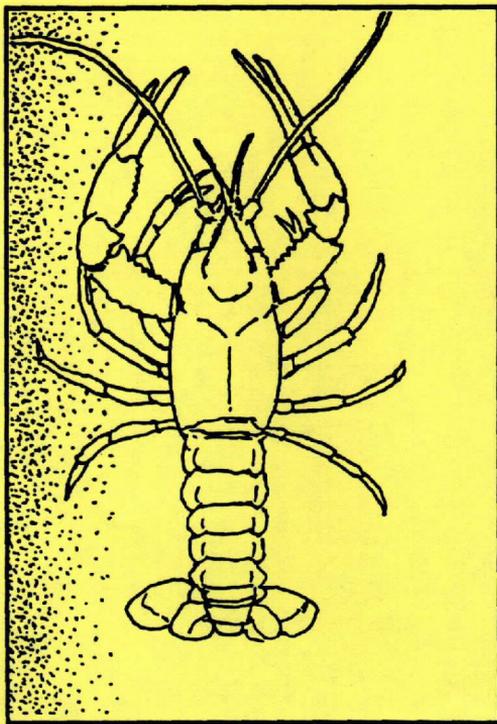


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Recovery Plan For The Cave Crayfish (*Cambarus aculabrum*)



Sam Beibers



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

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CAVE CRAYFISH
Cambarus aculabrum

RECOVERY PLAN

Prepared by

Theresa R. Jacobson
U.S. Fish and Wildlife Service
Jackson, Mississippi

for

Southeast Region
Atlanta, Georgia

Approved:

Noreen K. Clough
Noreen K. Clough, Regional Director, Southeast Region,
U.S. Fish and Wildlife Service

Date:

October 30, 1996

EXECUTIVE SUMMARY

Current Status: *Cambarus aculabrum* (cave crayfish) is only known from two cave streams in Benton County, northwest Arkansas. One of the caves (Logan) is federally owned as part of the National Wildlife Refuge System while the other cave (Bear Hollow) is privately owned. The surrounding watershed and recharge area of both caves are in private ownership. This species was listed as endangered without critical habitat in 1993.

Habitat Requirements and Limiting Factors: Cave crayfish are highly specialized for living in stable cave environments with low light and low temperatures and are unable to cope with changes in their habitats that may be induced by human activities. Water quality degradation represents a major threat to *Cambarus aculabrum*. This species is also vulnerable due to its limited distribution, with only two known populations containing a small number of individuals; its limited reproductive potential; and the potential for take by humans.

Recovery Objective: Reclassification to threatened.

Recovery Criteria: This species will be considered for reclassification to threatened when the two known populations are self-sustaining and are protected to the degree that they are secure from present or foreseeable threats.

Actions Needed:

1. Protect populations and habitat.
2. Educate public on sensitivity of groundwater and fauna to pollution.
3. Monitor populations and habitat, including water quality.
4. Search for additional populations.
5. Study species biology.
6. Monitor and study troglomorphic and epigean species.

Total Estimated Cost of Recovery: Implementation of recovery tasks for which cost estimates have been made totals \$181,000.

Date of Recovery: Unable to determine at this time.

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I. INTRODUCTION

Background

There are five species of obligate cave-dwelling (troglotic) crayfish reported for the Ozark region. Only two troglotic crayfish are known from Arkansas, the endangered *Cambarus zophonastes* and the endangered *Cambarus aculabrum*. *C. aculabrum* was described from two cave streams in Benton County, Arkansas by H. H. Hobbs, Jr. and A. V. Brown (1987). It is a small, white (unpigmented) crayfish with reduced eyes. There is no common name for *C. aculabrum*.

Cave organisms, including *C. aculabrum*, are specially adapted to survive in cave ecosystems. Many cave dwelling species have reduced metabolism, delayed reproduction, reduced fecundity, increased longevity, reduced or nonexistent eyes and loss of pigmentation (Culver 1982, Brown et al. 1994). In general, almost nothing is known about the ecology and natural history of cave crayfish, and only limited observations have been made of this species. First form males (reproductively active) have been collected during the months of October, December, January and February (Hobbs and Brown 1987). Females carrying eggs and young *C. aculabrum* have not been observed.

On July 15, 1988, the U.S. Fish and Wildlife Service (Service) was petitioned by Dr. Arthur Brown, University of Arkansas, to list *Cambarus aculabrum* as an endangered species. The Service published a finding of insufficient information to warrant the petitioned action on December 28, 1988 (U.S. Fish and Wildlife Service 1988). The finding noted that at the time of the petition there were 29 caves within the Springfield Plateau that were known to harbor cave crayfish, and in only seven of these had the species of crayfish been determined. Examination of past surveys and subsequent cave crayfish surveys (Smith 1984, Figg and Lister 1990), and an electrophoretic investigation (Koppelman 1990), resulted in the identification of these cave crayfish populations, and confirmed the restricted distribution of *C. aculabrum*. The final rule to list the cave crayfish, *C. aculabrum*, as an endangered species was effective on May 27, 1993 (U.S. Fish and Wildlife Service 1993).

Description and Taxonomic Status

Cambarus aculabrum is a small, white, troglotic crayfish with an overall body length reaching about 48 millimeters (1.8 inches). This species is distinguished from related surface (epigean) species by a total lack of pigment, and by reduced eyes. It is distinguished from its closest troglotic relatives by an acute or subacute apex of the anteromedian lobe of the epistome. First form males (those with fully formed and hardened first pleopods, or reproductive appendages) are further separated from the closely related troglotic species, *C. setosus* and *C. tartarus*, by the absence of a transverse groove separating the proximolateral

lobe from the shaft on the first pleopod. It differs from first form males of another closely related cave species, *C. zophonastes*, by a longer central projection of the first pleopod which also has a shallow subapical notch (Hobbs and Brown 1987). Recent studies indicate that *C. aculabrum* is genetically distinct from the other cave crayfish species (Koppelman 1990, Koppelman and Figg 1995).

Distribution

Cambarus aculabrum is presently known from only two cave streams in Benton County, Arkansas (Figure 1). The type locality, Logan Cave, is an Ozarkian solution channel located in the Mississippian cherty-limestone, Boone Formation of the Springfield Plateau (Hobbs and Brown 1987). A stream approximately 1 kilometer (km) or 4,000 feet (ft) flows through the entire length of the cave. Logan Cave also contains a pool approximately 200 meters (m) or 660 ft long, 2-4 m or 6-13 ft wide, and 2-3 m or 6-9 ft deep. A sinkhole formed by the collapse of the cave roof is found upstream of the pool. Water exits the cave approximately 300 m or 990 ft from the pool. The cave's recharge area covers 30.1 square km or 11.6 square miles), most of which is privately owned (Aley and Aley 1987). The Service purchased 49.6 hectares or 123.9 acres at Logan Cave, including the property that contains the cave entrances, in 1989.

Cambarus aculabrum is also known from Bear Hollow Cave, located approximately 38 kilometers (23 miles) from Logan Cave. Bear Hollow Cave is also a solution tunnel in the Boone Formation and contains a small stream approximately 200 m or 660 ft long (Hobbs and Brown 1987) and an undescribed pool. The cave stream flow and depth varies. At times, parts of the stream may dry up leaving tiny pools of water or parts of the stream may completely disappear underground leaving no trace. After some rainfall events the cave may nearly fill up with water, as evidenced by trash found lodged up near the cave ceiling. The cave's entrance and surrounding property are privately owned. The stream hydrology of Bear Hollow Cave and its recharge area are unknown.

