The 2007 Census of *Gammarus acherondytes* Communities in Southwestern Illinois

Final Report

Endangered Species Program
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Introduction

The purpose of the 2007 project was to conduct the annual monitoring of the status of the endangered Illinois cave amphipod Gammarus acherondytes as mandated by the recovery plan for the species. The last census was conducted in 2003.

In 2007 we censused one or more sites in each of the following groundwater basins (where we believed Gammarus acherondytes was extant): (1) Frog Spring, (2) Annbriar, (3) Pautler Cave, (4) Illinois Caverns, (5) Fogelpole Cave, (6) Krueger/Dry Run Cave, (7) Luhr Spring and (8) Dual Spring. Lewis (2003) established 100 foot transects in one cave in each basin, and mapped the area and habitat to allow extrapolation of the transect population from Surber quadrats.

Methods

The census method was described by Lewis (2000, 2001, 2003). Following the format of Lewis (2003) the transect in each cave was a standardized 100 foot length. Each transect was divided into ten areas of 10 feet in length each. Within each 10-foot sub-transect a two digit random number determined the placement of the quadrat up and across the area. For example, the number 63 would indicate a quadrat placement of 6 feet up the length of the transect and 30% of the total width of the stream. In the case of short caves, e.g., Reverse Stream Cave or Wednesday Cave, a belted transect was censused. In this type of transect a quadrat is placed each linear foot, with the distance across the stream designated as a percentage generated from a random number. A Surber square foot sampler was used as in past surveys to extract the samples. One or more sites in all of the eight groundwater basins where Gammarus acherondytes was known to remain were censused during the 2007 project.

An approximate location for each cave entrance is provided, measured from the intersection of highways 3 and 156 in Waterloo. A GPS location for each cave was taken and has been provided to the Illinois Cave Survey. To aid in the location and recognition of the sites in perpetuity, a photograph of each cave entrance and transect was provided by Lewis (2003) or in the case where new sites were added, in the present report.

Results: Individual Sites

FROG SPRING GROUNDWATER BASIN

Frog Cave

Location: Frog Cave is near Bond Creek approximately 5 miles west of Waterloo.

Description: The cave is entered by a shallow pit that gives immediate access to a short section of walking-height stream passage that comprises the transect. The stream sumps below the entrance pit then re-emerges nearby as a spring.

Transect: A 100 foot transect (map 1) was established starting at a point in the twilight zone of the cave where a breakdown boulder spans the stream. The habitat consists of a mixture of gravel/cobble riffles and pools, with a sections of scoured limestone in the upstream part of the transect. Measurement of stream cross-sections revealed an estimated 533 square feet of habitat in the 100 linear foot transect.

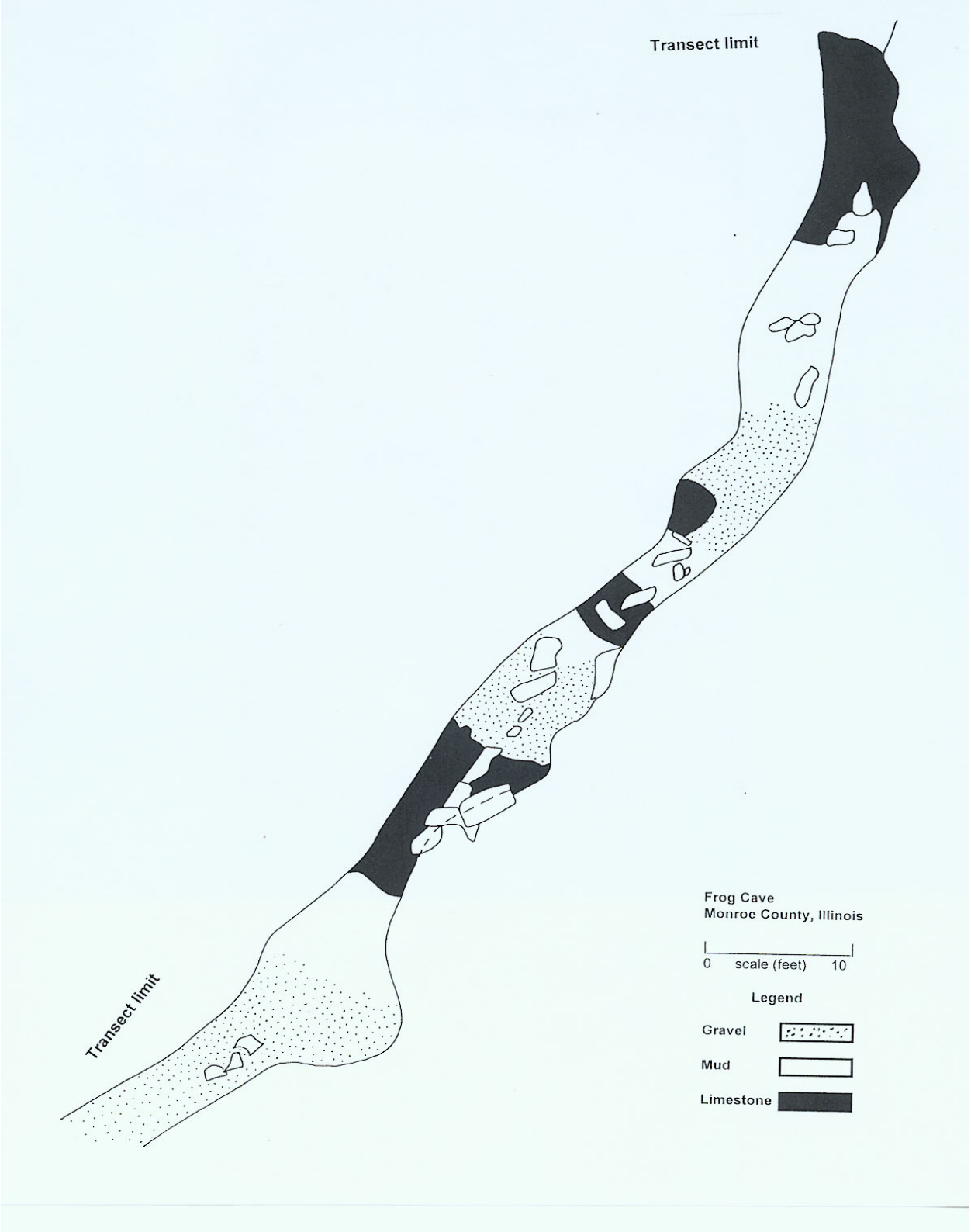
Community: Frog Cave was previously surveyed on 26 May 2001, in which 17% of the fauna was stygobitic; 4 July 2001, when 47% of the animals were stygobitic; and 26 March 2003 with 32% stygobites. During the present survey Frog Cave was visited on 6 October 2007 (appendix, table 1). At that time, of the 73 animals present in the quadrats, 36% were stygobitic.

