upon subterranean habitats. Proceedings of the Oklahoma Academy of Sciences, 87: 1–14.

Graening, G.O. D.B. Fenolio, M.L. Niemiller, and A.V. Brown. 2010. Analysis of the 30-year recovery effort for the Ozark cavefish (*Amblyopsis rosae*), with current distribution, population dynamics, and status of this threatened species. Environmental Biology of Fishes, 87: 55–88.

Grigsby, E.M. and W.L. Puckette. 1984. A study of three endangered bats occurring in Oklahoma. Report to the U.S. Fish and Wildlife Service: Contract number 14-16-0002-81-202. 23 Pp.

Grigsby E.M., W.L.Puckette, and K.W. Martin. 1993. Comparative numbers of gray bats (*Myotis grisescens*) at six maternity caves in northeastern Oklahoma. Proceedings of the Oklahoma Academy of Science 73:35-38.

Harvey, M. J., J. J. Cassidy, and G. G. O'Hagan. 1981. Endangered bats of Arkansas: distribution, status, ecology, and management: Arkansas Game and Fish, United States Forest Service, and United States National Park Service-Buffalo National River.

Arkansas Game and Fish Commission, Little Rock, Arkansas, USA.

Harvey, M.J., J.S. Altenbach, and T.L. Best. 1999. Bats of the United States. Arkansas Game and Fish Commission, Little Rock, AR 64 pp.

Holsinger, J.R. 1988. Troglobites: the evolution of cave dwelling organisms. American Scientist 76: 147–153.

Huffman, G. G. 1959. Mississippian stratigraphy and tectonics of the Oklahoma Ozark area. Tulsa Geological Society Digest 27: 104–176.

Humphrey, S.R. and T.H. Kunz. 1976. Ecology of a Pleistocene Relic, the Western Big-eared Bat (*Plecotus townsendii*), in the Southern Great Plains. Journal of Mammalogy 57:470-494.

Lewis, J.J., G.O. Graening, D.B. Fenolio, and E.A. Bergey. 2006. *Caecidotea mackini*, new species, with a synopsis of the subterranean asellids of Oklahoma (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington, 119(4):563–575.

Mace, R.E., R. Petrossian, R. Bradley, and W.F. Mullican III. 2006. A streetcar named desired future conditions: The new groundwater availability for Texas. The State Bar of Texas 7th Annual The Changing Face of Water Rights in Texas (Chapter 3.1). May 18-19th 2006, San Antonio, TX.

Margat, J. 1994. Groundwater operations and management. Pages 508-522, from Gibert, J., D. Danielopol, and J. Stanford (eds.). Groundwater ecology. Academic Press.

Martin, K. W., W.L. Puckette, S.L. Hensley and D.M. Leslie, Jr.. 2000. Internal cave gating as a means of protecting cave-dwelling bat populations in eastern Oklahoma. Proceedings of the Oklahoma Academy of Science 80:133-137.

Martin, K. W., D.M. Leslie, Jr., M. E. Payton, W.L. Puckette, and S.L. Hensley. 2003. Internal cave gating for protection of colonies of the endangered gray bat (*Myotis grisescens*). . Acta Chiropterologica 5:143-150.

Martin, K. W., D.M. Leslie, Jr., M. E. Payton, W.L. Puckette, and S.L. Hensley. 2006. Impacts of passage manipulation on cave climate: Conservation implications for cave-dwelling bats. Wildlife Society Bulletin 34:137-143.

McCracken, Gary F. 1989. Cave conservation: Special problems of bats. National Speleological Society Bulletin 51:49-51.

Pierson, E.D. 1999. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Kunz T.H., P. Racey, editors. Bat biology and conservation. Smithsonian Institution Press, Washington, D.C. p. 309-325.

Puckette, W. L. 2000. Annual report to the U.S. Fish and Wildlife Service FWS Agreement 1448-0002-95-0860. Ecological Services Office, Tulsa, Oklahoma, USA.

Tuttle, M.D. 1979. Status; Causes of decline and management of endangered gray bats. Journal of Wildlife Management 43(1):1-17.

U.S. Fish and Wildlife Service. 1982. Gray Bat recovery plan. U.S. Fish and Wildlife Service, Washington, D.C. 94 Pp.

U.S. Fish and Wildlife Service. 1983. A recovery plan for the Ozark Big-eared Bat and the Virginia Big-eared Bat. Twin Cities, MN 61 Pp.

U.S. Fish and Wildlife Service. 1995. Ozark Big-eared Bat Recovery Plan, Revised. Albuquerque, NM 80 Pp.