The numbers of crayfish observed in Logan and Bear Hollow Caves may vary dramatically between cave visits. The greatest number of crayfish observed in a single visit is nine in Bear Hollow Cave (Hobbs and Brown 1987) and 21 in Logan Cave (J. Johnson, *in litt.*, 1995). In 14 visits to Logan Cave, Brown observed crayfish on only three occasions (A. Brown *in litt.*, 1987). Brown has also found three dead cave crayfish in Logan Cave (A. Brown, Univ. Ark., pers. comm.). In a 1990 survey, Service biologists saw three *Cambarus aculabrum*, one of which was dead, in Logan Cave and only a single crayfish in Bear Hollow Cave. Six crayfish were observed in Logan Cave during another cave visit by Service biologists in 1995 while four were observed in Bear Hollow Cave. While working on his University of Arkansas graduate research project on the threatened Ozark cavefish (*Amblyopsis rosae*) in Logan Cave, Zack Brown observed a mean of 12.5 cave crayfish (range 7 to 21) during his monthly trips from October 1994 through September 1995 (J. Johnson, *in litt.*, 1995).

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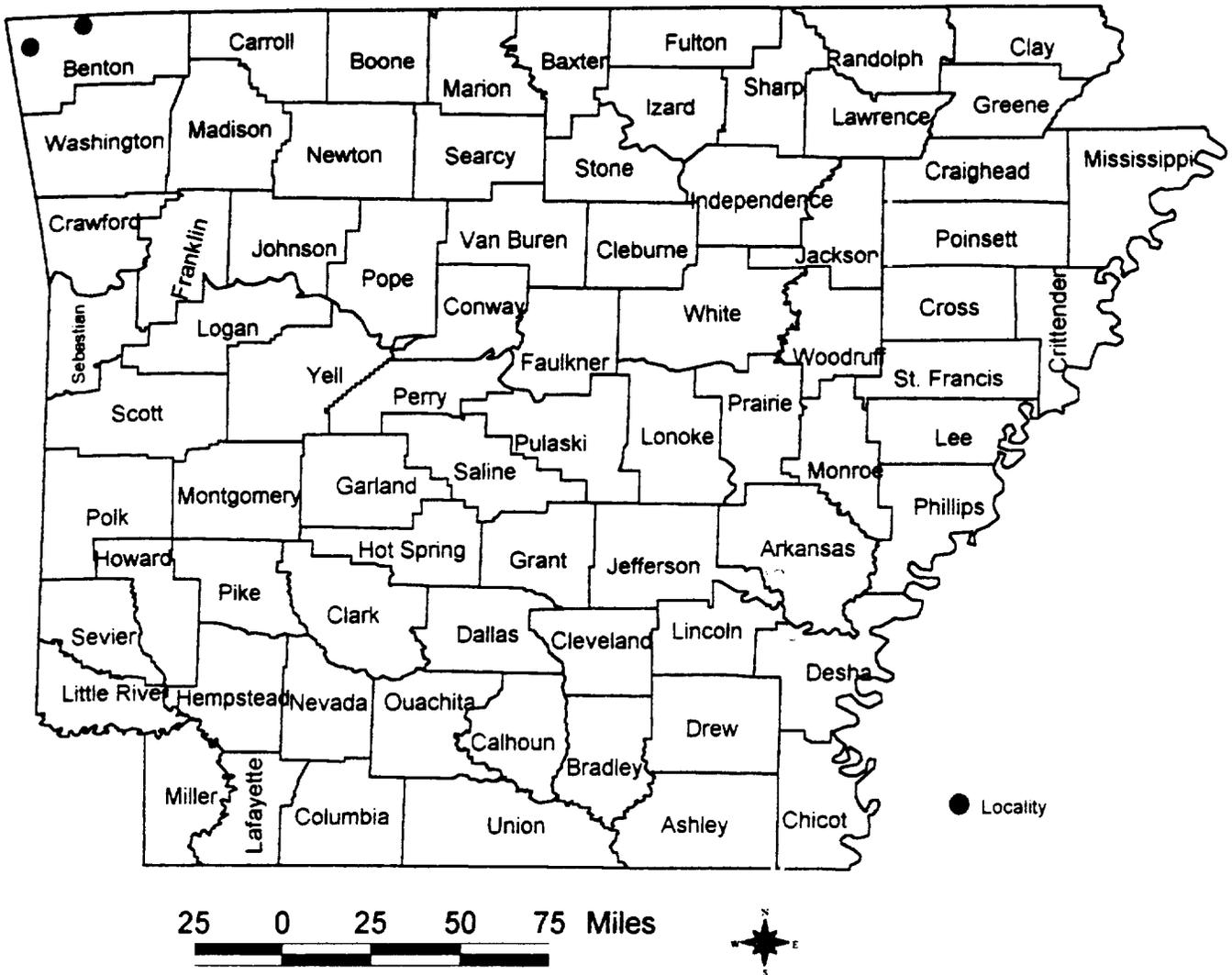


Figure 1: Range of the cave crayfish, *Cambarus aculabrum*

Habitat

The terrestrial environment in most caves is relatively stable, with low temperatures, high humidity, and constant darkness. The aquatic environment of caves can also be quite stable but changes in water qualities can occur rapidly. The physical and chemical qualities of Ozark Highland cave streams are affected by surface conditions and land use practices in the recharge area. Some water quality measurements have been taken for Logan Cave in the past years (see Husted 1992 and Means 1993) but no data has been recorded for Bear Hollow Cave. Water temperature in Logan Cave reflects the annual ground water temperature of around 14° C (57° F) and varies approximately 1° C (34° F) throughout the year (Husted 1992, Means 1993). Water quality and clarity of Logan Cave Stream is generally high (Means and Johnson 1995) and many water parameters remain relatively constant for much of the year (Means 1993). Most changes in water properties occur when the cave's stream flow increases after a storm (Husted 1992).

Cave environments are resource poor (food is limited); consequently, cave crayfish and all other troglobites rely on outside sources of organic matter for food. Nutrients are transported from the surface as particulate organic matter or dissolved organic matter. Dissolved organic matter is transported from the surface by cave streams, seeps or percolation. Particulate organic matter, such as leaf litter, is carried in by cave streams or blown into the cave entrance(s) or sinkhole(s) by the wind. Animals, such as bats, also provide particulate organic matter through their feces (guano) or their bodily remains.

Besides the endangered cave crayfish, Logan Cave supports another threatened troglobite, the Ozark cavefish (*Amblyopsis rosae*). Non-obligate, cave inhabitants (troglaphiles) and surface dwelling (epigean) species seen in Logan include banded sculpins (*Cottus carolinae*), two species of crayfish (*Orconectes neglectus* and *O. punctimanus*), and at least three salamanders (Brown et al. 1994). Other important species using Logan cave seasonally or occasionally include threatened Indiana bats (*Myotis sodalis*), eastern pipistrelle bats (*Pipistellus subflavus*) and a maternity colony of endangered gray bats (*M. grisescens*).

Bear Hollow Cave has not been studied to the same extent as Logan Cave because it is located on private property. Besides *Cambarus aculabrum*, grotto salamanders (*Typhlotriton spelaeus*) and eastern pipistrelle bats have been seen inside the cave. A scale of the Ozark cavefish (*Amblyopsis rosae*) was found in Bear Hollow Cave although no cavefish have been seen inside the cave (Willis and Brown 1985).

Cambarus aculabrum have been observed throughout all parts of Logan and Bear Hollow streams, excluding the stream portion near the cave entrance or mouth. When found, crayfish are usually seen along the walls of pools or along stream edges. They can be found on silt, gravel, rubble and bedrock, or even hiding underneath trash, such as an old discarded boot. During Zack Brown's monthly trips to Logan Cave, he noted that almost all of the crayfish were seen in the pool/riffle reach above the large pool and none were seen in the reach from pool to cave mouth (J. Johnson, *in litt.*, 1995).