Gammarus acherondytes status: As noted above, two surveys were conducted at this site in 2001. The first survey on 26 May 2001 revealed 27 Gammarus acherondytes in 20 quadrats and the 4 July 2001 survey demonstrated 53 Gammarus acherondytes in 20 quadrats. In 2003, 20 Illinois cave amphipods were found in 10 quadrats, comprising 18% of the animals found in the transect.

In 2007, 24 Gammarus acherondytes were found in the 10 quadrats, comprising 33% of the fauna of the transect. Extrapolation of the quadrat samples indicated 1279 of the amphipods occurring in the transect, a modest increase from the 2003 census.

The present transect encompasses over half the available stream habitat in the enterable part of the cave. Considering that Frog Cave is the downstream terminus of this groundwater system, more Gammarus acherondytes presumably occur upstream of Frog Cave if suitable habitat continues beyond the upstream sump

Map 1. Stream transect in Frog Cave, Monroe County, Illinois (stream only).



DUAL SPRING GROUNDWATER BASIN

Snow White Cave

Location: Snow White Cave is near Fountain Creek approximately 3 1/2 miles west of Waterloo.

Description: The main entrance to the cave is via the bottom of a sinkhole that gives access to a wide hands-and-knees crawlway that becomes a walking-height stream passage. A second entrance is located in an adjacent sinkhole that connects the two entrances via a low crawlway. The cave is reported to be 2000 feet in length (map 2), with the habitat changing to a mud substrate near the end due to back-flooding from Fountain Creek.

Transect: The downstream end of the 100 foot transect (map 3) was established starting at the upstream end of a pile of breakdown boulders that spans the stream passage. The habitat consists of a mixture of gravel/cobble riffles and pools, with much of the underlying substrate being cemented stream gravel creating an undulating appearance to the habitat. Lewis (2003) mapped the census area showing an estimated 434 square feet of habitat in the 100 linear foot transect.

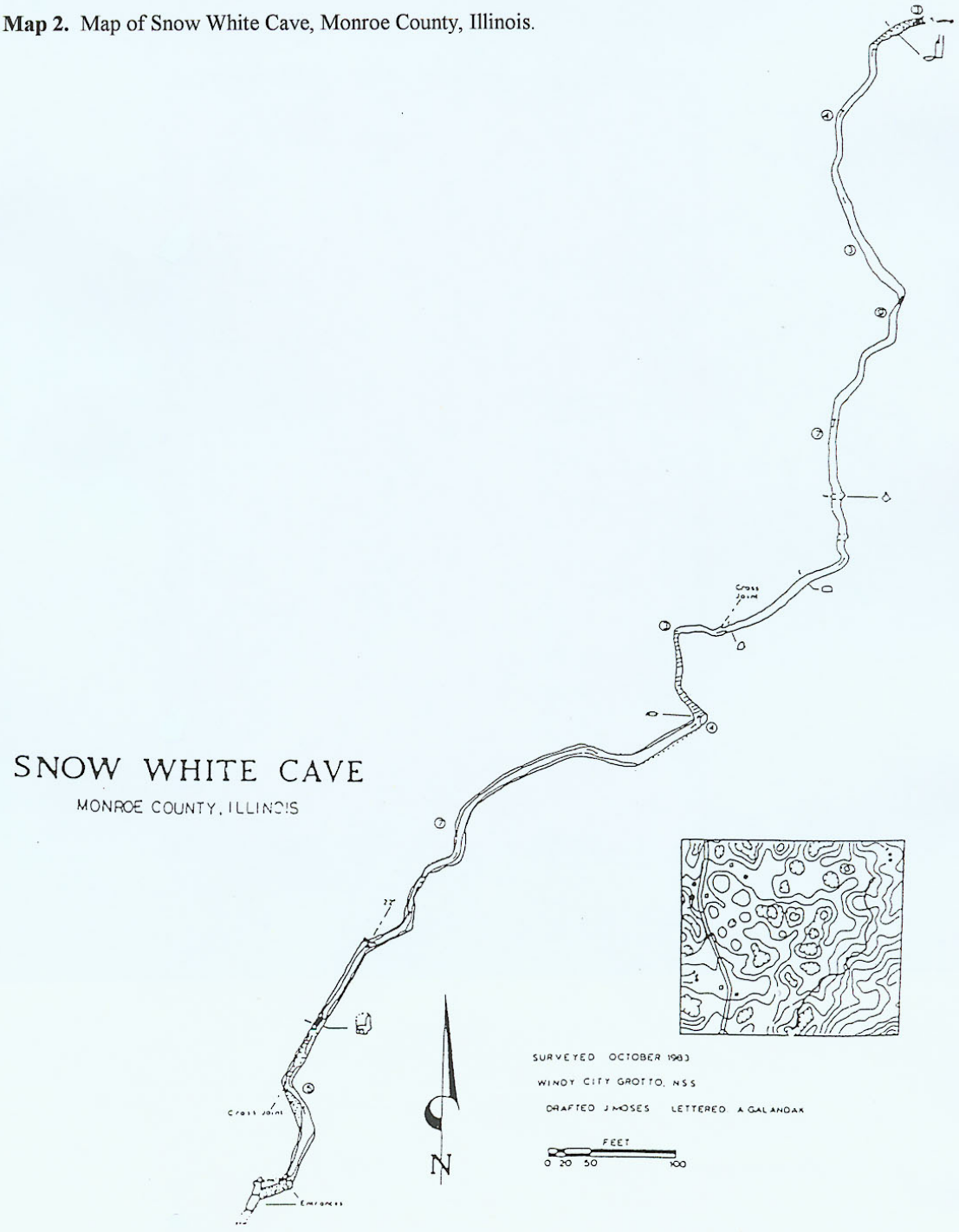
Community: The established transect was censused by J. Lewis, S. Lewis and D. Tecic on 8 July 2007 (appendix table 2). With similar results to the 2003 data, the stygophilic isopod Caecidotea brevicauda was the numerically dominant species with 52 animals found. Only one Gammarus acherondytes was found in the quadrats. Other fauna found were 5 Gammarus troglophilus and 1 Sphalloplana hubrichti. As noted previously, in areas of Monroe County caves where the habitat is flowstone the species that seems to be most able to use it is Caecidotea brevicauda, which was certainly the case in Snow White Cave. The isopods were found even in rapidly flowing water perched on the exposed surfaces of the undulating flowstone substrate.

In the sample of 27 March 2003 Caecidotea brevicauda was dominant with 47 present, followed distantly by 4 of the stygophilic amphipod Gammarus troglophilus. Of the 55 animals found in the quadrats, 95% were non-stygobites.

Gammarus acherondytes status: The presence of the Illinois cave amphipod was discovered in this groundwater basin on 27 September 2001 by J. Lewis and P. Moss (Lewis 2001). The 2007 survey is the second population estimate conducted at this location.

In 2007 one Illinois cave amphipod was found comprising 1.6% of the animals found in the transect, which suggests that there were 43 of the amphipods occurring in the area of the transect. The 2003 census revealed 2 of the amphipods with a population of about 87 in the transect.

Map 2. Map of Snow White Cave, Monroe County, Illinois.