Reasons For Listing

This species is known from only two cave sites in northwest Arkansas and is vulnerable to disturbance. Factors most likely to limit or cause the decline of *Cambarus aculabrum* include the following: (1) destruction of habitat including water quality degradation; (2) disturbance by amateur spelunkers or trespassers; (3) collecting; (4) low reproductive potential; and (5) competition and predation by troglomorphic or epigean species.

Cambarus aculabrum is an aquatic organism which has adapted to living in cave streams containing relatively clean water. Any factor which impacts surface water and groundwater quality in the vicinity of the caves' recharge area can ultimately impact the survival of *C. aculabrum* and other cave creatures. Crayfish and other aquatic organisms must have dissolved oxygen in the water for respiration. Severe water contamination by sewage, animal waste, landfills, petroleum products, ammonia fertilizer, or a number of other materials, may result in seriously depleted oxygen concentrations causing suffocation of cave crayfish and other aquatic species. Low oxygen levels may also reduce reproductive success by killing eggs or newly hatched crayfish. Contamination by toxic compounds, including heavy metals, many organic chemicals, and pesticides can be lethal to aquatic cave fauna, including crayfish. Sedimentation can clog gills and harm invertebrates upon which crayfish feed. Additional threats to water quality include alteration of drainage or hydrologic patterns; lower ground water levels; and physical destruction of the cave.

The water quality of Logan Cave is primarily threatened by hog and poultry operations adjacent to or within the groundwater recharge area (Aley and Aley 1987). These operations produce large amounts of animal waste which if not disposed of properly may contaminate Logan Cave Stream and aquifer. The practice of using liquid animal waste to fertilize pasture lands in the Logan Cave recharge area can also cause water contamination when the fertilizer is improperly applied or if heavy precipitation follows application. Construction of the Northwest Arkansas Regional Airport and associated commercial and industrial growth may also degrade water quality or alter groundwater recharge of Logan Cave. The Aley and Aley study (1987) also identified residential development as a potential source of water contamination in the Logan Cave aquifer.

Residential development is the primary threat to the Bear Hollow Cave crayfish population. Residential development may degrade water quality in caves by leakage from sewage disposal systems and solid waste landfills; sedimentation; increased storm runoff; and increased use of lawn fertilizers, herbicides, and pesticides. Residential growth also attracts secondary developments such as roads and gasoline stations which contribute to water quality degradation, e.g., sedimentation, storm runoff, and fuel or oil spills (Aley and Aley 1987).

Both cave sites have been vandalized and disturbed frequently in the past. The entrances to Logan Cave have been purchased by the Service and access is restricted. Despite protection afforded the cave, refuge staff estimated 10 cases of trespass for the period from

April-July 1995. At least two researchers also visit the cave each month (C. Mitchell 1995, *in litt.*). Logan Cave is monitored by a light sensitive device located inside that records the time and date when activated, but it is not regularly checked nor maintained. The private land owners of Bear Hollow Cave in cooperation with Arkansas Game and Fish Commission had the cave entrance gated in 1993, but, vandals destroyed the gate door and subsequently entered the cave 1 month later. The gate was repaired several months later but was vandalized again. It is unknown when the second act of vandalism occurred since there is currently no one scheduled or responsible for monitoring cave trespass. The Service is presently working with the landowners to re-gate Bear Hollow Cave.

Disturbance by amateur cavers and trespassers impacts the physical condition of individual cave crayfish. Obligate cave dwellers have a low metabolic level and have limited opportunities to feed (Culver 1982). Any physical activity resulting from disturbance uses up energy that would be used in feeding or possibly reproduction. Physical disturbance is a direct threat in Bear Hollow Cave because it agitates stream bottom sediments causing turbidity and reduced visibility which greatly increases the likelihood that a cave crayfish may be stepped on, causing injuries or death. Disturbances at Logan Cave can interrupt breeding or feeding activities of the endangered cave crayfish, the endangered gray bat, the threatened Ozark cave fish, and the threatened Indiana bat, along with other cave creatures. It is especially important to protect the maternal colony of gray bats at Logan Cave because both the cave crayfish and Ozark cavefish rely indirectly or directly on the bat guano (organic input) for food.

Most troglobitic species, including *Cambarus aculabrum*, have a low reproductive rate and need a relatively long period to attain maturity. Removal of any cave crayfish by collectors will affect the ability of the species to reproduce. Loss of mature individuals capable of reproducing obviously causes a decline in population levels.

Troglophilic and epigeal predation and competition may impact cave crayfish population levels. In general, food resources are poor in cave environments (Culver 1982, Brown et al. 1994). As part of an organic carbon resources study in Logan Cave, Brown et al. (1994) analyzed gut contents of 15 epigeal crayfish (*Orconectes neglectus* and *O. punctimanus*) and found that they had eaten other crayfish, but it could not be determined what species of crayfish were eaten. There is the possibility that *C. aculabrum* is preyed upon by troglphilic and epigeal crayfish, especially near the cave entrance where troglphilic and epigeal species are more abundant. The remains of *C. aculabrum* has been found inside the stomach of a sculpin captured from Logan Cave (Means and Johnson 1995, Brown et al. 1994). Brown et al. (1994) found troglphilic and epigeal sculpin and crayfish more abundant at the cave entrance while *C. aculabrum* were more numerous further inside the cave. Further research is needed to determine whether the increase in food resources near cave entrances is human induced (anthropogenic enrichment) and whether the abundance of troglphilic and epigeals is related to the increased food resources.

Conservation Measures

Cambarus aculabrum receives protection at the State and Federal level. All troglobitic species (including the cave crayfish) are protected by Arkansas Game and Fish Commission Regulation number 1817 entitled, "Wildlife Pet Restrictions". They cannot be possessed as pets and their sale is prohibited (Wilson 1990, *in litt.*). The Service purchased 49.6 hectares or 123.9 acres at Logan Cave, including the cave's entrances in 1989. Land acquisition affords the cave protection and management under the National Wildlife Refuge System. Various research studies and monitoring efforts are ongoing in Logan Cave for the endangered gray bat, threatened Ozark cavefish, and endangered cave crayfish and other species. A watershed protection initiative is being developed for Bear Hollow and Logan Caves by the Service, Arkansas Nature Conservancy, Arkansas Game and Fish Commission, and other partners. This initiative is being modeled after a successful outreach program developed by Missouri Department of Conservation for protecting groundwater and the Ozark cavefish. As part of this initiative, the Arkansas Game and Fish Commission is planning to fund a recharge survey for Bear Hollow Cave. Mitigation measures (pertaining to the cave crayfish) for construction of the Northwest Arkansas Regional Airport include continuous water quality testing during construction and during the first year of operation, with sampling once a year continuing for the life of the project and the capture of "first flush" one-half inch rainfall from runways for treatment (Arkansas Department of Transportation 1994).

II. RECOVERY

Recovery Objective

The recovery objective is to reclassify this species to threatened status. *Cambarus aculabrum* will be considered for reclassification when the two known populations are self-sustaining and protected from trespass and water quality degradation for a period not less than 10 years. A self-sustaining population is one which is shown by monitoring data to be reproducing and stable (or increasing) in size.

These recovery criteria are preliminary and may be revised on the basis of new information. Reclassification, rather than delisting, appears to be the more realistic goal at this time because there are only two known populations and limited amount of protection for the one site on private land. Full recovery and delisting are not likely in the foreseeable future.