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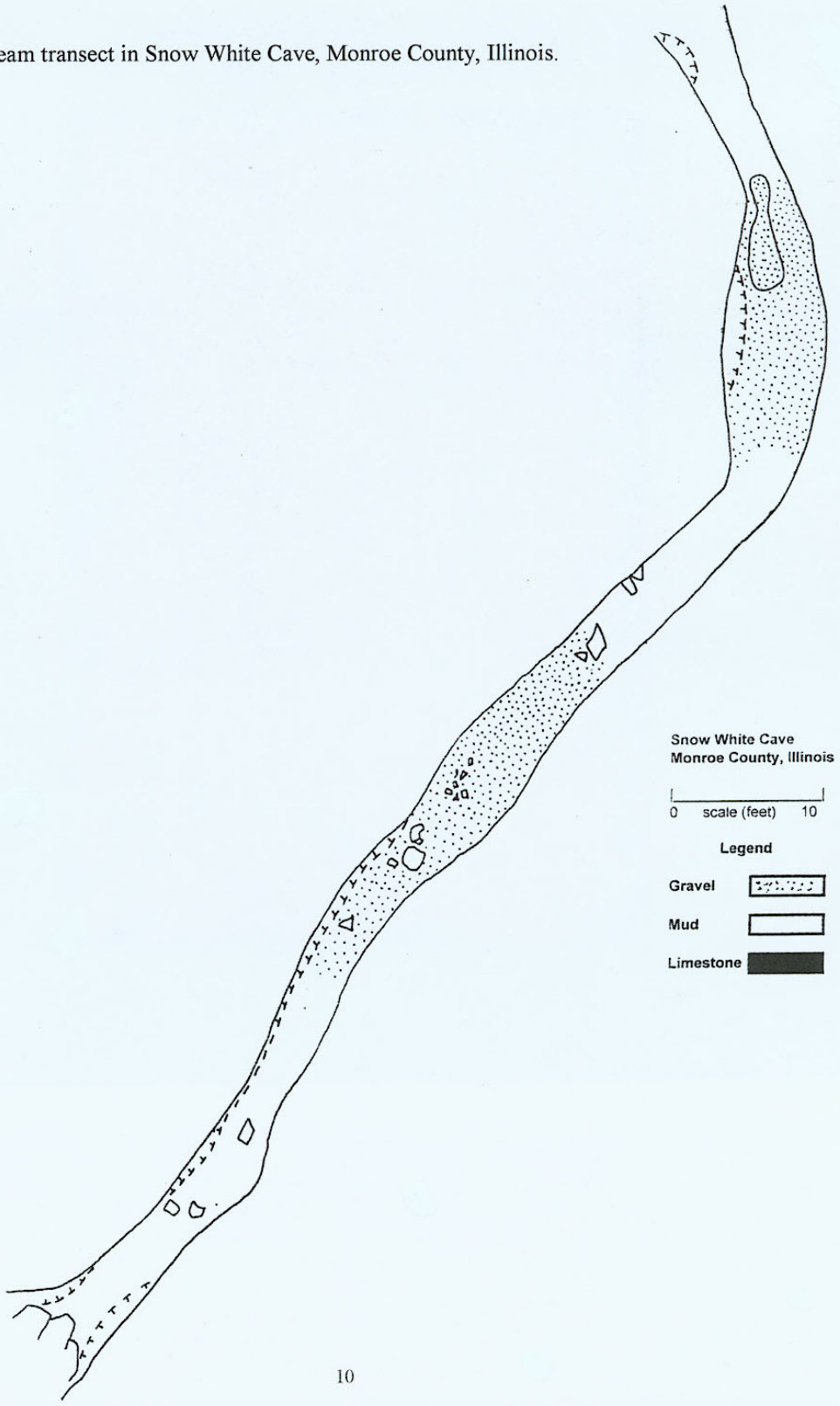
Map 3. Stream transect in Snow White Cave, Monroe County, Illinois.



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LUHR SPRING GROUNDWATER BASIN

Pump House Cave

Location: Pump House Cave is found near Fountain Creek approximately 4 miles WNW of Waterloo.

Description: The cave was entered via the Rick's Pit entrance, which consists of a pit about 16 feet deep in the bottom of a sinkhole. Entry requires a hand line. At the base of the pit lies a low, wide stream passage that gradually increases in size to a standing height area. Other entrances allow access to low crawlway passages that were not suitable for population studies (map 4).

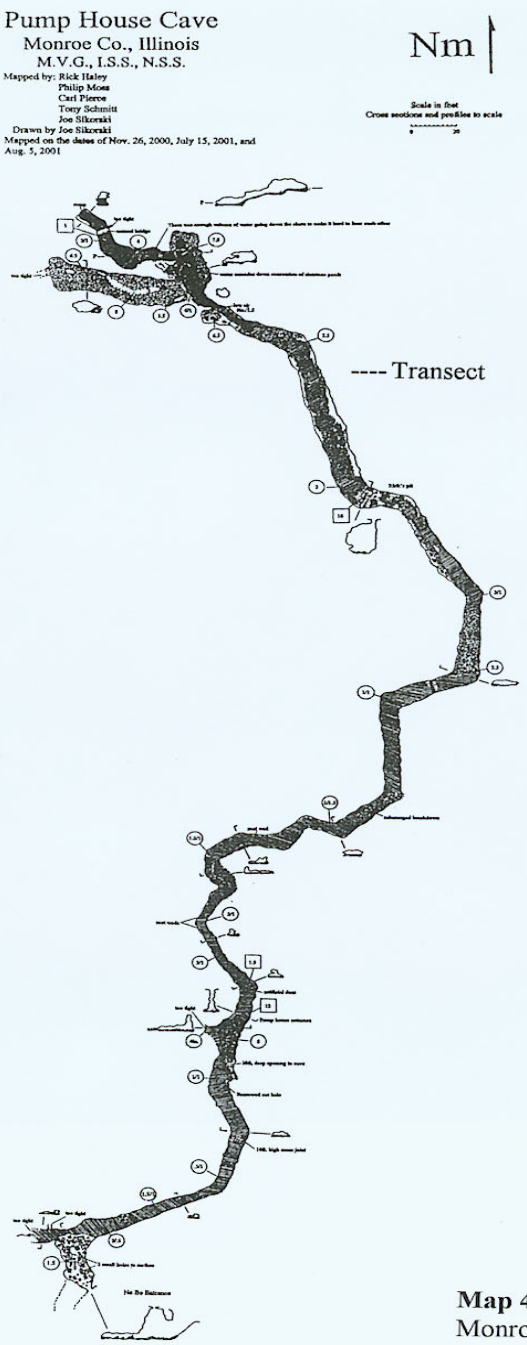
Transect: The downstream end of the 100 foot transect (maps 4 and 5) was established starting at the pool where the stream nearly sumps at the base of several short waterfalls, and extends upstream in low passage nearly to the Rick's Pit entrance. The habitat consists of a mixture of gravel/cobble riffles and pools. Measurement of stream cross-sections revealed an estimated 483 square feet of habitat in the 100 linear foot transect (map 5).

Community: The cave was visited on 6 July 2007 by J. Lewis and S. Lewis (appendix table 3). A total of 42 animals were found in the census area, of which the stygophilic isopod Caecidotea brevicauda was numerically dominant with 13 in the sample, followed by the stygobitic flatworm Sphalloplana hubrichti and amphipod Gammarus troglophilus each with 8, and the Illinois cave amphipod Gammarus acherondytes with 6. This represents a rather large drop in the number of Caecidotea brevicauda present, but otherwise the numbers were similar to that of 2003. Of the 42 animals in the quadrat, 19 were stygobitic (45%). Numerous Illinois cave amphipods were noted while crawling to and around the census area, as well as many flatworms and large stygobitic isopods Caecidotea packardi (of which 5 also turned up in the quadrats).

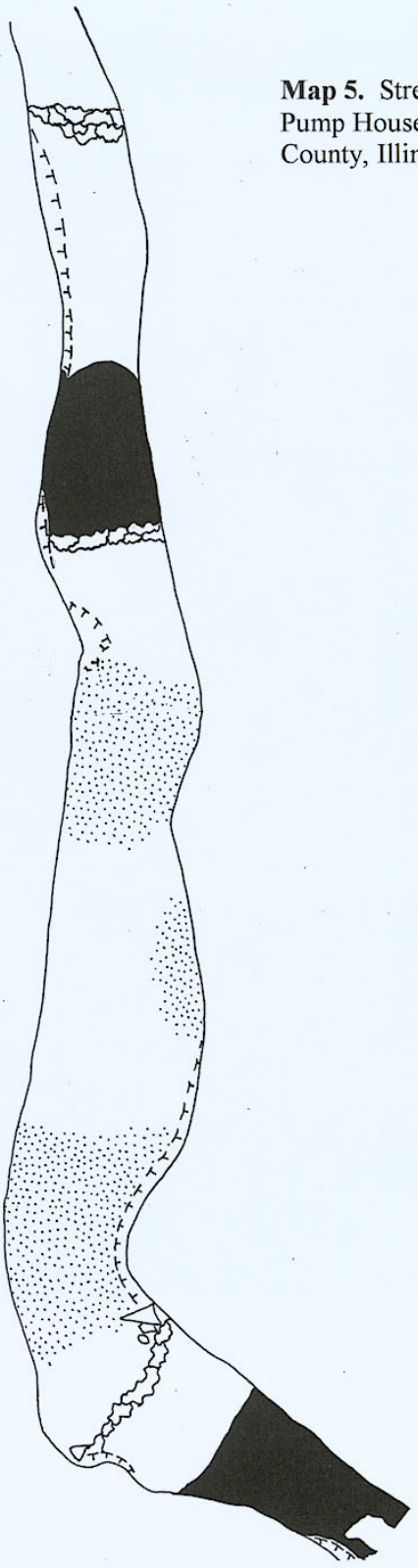
In the sample of 28 March 2003 the stygophilic isopod Caecidotea brevicauda was the numerically dominant species with 52 in the sample, followed by the stygobitic flatworm Sphalloplana hubrichti with 10 found in the sample and the Illinois cave amphipod Gammarus acherondytes with 7. Of the 78 animals found in the quadrats, 72% were non-stygobites. Part of the habitat surveyed is marginal for Gammarus acherondytes because it was bedrock or flowstone, but a significant part of the transect appeared to be very good habitat and numerous of the amphipods were noted as we traversed the passage. The stygobitic amphipod Bactrurus brachycaudus was found in hand collecting in 2001.

Gammarus acherondytes status: The presence of Gammarus acherondytes was discovered at this site on 27 September 2001 by J. Lewis and P. Moss (Lewis 2001). The 2007 survey is the second population estimate for this site.

In 2007 six Illinois cave amphipods were found in 10 quadrats, comprising 14.3% of the animals found in the transect. Extrapolation of the quadrat samples suggests that there are 290 of the amphipods occurring in the transect.



Map 4. Pump House Cave, Monroe County, Illinois



Map 5. Stream transect in Pump House Cave, Monroe County, Illinois.

ILLINOIS CAVERNS GROUNDWATER BASIN

Illinois Caverns

Location: The main entrance of Illinois Caverns is approximately 7 miles south of Waterloo and is indicated as "Mammoth Cave" on the Renault Quadrangle map. There are multiple entrances to this cave system on private properties, but the main entrance is owned and gated by the Illinois Department of Natural Resources on the property of Illinois Caverns State Natural Area.