Narrative Outline

1. Protect populations and habitat. Protection of the two existing cave sites and surrounding habitat (recharge area) is critical to ensure the survival of this species. Logan Cave is owned by the U.S. Fish & Wildlife Service and Bear Hollow Cave is owned by Bella Vista Village. The private landowners are aware of the occurrence of the crayfish in their cave and are supportive of its protection.
 - 1.1. Develop and implement a protection and management plan for Bear Hollow Cave. Permanent long-term protection of the cave entrance should be sought for Bear Hollow, and any other caves found to contain *Cambarus aculabrum*. The Service should work with Bella Vista Village to develop protection/management plans to ensure the long-term survival of the crayfish (Task 1.3-1.5, 2.2, 2.4 and 3.1-3.3).
 - 1.2. Develop and implement management plan for Logan Cave National Wildlife Refuge. A management plan needs to be developed, funded and implemented to ensure the long-term survival of the crayfish and other listed species (tasks 1.3-1.5, 2.1, 2.4, and 3.1-3.3).
 - 1.3. Construct and maintain cave gates, fences, signs, and other security devices needed for protection. Bat-friendly gating or fencing of the cave entrances is required to ensure protection of the cave crayfish and other listed cave species. Appropriately worded warning and interpretive signs are needed to aid the Service's Law Enforcement Division and other law enforcement agencies in prosecuting trespass cases. Gates, fences, signs,

and all other security devices need to be maintained on a regular basis. The installation of an electronic remote surveillance system may be needed at Logan and Bear Hollow Caves if trespass continues and if the cave gates continue to be vandalized.

- 1.4. Monitor cave trespass and involve law enforcement agencies in protecting *Cambarus aculabrum*. A management plan needs to be developed for Logan Cave that incorporates cave visits. Refuge personnel or refuge law enforcement personnel should check Logan Cave for disturbance and trespass at least twice a month. Local law enforcement officials should be contacted for assistance with cave protection (i.e., more frequent patrols in cave area). Private landowners (Bear Hollow Cave) should be asked to notify the appropriate law enforcement agency of cave trespass and cave-related vandalism. Any easements or conservation agreements should include wording that encourages access by law enforcement personnel to control trespass and Endangered Species Act violations.
- 1.5. Ensure recharge area protection of both Logan and Bear Hollow Caves. Long-term protection should be sought for the surrounding recharge area through conservation easements or by jointly working with the local landowners. The Service, Arkansas Nature Conservancy, Arkansas Game and Fish Commission, and other partners are developing a plan to work with landowners in the surrounding recharge area to identify and reduce ground water pollution (Task 2.1 and 2.2). This plan should inform private landowners about programs and agencies which may be able to assist them with watershed management.
2. Educate public on sensitivity of groundwater and fauna to pollution. This species is extremely vulnerable to water quality degradation. Public support can be very important in reducing and reversing water quality degradation. General information on this species and its conservation needs should be provided to landowners, governmental agencies, recreational caving organizations, local schools, local parks, and nature centers, as well as the media. Educational efforts should be directed to three main groups of people: recreational cavers, the retirement community of Bella Vista Village, and private landowners (farmers) near Logan Cave. Information can be distributed through brochures, slide shows, technical assistance workshops, or educational seminars by the Service or others. Protection and recovery of this species will largely depend on voluntary efforts by private landowners and local governments.

- 2.1. Public education emphasis for Logan Cave. As part of the watershed protection initiative, private landowners and farmers in the recharge area of Logan Cave will be contacted and encouraged to protect groundwater, *C. aculabrum*, and other endangered and threatened species in their area. In addition, Refuge staff at Logan Cave will inform refuge visitors about endangered cave fauna, including the cave crayfish, through fact sheets, brochures, slide shows, video, interpretive signs, or educational programs.
 - 2.2. Public education emphasis for Bear Hollow Cave. As part of the watershed protection initiative, the community of Bella Vista Village will be contacted and encouraged to protect groundwater and *C. aculabrum*. Fact sheets or other printed materials can be made available to the community and an endangered species-cave ecosystem appreciation and technical assistance workshop or evening program could be conducted.
 - 2.3. Public education emphasis with recreational cavers. Recreational cavers need to be informed about the endangered cave crayfish. Contacts should be established with local grotto groups. The Service and others can provide printed information along with interpretive-warning signs posted at inhabited caves. Area cavers may know of other caves containing cave crayfish or may be recruited to help locate additional populations. Grotto club members may also be recruited to help in cave protection and outreach.
 - 2.4. Recruit "watch dog" volunteers to assist in cave habitat protection. Interested individuals, including recreational cavers or local grotto groups, may be recruited to help report cave vandalism and events (chemical spills, highway accidents) that may degrade water quality for Bear Hollow or Logan Caves.
3. Monitor populations and habitat, including water quality. By monitoring populations and habitat, trends can be tracked and recovery progress can be evaluated. Baseline information should be gathered for all known sites.
 - 3.1. Monitor cave crayfish populations. A cave crayfish monitoring plan needs to be developed and implemented. This plan must describe survey methods, survey duration, and frequency of sampling. Due to the loose bottom sediments, which are easily disturbed causing turbidity, it is difficult to conduct cave crayfish surveys at Bear Hollow. The monitoring plan must incorporate ways to minimize turbidity during the surveys. Cave crayfish monitoring should be incorporated into Ozark cavefish surveys or studies.

3.2. Gather baseline habitat and water quality data.

Degradation of water quality poses the greatest threat to the crayfish's continued existence. Background information needed for each inhabited cave site includes: identification of surrounding land use practices, recharge area delineation of Bear Hollow, baseline water quality data, and a listing of associated cave species including their relative abundance for each site. Needed water quality data needed include pH, water and air temperature, turbidity, dissolved oxygen, biological oxygen demand, dissolved organic carbon, conductivity, total dissolved and suspended solids, nitrates, metals and pesticides. The cave streams should be sampled monthly for 1 year to provide a baseline for future comparisons. Metals could be sampled once for baseline and additional tests if warranted. Testing for pesticides, insecticides, or lawn chemicals should be done after a rainfall of at least 254 millimeters or 1 inch. Data needs to be gathered on anthropogenic enrichment and organic loading of Logan Cave.

3.3. Monitor habitat and water quality. Once baseline data are collected (Task 3.2), water quality testing should be done at least once every year. Metal testing should be done every 5 years or when warranted.

4. Search for additional populations. Identify and survey caves in the Ozark area that have not been surveyed for crayfish. Re-survey any caves containing unidentified crayfish. The location and protection of additional *Cambarus aculabrum* populations would enhance recovery efforts and aid in downlisting to threatened status.

4.1. Recruit volunteers to assist with surveys. Through an educational effort, recreational cavers will be recruited to help survey caves for crayfish. The Service or others designated should check reports from recreational cavers on previously unknown caves which contain crayfish.

4.2. Coordinate and incorporate cave crayfish surveys with Ozark Cavefish surveys. Include the cave crayfish with ongoing Ozark Cavefish surveys and monitoring programs.

5. Study species' biology. Little is known about the ecology and natural history of troglobitic crayfish, and only limited observations have been made of *Cambarus aculabrum*. Population levels appear to be too low to risk individuals in studies that may result in mortality. Studies such as species habitat utilization, fecundity, mortality rate, longevity, food preference, etc., should only be initiated when it is determined that such studies will have no impact on the ability of the species to survive. Notes on behavior, location, reproductive status should be taken of any observations of cave crayfish made during the studies of the Ozark cavefish or other cave creatures at Logan Cave.

6. Monitor and study troglophilic and epigeal species. Studies are needed to determine the extent of competition and predation on *Cambarus aculabrum*. Annual surveys of troglophiles and epigeans should be conducted at Logan Cave and also at Bear Hollow Cave. Troglophilic and epigeal studies should be conducted in such a way that they do not harm *C. aculabrum*.

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III. IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines recovery actions and their estimated costs for the first 3 years of the recovery program. It is a guide for meeting the objective discussed in Part II of this plan. This Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs.

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

- 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
- 3 - All other actions necessary to provide for full recovery of the species.

Key to acronyms used in Implementation Schedule

- NWR - Logan Cave National Wildlife Refuge
ES - Ecological Services Division, U.S. Fish and Wildlife Service
R - Realty, U.S. Fish and Wildlife Service
LE - Law Enforcement, U.S. Fish and Wildlife Service
ANHC - Arkansas Natural Heritage Commission
TNC - The Nature Conservancy (Arkansas Field Office)
AGFC - Arkansas Game & Fish Commission
BVV - Bella Vista Village (private land owner)
UA - University of Arkansas
Pvt. - Private individual, interest groups, local grotto
BHC - Bear Hollow Cave
LC - Logan Cave

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS/NOTES
				USFWS		Other	FY 1	FY 2	FY 3	
				Reg.	Div.					
1	1.1	Develop and implement management & protection plan for Bear Hollow Cave.	continuous	4	ES, R	BVV, AGFC, TNC				Cost to be determined-private land protection through Partners for Wildlife or conserv. agreements
2	1.2	Develop and implement management & protection plan for Logan Cave.	continuous	4	ES, NWR		17	16	16	Operational funding needed through Holla Bend NWR
1-BHC 2-LC	1.3	Construct and maintain security gates, etc.	continuous	4	ES, LE, NWR	BVV, AGFC, TNC, Pvt.	2	1		Cost to be determined-may use Sec. 6 or Partners for Wildlife funds
2	1.4	Monitor cave trespass.	continuous	4	NWR, LE	BVV, UA				Use existing program funding
1	1.5	Protect recharge area.	continuous	4	NWR	BVV, Pvt.				Cost to be determined
1	2.1-2.4	Public education	continuous	4	ES, NWR	BVV, AGFC, TNC, ANCH, UA, Pvt.	1	2	1	

IMPLEMENTATION SCHEDULE										
PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS/NOTES
				USFWS		Other	FY 1	FY 2	FY 3	
				Reg.	Div.					
2	3.1	Monitor crayfish populations.	continuous	4	ES, NWR	BVV, AGFC, TNC, ANCH, UA, Pvt.	5	5	5	
3	3.2	Collect baseline data on habitat & water quality.	1 year	4	ES, NWR	BVV, AGFC, TNC, UA	30	-	-	
3	3.3	Monitor habitat & water quality.	continuous	4	ES, NWR	BVV, AGFC, TNC, ANHC, UA Pvt.	-	-	15	
3	4.1-4.2	Search for new populations.	3 years	4	ES, NWR	ANHC, TNC, ANHC, UA, Pvt.	10	5	5	
3	5-6	Study biology and troglaphiles and epigeans.	5 years	4	ES, NWR	AGFC, TNC, ANHC, UA	15	15	15	

IV. LIST OF REVIEWERS

The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of this plan.

Holla Bend National Wildlife Refuge
Rt. 1, Box 59
Daranelle, AR 72801

Oklahoma Bat Caves National Wildlife Refuge
Rt. 1, Box 18A
Vian, OK 74962

Oklahoma Ecological Services Field Office
222 S. Houston, Suite A
Tulsa, OK 74127

Ecological Services Field Office
2524 S. Frontage Road, Suite B
Vicksburg, MS 39180-5269

Dr. Art Brown*
University of Arkansas
Dept. of Zoology
Fayetteville, AR 72701

Dr. James Johnson
University of Arkansas
Dept. of Zoology
Arkansas Coop. Research Unit
Fayetteville, AR 72701

Arkansas Game and Fish Commission
2 Natural Resources Drive
Little Rock, AR 72205

Karen Yaich
Arkansas Game and Fish Commission
Rt. 1, Box 188-A
Humphrey, AR 72073

Stan Todd
Arkansas Game and Fish Commission
Rt. 1, Box 139
Clarendon, AR 72029

Lance Peacock
Arkansas Nature Conservancy
601 N. University, Suite A
Little Rock, AR 72205

Arkansas Natural Heritage Commission
Suite 1500, Tower Building
323 Center Street
Little Rock, AR 72201

Arkansas Dept. of Parks and Tourism
Division of State Parks
One Capitol Mall
Little Rock, AR 72201

Arkansas Dept. of Transportation
P.O. Box 2261
Little Rock, AR 72203

Department of Pollution Control and Ecology
8001 National Drive
P.O. Box 8913
Little Rock, AR 72219

Tom and Kathy Aley
Ozark Underground Laboratory
Rt. 1, Box 62
Protem, MO 65733

Dr. Horton Hobbs, III*
Dept. of Biology
Wittenberg University
P.O. Box 720
Springfield, OH 45501-0720

Dennis Figg*
Endangered Species Coordinator
Missouri Dept. of Conservation
P.O. Box 180
Jefferson City, MO 65102

Gene Groseclos
432 Town Center
Bella Vista, AR 72714

Ozark Resources Network
P. O. Box 431
Jasper, AR 72641

*Independent peer reviewers

V. COMMENTS RECEIVED ON DRAFT RECOVERY PLAN

THE Nature Conservancy

ARKANSAS FIELD OFFICE

November 1, 1995

Robert Bowker
Jackson Field Office
Fish and Wildlife Service
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

RECEIVED
OCT 03 1995
U.S. FISH & WILDLIFE SERVICE
JACKSON, MISSISSIPPI

Dear Robert:

We appreciate the opportunity to review the Draft Recovery Plan for cave crayfish. The Arkansas Field Office of The Nature Conservancy is keenly interested in protecting threatened and endangered species and ecosystems that occur in the state. *Cambarus aculabrum* is among the rarest of the threatened and endangered species dependent on cave ecosystems.

Given that little is known about the ecology of the species, the plan provides a comprehensive overview of the current and potential threats to the species. Cave gating and surveillance are important in reducing trespass into the caves. Unfortunately, we recognize that the real threat in the long term is water quality which is much more difficult to control.

We believe The Nature Conservancy may be most effective in the implementation of protection activities at Bear Hollow Cave. The Conservancy has a long history of working with private landowners to protect important habitats. There is great potential to establish such a relationship with the landowners at Bear Hollow Cave.

We look forward to continued participation in recovery efforts for the cave crayfish.

Sincerely,



Chris Wilson
Land Steward

Arkansas Game & Fish Commission
2 Natural Resources Drive Little Rock, Arkansas 72205

Steve N. Wilson
Director

Scott Henderson
Assistant Director



10/25/95

Arkansas Game Fish Comm.
1201 North Highway 49
Brinkley, AR 72021
(501) 734-4581
(501) 734-4585 FAX

Theresa Jacobson
U.S. Fish Wildlife Service
Jackson Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

RECEIVED

OCT 26 1995

U.S. FISH & WILDLIFE SERVICES
JACKSON, MS

Dear Theresa:

I appreciate the opportunity to comment on the TECHNICAL/AGENCY DRAFT RECOVERY PLAN FOR CAVE CRAYFISH (*Cambarus aculabrum*). Please find attached comments concerning this plan. Hopefully you can extract some helpful ideas.

Cave crayfish are part of a cave ecosystem and cannot be safeguarded without protecting associated species and habitats where they evolved. Cave communities are relatively simple, with few species, compared to terrestrial systems. Caves are resource limited and directly dependent on their recharge areas. Most of my comments reinforce these ideas.

You've done a great job compiling this draft and I generally agree with your recommendations. Thank you again for the opportunity to review this draft. If I can provide any further information please feel free to contact me.

Sincerely,

A handwritten signature in cursive script that reads "C. Stan Todd".

C. Stan Todd
Assistant Fisheries Biologist
District 4

cc. Karen Yaich

Executive Summary

The use of relative terms "low light and low temperature" are understood by people familiar with Ozark caves and do little to describe the ecology of these systems. These caves are in total darkness with stable temperatures and are resource poor. It is important to describe cave ecosystems as connected to and reliant on permeable recharge areas for water and organic input. Bats may be another important source of organic material.