Description: The cave was entered via the main entrance via a concrete staircase that descends about 30 feet deep to the bottom of a pit-like sinkhole. At the base of stairs is a spacious stream passage. Illinois Caverns is comprised of approximately five miles of passages in a dendritic pattern comprised of the main stream passage and several major side passages (map 6), each contributing water.

Transects: The downstream end of the standardized 100 foot transect (map 7) lies at a point where the stream disappears under a wall ledge. The habitat consists of a mixture of gravel and cobble riffles and pools. Measurement of stream cross-sections revealed an estimated 634 square feet of habitat in the 100 linear foot transect. The transect is crossed on the upstream end by the main path through the cave.

In 2007 two other areas were also censused in the main stream passage of Illinois Caverns. The areas were not mapped, but otherwise the same censusing protocol was used. Transect 2 was placed immediately upstream from the Cascade Canyon Passage. Transect 3 was placed around the first bend in the passage below the Rimstone River Passage (map 6).

Community: On the survey of 3 September 2007 (appendix table 4) the Illinois cave amphipod Gammarus acherondytes was the numerically dominant species with 10 in the sample, followed by the stygophilic amphipod Gammarus troglophilus with 6, 3 of the isopod Caecidotea brevicauda, 1 of stygobitic isopod Caecidotea packardi and 1 stygobitic flatworm Sphalloplana hubrichti. Of the 21 animals found in the quadrats, 12 (57%) were stygobites. The number of Caecidotea brevicauda decreased from 41 in 2003 to 3 in 2007. If C. brevicauda is subtracted from the sample, the number of animals present in the survey area was almost identical between 2003 (with 17) and 2007 (18). A major change in the community composition has occurred, with stygophilic isopods essentially disappearing and the Illinois cave amphipod becoming the dominant member.

On 12 October 2007 transect 2 (immediately above the Cascade Canyon Passage) was censused (appendix table 5). Within this transect we found 13 Gammarus troglophilus, 6 Gammarus acherondytes, 5 Caecidotea brevicauda, 6 Physella sp., 1 Sphalloplana hubrichti and 1 Eurycea larva. On 22 November 2007 transect 3 (below Rimstone River Passage) was censused and yielded only 12 animals (appendix table 6): 5 Gammarus troglophilus, 7 Caecidotea brevicauda and 2 Physella sp. None of the fauna found at transect 3 was stygobitic.

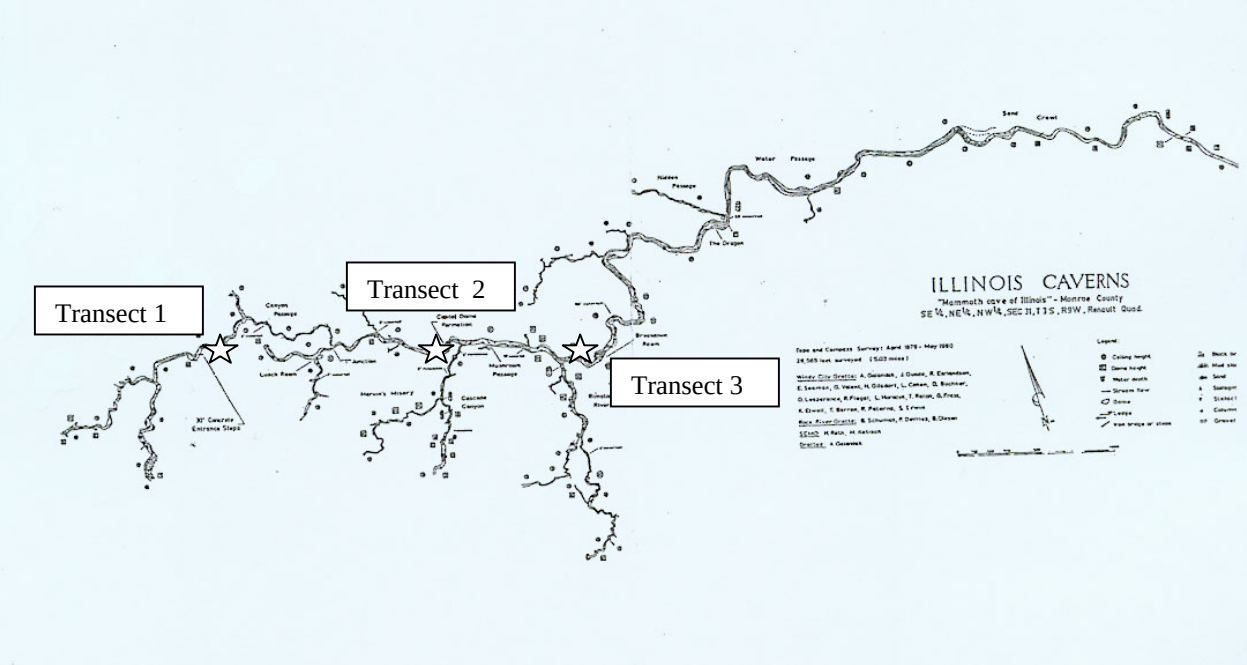
Gammarus acherondytes status: This transect was established as part of the initial project establishing the methodology for censusing Gammarus acherondytes. Previous survey data yielded the following numbers of Gammarus acherondytes taken in 10 quadrats in this transect: 2 (4 July 2000), 1 (2 September 2000), 3 (3 July 2001) 4 (2 September 2001), and 4 (28 March 2003).