Introduction

I have heard that Mr. Rex Roeberg, formerly with AGFC endangered species, has collected a new species from Arkansas but I do not know the status of this crayfish. I believe Rex was working with Dr. Hobbs concerning this.

First form males have been found in October, December, January and February. Does this refer to *Cambarus aculabrum* or all cave crayfish? Is there a reference for this?

Distribution

The location of the two caves are incorrectly placed on figure 1. Bear Hollow should be along the northern edge of the county and just to the right of center. Logan is approximately one quarter the width of the county from Oklahoma and one quarter the height of the county from the southern edge.

I have also seen crayfish along the walls of pools, however, in other parts of the stream with gravel, rubble or bedrock substrates, crayfish were more evenly distributed across the stream.

Total number of crayfish seen over a period of years provides little if not misleading information. An average number, or number per trip would be more useful.

Although the entrance to Bear Hollow is periodically inundated, I do not believe the entire cave fills up. Flooding may be important, however, in connecting pools that are isolated at low water levels and allowing movement of crayfish through the cave. I have seen crayfish in Bear Hollow in isolated pools only. Crayfish either must traverse long reaches of dry streambed or more likely move when pools are connected by flow.

There is no evidence of less habitat in Bear Hollow than in Logan. There is probably less habitat accessible by humans. Diving the flooded section of the cave may reveal a much larger accessible system. In any case the best estimate of the size of a cave system is recharge area. Cave crayfish may utilize any water filled or damp passage large enough for its body to pass, including coarse gravel. Passages utilized by crayfish might exist in any part of the recharge area.

Habitat

An important concept concerning Ozark caves is that these ecosystems include the entire recharge area and are directly affected by activities in the recharge area. Ozark caves are resource poor environments limited by organic material brought into the cave through the recharge area or by other animals. Most organic carbon brought in through the recharge area is probably dissolved and utilized by bacteria in the cave. Bacteria are then consumed by crayfish and other invertebrates. The contribution of detritus in water percolating through the recharge area probably varies between caves and I suspect it is less important than dissolved organics. Detritus and guano increase in importance if a cave has an open sink or a bat population.

As cave crayfish adapted to a resource limited habitat they enjoyed reduced predation and competition from epigeal species. Epigeal species are unable to survive in resource poor caves. Increased organic loading within a cave may allow epigeal species to out compete cave organisms.

Cambarus aculabrum are observed throughout all parts of the streams in Logan and Bear creek caves. They are found on silt, gravel, rubble and bedrock. Although I have seen most crayfish in silt bottomed pools, they probably prefer coarse substrates where they are more difficult to observe. In pools, crayfish are most often found near vertical walls, indicating a cryptic nature. Crayfish are more likely to be scattered across the stream in habitats other than pools.

Crayfish do require dissolved oxygen, however, they are probably much more tolerant of low oxygen conditions than many other aquatic organisms. There are several studies showing epigeal crayfish with a high tolerance to low oxygen levels. Low oxygen levels are more likely to harm invertebrates cave crayfish rely upon for food.

Myotis grisescens bring large amounts of organic material into Logan cave and the ecology of this system is probably somewhat dependent on bat guano. Both *Cambarus aculabrum* and *Amblyopsis rosae* in Logan Cave are dependent on a species that is itself endangered. Without a large bat population, Bear Hollow is almost completely dependent on organic material brought in through the recharge area.

Reasons for Listing

Loss of the endangered grey bat should be included.

Although cave crayfish are probably tolerant of low oxygen conditions, severe oxygen depletions may directly kill crayfish. Less severe oxygen depletions may kill invertebrates crayfish rely upon for food. Low oxygen conditions may reduce reproductive success by killing eggs or newly hatched crayfish.

Sedimentation is probably not a threat to Ozark cave streams. Crayfish are probably fairly tolerant of high sediment levels. Since females carry eggs and small crayfish, sediment should not cover crayfish at this stage.

Increased organic loading is one of the biggest threats to water quality in cave systems. Increased food within a cave can allow epigean species to successfully compete within a cave, possibly to the point of replacing cave adapted organisms. Dr. Brown (UofA) has found higher numbers of epigean species below the sink at Logan Cave. has also shown higher levels of organics in this same section. Bear Hollow does not have bats or a sink and relies almost entirely on organic material percolating through the recharge area. I suspect this cave has lower organic levels than Logan Cave. I have never seen epigean species in Bear Hollow. The role of organics within caves deserves more attention.

I'm not sure when Bear Hollow was originally gated. Mrs. Karen Yaich (AG&FC) should have this information on file. In any case the gate is not functional at this time and needs repair/replacement.

In 1994, Dr. Brown analyzed gut contents of 15 individual crayfish not 15 species.

Recovery Objective

It will be difficult if not impossible to determine when these populations are self sustaining. We simply cannot accurately estimate the numbers of individuals in these populations. Visual counts yield relative abundance of individuals only within the accessible portion of the cave. We do not know how many individuals are in inaccessible areas. Loss of crayfish in accessible areas does not mean the entire population has been lost and increases do not mean crayfish have not been extirpated from inaccessible areas. Counts do yield valuable information on the quality of the accessible cave.

Mark recapture studies are invalid in open systems. Mark recapture studies are much more invasive, time consuming and possibly harmful to crayfish. They yield no more information about actual population numbers than visual counts.

Narrative Outline 3.1

I would recommend a visual count since no more information is gathered by other methods that are potentially harmful to crayfish.

We probably have sufficient baseline information from crayfish counts in Logan Cave by UofA students researching cavefish in this system.

In Bear Hollow I have counted greater numbers of crayfish immediately following rains. During dry periods I often found no crayfish at all. Water flow within the system may allow movement of crayfish until pools are isolated again. Predators or collectors may remove crayfish from accessible pools before the next rain. This should be taken into account during surveys.

I have also worried about stepping on crayfish during surveys. A walkway would be ideal, but, would be expensive and difficult to construct. Until then, crayfish could be placed in buckets, left at the point of capture and released unharmed when leaving the cave.

Narrative Outline 3.2

Land use practices should be estimated on an area basis. Sensitive areas, such as sinking streams, should be identified and protected. Land use estimates should be periodically updated.

Listing of associated cave species should be more than a simple cave survey. Baseline data should include densities and distribution of the microbial community and aquatic invertebrates and locations and numbers of bat colonies. Habitat preferences should be described for abundant species.

254mm should be 25.4mm.

Narrative Outline 3.3

Water quality testing every two years is much too infrequent. Elevated dissolved carbon from field application of animal wastes may pass through the cave system in a matter of months and pesticides may only take days. Testing for pesticides after a heavy rain would probably miss a short term event and is not representative of normal flows. Mr. Kenneth Lister and Dr. Douglas Noltie with the University of Missouri are studying in situ habitat utilization by the Ozark cavefish. They are using a permeable lipid sampler to absorb pesticides over a long period. These samplers should give a more realistic picture of pesticides within the cave. Complete water quality testing should be done at least annually.

Continuous monitoring of several parameters are possible and relatively inexpensive. These measurements may offer indications where other more time consuming tests should be made. Continuous monitoring will be more difficult in Bear Hollow.

Narrative Outline 4.1

Recreational cavers in Northwest Arkansas have been opposed to cave closures. Closures would result from their disclosure of caves containing crayfish. This avenue should not be ignored, however, I doubt if we will get much support.

Research needs

The recharge area for Bear Hollow Cave should be delineated. Sensitive areas within recharge areas of both caves should be described.

Caves containing *Cambarus aculabrum* should be surveyed and data collected on associated cave species. Baseline data should include densities and distributions of the microbial community and aquatic invertebrates and locations and numbers of bat colonies. Habitat preferences should be described for important species.