In the 3 September 2007 survey, 10 Illinois cave amphipods were found in 10 quadrats, comprising 48% of the animals found in the transect. Extrapolation of the quadrat samples, i.e., 1/square foot, suggests that there are 634 of the amphipods occurring in the transect.

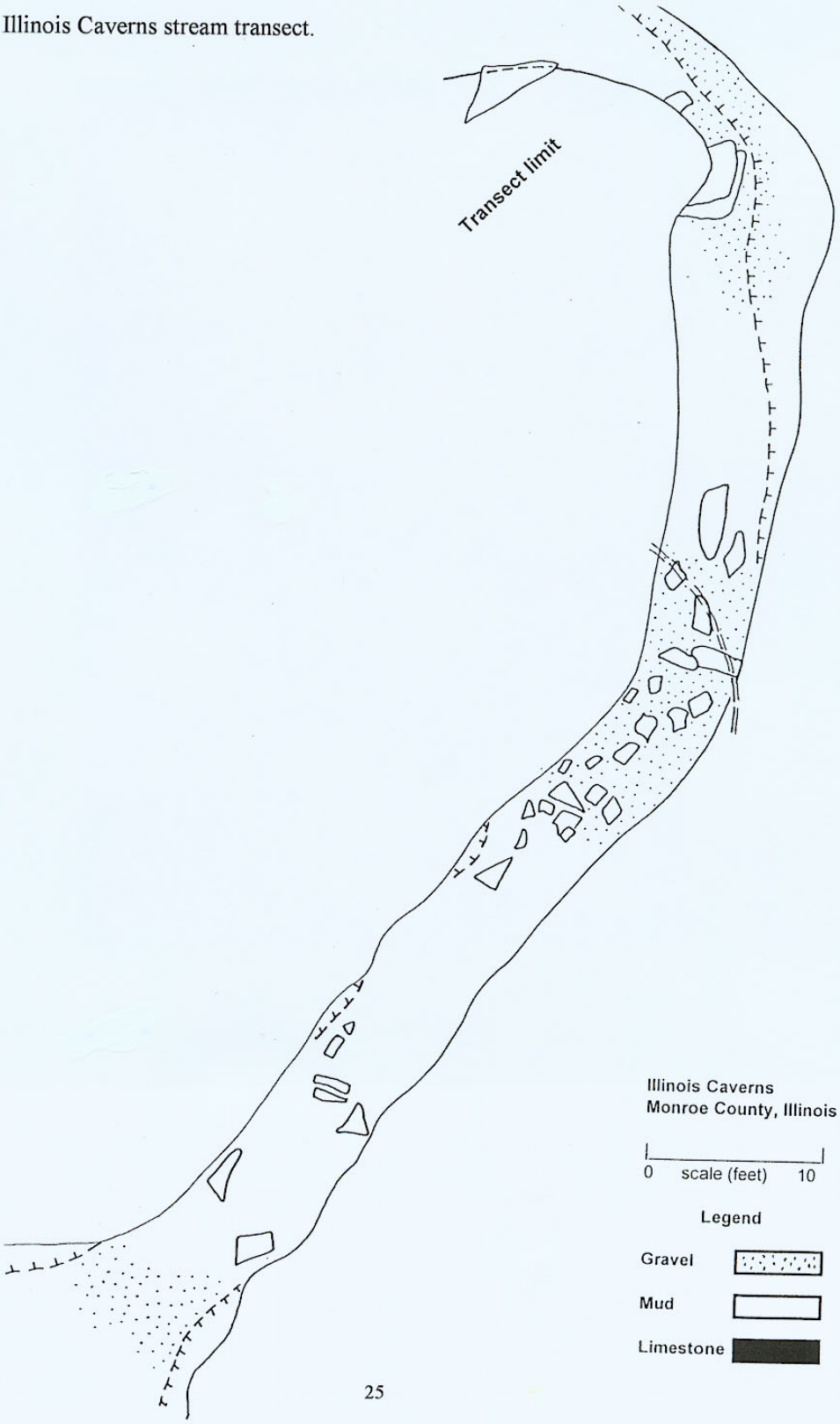
Downstream of the T-junction the cave stream was examined and the Illinois cave amphipod's presence was noted to the limit of our exploration on that day, at the confluence of the Cascade Canyon passage. A square foot area within a pool about 150 feet upstream in this passage was examined and contained 4 large Gammarus troglophilus (14-18mm) and 2 Gammarus acherondytes (6-8mm).

In the 12 October 2007 transect 2 in the main stream immediately above the Cascade Canyon Passage we found 6 Gammarus acherondytes, constituting about 19% of the stream fauna in that part of the cave. In transect 3 Gammarus acherondytes was not found.

Map 6. Illinois Caverns.



Map 7. Illinois Caverns stream transect.



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ANNBRIAR SPRING GROUNDWATER BASIN

Reverse Stream Cave

Location: Reverse Stream Cave is found approximately 4 miles west of Waterloo.