A comprehensive carbon budget should be done in caves with crayfish populations. This would provide insight into cave ecology and define critical species associations.

The life history and habitat utilization/preferences of *Cambarus aculabrum* should be described.

MISSOURI DEPARTMENT OF CONSERVATION

Headquarters

2901 West Truman Boulevard, P.O. Box 180, Jefferson City, Missouri 65102-0180
Telephone: 314/751-4115 ♦ Missouri Relay Center: 1-800-735-2966 (TDD)

JERRY J. PRESLEY, Director

November 22, 1995

RECEIVED

NOV 27 1995

U.S. FISH & WILDLIFE SERVICE
JACKSON

Robert Bowker
Field Supervisor
U.S. Fish and Wildlife Service
Jackson Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

Dear Mr. Bowker:

I appreciate the opportunity to comment on the technical/agency draft recovery plan for the cave crayfish (*Cambarus aculabrum*).

Part I of the report is fine. Descriptions of the species, the habitat and reason for listing are adequate and relevant. Only one bit of information needs attention. Section D refers to a report of a "fish scale of the Ozark cavefish" reported from Bear Hollow Cave, yet the next sentence indicates that the cave "could support" cavefish. If the report by Willis and Brown is verified, then let's consider this a cavefish site. If this report is anecdotal, then it should be removed from text. Given the common association between cave crayfish and Ozark cavefish it is appropriate to suggest that Bear Cave might also be occupied by Ozark cavefish, but the fish scale information should not be included unless verifiable.

Part II is adequate, but too general. Like many recovery plans it identifies a lot of activities that "may" or "could" be implemented, but as presented in this draft it prioritizes categories of action when it should prioritize real recovery activities and clearly identify the responsible agency or individuals. For species that range widely this can be difficult. Given the limited land area relative to this species, the recovery plan should be much clearer about what is to be done and by whom. Part II of this plan needs additional development.

Narrative outline should be edited considerably. Since there are only two sites, simply refer to them by name instead of the convention "One cave site (Logan Cave)....", and "The other cave site (Bear Hollow)....".

Regarding 1.1, has the Service or Arkansas Game and Fish visited with Bella Vista Village folks? Text presented in this report makes the relationship sound so tenuous. Are they a cooperator or not? Text also indicates that "the Service and others should

COMMISSION

29

ANITA B. GORMAN
Kansas City

RANDY HERZOG
St. Joseph

JOHN POWELL
Rolla

RONALD J. STITES
Plattsburg

Robert Bowker
Page 2
November 22, 1995

work with Bella Vista Village". Who are the others? The Service and the state need to talk about this opportunity and decide who has the lead and the recovery plan should simply state who will take what actions with Bella Vista Village to protect the entrance to Bear Hollow Cave.

Regarding 1.2, text indicates that gating or fencing "may be required", but there is already agreement that gates are necessary to protect these sites. Text should simply indicate that gates need to be constructed and identify the lead person and agency. The lead is obvious for Logan Cave and needs to be established for Bear Hollow Cave.

Section 2 identifies a public education need. This is important and text identifies three main target groups. Text indicates that "recovery of this species will depend a large part on the voluntary protection provided by private landowners and local governments," but the plan is weak on exactly what that entails or who will take the lead. Landowners need targeted technical assistance to help them understand and respond to water quality issues in the recharge areas of these caves. Who or what agency in Arkansas can best satisfy this need? Has this entity been contacted and recruited for their input? Perhaps they are reviewing this plan now.

The Logan Cave recharge area should already have a cave recharge protection program in place and the Service can play a strong role here. I am not sure who should take the lead at Bear Hollow Cave, but recharge protection will require more than programs and printed materials.

Section 3 identifies population monitoring. We have been monitoring cave crayfish populations at many sites in Missouri for a number of years. Some are monitored more frequently than others. We monitor presence or absence and record the number of individuals observed per visit. After looking over several years of data there appears to be no reliable trend information and frequency of visitation doesn't seem to make much difference. Twice yearly visits are not a bad idea, but I suspect they will not tell you any more than annual visits. On the other hand, surveys every third year are not adequate for a federally Endangered species, even at protected sites. I recommend annual monitoring at both sites.

How many cave crayfish occur at any one site? It varies tremendously. Some sites in Missouri always seem to have 8-12 individuals and some sites always have one or two. We have made several observations at bristly cave crayfish sites that might be

Robert Bowker
Page 3
November 22, 1995

useful here. First, there are some sites that experience almost continuous removal of crayfish (Elm Spring). Cave crayfish are being washed out or eaten by racoons regularly. This has not seemed to have a negative effect on the population, assuming the number of individuals in the spring box is a reliable indication. The second observation is that baiting crayfish into live traps (Jackson Cave) revealed many more individuals than casual observations would suggest. I support high levels of protection for all populations, whether large or small, but I suspect there are more individuals present at these sites than walk through monitoring would indicate. We probably need a mark recapture study at a good population to learn more about population size.

Monitoring for presence or absence is easy. Monitoring for population changes has not been successful with the amount of effort committed to these sites to date. A more sophisticated monitoring program should be developed if we really want to evaluate changes in population.

Regarding 3.2, water quality monitoring should be routine at all cavefish sites and at these cave crayfish sites. So far we have barely begun the process at cavefish sites. More important than monitoring is implementing targeted technical assistance to see that inappropriate surface threats to water quality are eliminated or managed properly. This plan is weak on identifying threats to water quality and how to deal with them. We should go back and rethink recovery actions and make water quality protection the priority 1 activity in these recharge areas. I am not sure who the responsible agency for water quality is in Arkansas, but they need to be brought into this effort in the planning phase.

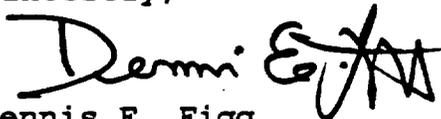
Regarding the assignment of priority numbers, I note that entrance protection is priority 1, while recharge protection is priority 2. Entrance protection will keep people out, but water quality degradation is the major threat. Protecting the recharge area should be the highest priority. This plan needs considerable development regarding the how, when and who will tackle cave watershed protection. Groundwater protection can be a priority 2 action if there are no significant identifiable threats to water quality. This plan did little to describe the current land use and immediate threats to water quality.

This plan is a good example of a plan that identifies a lot of generally good things to be done by the "Service and others". It offers opportunity but fails to commit specific agencies or people to specific actions that will move this species toward recovery. Enclosed please find a recent publication about cave

Robert Bowker
Page 4
November 22, 1995

crayfish genetics. It confirms the genetic integrity of Cambarus aculabrum, but probably will not provide additional guidance for this recovery effort.

Sincerely,

A handwritten signature in black ink that reads "Dennis E. Figg". The signature is stylized, with the first name "Dennis" written in a cursive-like font and the last name "Figg" in a more blocky, bold font.

Dennis E. Figg
Endangered Species Coordinator

c: Karen Yaich
Janet Sternburg
Ken Lister
Jeff Koppelman
Paul McKenzie



United States Department of the Interior

National Biological Service
~~FISH AND WILDLIFE SERVICE~~

Arkansas Cooperative Fish and Wildlife Research Unit
SCEN 617

University of Arkansas
Fayetteville, Arkansas 72701

22 November, 1995

TAKE
PRIDE IN
AMERICA

RECEIVED

NOV 29 1995

US FISH AND WILDLIFE SERVICE
JACKSON, MS

TO: Terri Jacobson, USFWS, Jackson, MS
FROM: James E. Johnson, Unit Leader, NBS
SUBJ: Comments on Draft Cave Crayfish Recovery Plan

Enclosed are comments from Zack Brown and I on the Draft Cave Crayfish Recovery Plan. We find it generally well written but lacking in specific data due to the shortage of information available on this species. We have made suggestions directly onto the enclosed draft. In addition, we suggest the following:

1. Because so little is known about habitat needs of this species, you should be careful about firm statements like "this action will reduce cave crayfish survival." Instead, we suggest you say the action may reduce.... While it is likely that cave crayfish behave like other troglobitic organisms, we are not sure of this yet.
2. Description of Logan Cave has been improved with publication of Means and Johnson (1995). A reprint is attached. Change lake to pool.
3. Numbers of cave crayfish observed by Art Brown have been updated by Zack Brown (no relation). Zack Brown supplies the following data: I saw a mean of 12.5 cave crayfish per monthly trip through Logan Cave from October 1994 through September 1995 (range 7-21). Almost all of the crayfish were seen in the pool/riffle reach above the large pool, none were seen in the reach from the pool to the cave mouth.
4. Under reasons for listing (threats) we believe the Northwest Arkansas Regional Airport should be included. This facility, presently under construction, and its associated build-up of roads, businesses, and activities, is sure to alter the groundwater recharge that influences Logan Cave, and may also allow new pollutants to enter the groundwater and eventually the cave stream. U.S. Fish and Wildlife Service (Vicksburg, MS) has determined that the airport will not affect the Ozark cavefish in Logan or Cave Springs caves, but also notes the possibility of future impacts due to auxiliary build-up of services and businesses.
5. On page 10, the cave crayfish found in the stomach of a banded sculpin was found during Zack Brown's study of Ozark cavefish in Logan Cave. The study was funded by Arkansas Game and Fish Commission through Section 6 of the ESA. That

find was noted in Means and Johnson (1995).

6. In the Recovery Narrative Outline, we suggest under Section 1 that increased funding from U.S. Fish and Wildlife Service for Logan Cave NWR be included. Presently, Logan Cave is administered by Holla Bend NWR in central Arkansas, the closest administrative unit to Logan Cave funded by Refuges. However, no money was included in the Holla Bend NWR budget when personnel there were given the administrative responsibility for Logan Cave. Holla Bend NWR is presently limited in their management capabilities for Logan Cave due to insufficient funding. Holla Bend NWR should be charged with development of a plan to manage Logan Cave NWR and estimate likely costs. USFWS should then attempt to find sufficient funding to at least protect the status quo of that facility and its listed species.
7. Paragraph 1.1 - Care should be taken in gating Bear Hollow Cave to prevent debris build-up when flood waters pour into the cave mouth. Structural failure of the cave mouth or perhaps the cave itself might result if too much pressure was placed on that entrance area.
8. Paragraph 3.1 - In our opinion, it will not be possible to develop a baseline population estimate of cave crayfish in Logan Cave during two visits over a two year period. If our Ozark cavefish data is any indication, this will take a more intensive study, perhaps including mark and recapture using tags now being used for immature marine lobsters. Funds for that study should be included in the budget. In that same paragraph, we would question construction of anything in either Logan or Bear Hollow caves for reducing turbidity until tests on the impacts of turbidity on cave crayfish are funded and run. Funds for that study should also be included.
9. Some baseline water quality data is already available for Logan Cave. I have included copies of Lynda Hustead's (1993) and Myron Mean's (1994) Masters theses that discuss water quality.

Thank you for this opportunity to comment.

A handwritten signature in cursive script, appearing to read "Jim", is located in the lower right quadrant of the page.

OZARK UNDERGROUND LABORATORY

1572 Aley Lane • Protem, Missouri 65733 • (417) 785-4289

November 21, 1995

Mr. Robert Bowker
Field Supervisor
US Fish and Wildlife Service
6578 Dogwood View Parkway, Suite A
Jackson, MS 39213

RE: Recovery Plan for Cambarus aculabrum.

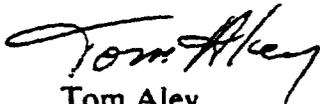
Dear Mr. Bowker:

I have reviewed the draft recovery plan dated September, 1995 for the species identified above.

One important task that seems to be missing is a delineation of the recharge area for Bear Hollow Cave. One cannot protect the recharge area for a cave unless the location and extent of the recharge area is known. We delineated the recharge area for Logan Cave under contract some years ago. However, similar work has not been done for Bear Hollow Cave.

I appreciate the opportunity to review this draft plan. Please let us know if we can be of any further help.

Sincerely,



Tom Aley
Director

REC-111
NOV 27 1995
U.S. FISH & WILDLIFE SERVICE
JACKSON, MISSISSIPPI



wittenberg
UNIVERSITY

November 27, 1995

RECEIVED

DEC - 4 1995

U.S. FISH & WILDLIFE SERVICES
JACKSON, MS

Mr. Robert Bowker
United States Department of the Interior
Fish and Wildlife Service
Jackson Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

Dear Mr. Bowker:

Thank you for the opportunity to review the Technical/Agency Draft Recovery Plan for the cave crayfish, Cambarus aculabrum Hobbs and Brown. Overall the plan looks good and clearly the two locations need to be monitored regularly and protected from perturbations. Obviously it is difficult to protect this troglobite if the recharge area is not understood for one of the two known caves it inhabits. I strongly urge working closely with the local landowners in the environs of Bear Hollow Cave and to carry out an intensive dye testing study so that the drainage basin can be delineated.

It seems to me that potentially you could run into disturbance problems, given the number of groups currently involved with the two caves (e.g., U.S. Fish and Wildlife Service, Arkansas Game and Fish Commission, researchers, amateur cavers, trespassers). Although placing durable, bat-friendly gates on caves is by no means the best strategy taken to protect a cave, it appears that both caves need to be protected from unauthorized entry.

Ten cases of trespass in Logan Cave during April-July 1995 represent excessive disturbance, particularly since two researchers enter the cave each month. Installation of electronic remote surveillance systems at both sites, although expensive, may be your best approach. Education and cooperative interaction with local landowners also will be critical in the protection of this species.

I wish you the best as you implement the plan and thank you for the opportunity to examine the draft.

Sincerely,

Horton H. Hobbs III
Professor and Chair
Department of Biology

HHH:er

36

Arkansas Game & Fish Commission
2 Natural Resources Drive Little Rock, Arkansas 72205

Steve N. Wilson
Director

Scott Henderson
Assistant Director



Hampton Waterfowl Research Center
Rt. 1 Box 188-A
Humphrey, AR 72073

1 December 1995

RECEIVED

DEC 11 1995

U.S. FISH & WILDLIFE SERVICES
JACKSON, MS

Robert Bowker, Field Supervisor
U.S. Fish and Wildlife Service
Jackson Field Office
6578 Dogwood View Parkway, Suite A
Jackson, MS 39213

Dear Mr. Bowker:

The Arkansas Game and Fish Commission appreciates the opportunity to comment on the technical/agency draft recovery plan for the cave crayfish (*Cambarus aculabrum*).

Attached please find comments on the draft plan prepared by Stan Todd, AGFC District Fisheries Biologist. Stan has been deeply involved in the Commission's cave crayfish monitoring efforts.

I have been working with the Arkansas Field Office of the Nature Conservancy regarding a cooperative effort to obtain a conservation easement or formal management agreement with Bella Vista Village/Cooper Communities to protect Bear Hollow Cave. The Arkansas Game and Fish Commission constructed a gate to this cave in March 1993. According to Commission records, the gate was vandalized one month after it was completed and repaired several months later. It has since been heavily vandalized. I believe that, at the minimum, a formal management agreement is necessary before constructing another gate at the cave entrance.

I look forward to working with USFWS personnel in, not only the effort to protect the entrance to Bear Hollow Cave, but the protection and management of the cave crayfish and their associated cave communities and ecosystems.

Sincerely,

A handwritten signature in cursive script, appearing to read "Karen L. Yaich".

Karen L. Yaich, Chief
Endangered, Nongame & Urban Wildlife Section