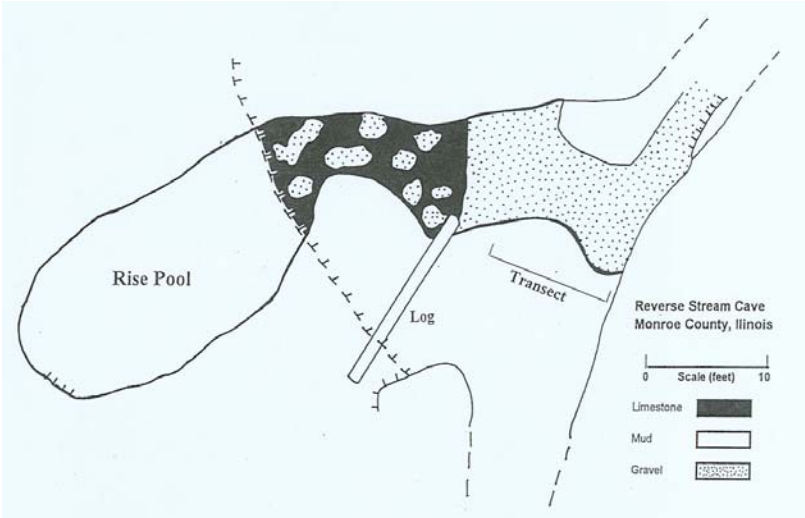
Description: The cave receives the flow from a spring rise pool that is adjacent to the entrance. The water from the rise flows into the low, wide entrance of Reverse Stream Cave, where it sumps after about 150 feet of low passage.

Transect: Due to the limited stream access and small passage size a belted transect was created (map 8), sampling 10 quadrats at one foot intervals, with the placement in the cross-section of the stream randomized. Measurement of stream cross-sections revealed an estimated 80 square feet of habitat in the 10 linear foot transect.

Community: The cave was entered on 6 July 2007 by J. Lewis and S. Lewis to census the fauna (appendix table 7). Of the 215 animals in the census area, roughly equal numbers were found of Gammarus troglophilus (68), Gammarus acherondytes (70), and Caecidotea brevicauda (72). One third of the animals in the transect were stygobitic.

In the sample of 31 August 2003 four species were present, dominated by the stygophilic isopod Caecidotea brevicauda with 54, followed by Gammarus acherondytes with 23 and Gammarus troglophilus with 17. The community was comprised of 28% stygobites.

Gammarus acherondytes status: The 2007 survey is the second census of this site, which revealed the highest number of Gammarus acherondytes found at any cave with 70 in the 10 quadrats. Extrapolation of the quadrat samples suggests a population of 560 Illinois cave amphipods in the 10 foot linear belted-transect.



Map 8. Stream transect in Reverse Stream Cave.

Triple Delight Cave

Location: Triple Delight Cave is found approximately 4.3 miles southwest of Waterloo.

Description: The cave remains unmapped, but is part of the Annbriar Spring groundwater system (Moss, email 2007). Multiple entrances are present in the immediate area where the census was conducted. The small part of the cave examined was a stream passage about 6-8 feet in width and varying from a hands and knees crawl to stoopway.

Transect: A belted transect was created sampling 10 quadrats at one foot intervals, with the placement in the cross-section of the stream randomized. Measurement of stream cross-sections revealed an estimated 43 square feet of habitat in the 10 linear foot transect.

Community: The cave was entered on 23 November 2007 by J. Lewis and S. Lewis to census the fauna. Of the 55 animals in the census area there were 27 Gammarus troglophilus and 17 Gammarus acherondytes. Approximately one third of the animals were stygobitic (appendix table 8).

Gammarus acherondytes status: The 2007 survey was the first census conducted at this site. Despite the fact that the site is surrounded by a growing subdivision, the Illinois cave amphipod has a significant presence in the community.

Triple Delight Entrance sinkhole, (coat/clipboard for scale on right).

Triple Delight stream transect, note ceiling ledge above clipboard marking upstream end of transect.

Wednesday Cave

Location: Wednesday Cave is approximately 3.8 miles WSW of Waterloo.

Description: The cave consists of about 30 feet of passage accessed by a crawlway entrance in the bottom of a large sinkhole. The stream flows into a large rimstone pool, falls about 3 feet down a rimstone dam, then flows across gravel and root mats and disappears into the floor.

Transect: A belted transect was created sampling 10 quadrats at one foot intervals. Most of the stream is less than one foot in width (the size of the Surber sampler), but in areas of greater width the center of the stream was sampled.

Community: The cave was entered on 13 October 2007 by J. Lewis to census the fauna, which revealed 10 Gammarus troglophilus, 9 G. acherondytes, 11 Caecidotea brevicauda, and 1 each of Bactrurus brachycaudus, Caecidotea packardi, Physella sp. and Sphalloplana hubrichti (appendix table 9). Most of the Caecidotea brevicauda were juveniles present at the base of a bedrock flume, a micro-habitat that seems unusable by other members of the community.

Gammarus acherondytes status: Due to the small size of the stream essentially the entire area of the transect was censused. Previous surveys revealed fewer amphipods due to the placement of the transect, which formerly surveyed the bare bedrock floor of the upstream pool and downstream flume area. This year the transect was placed in better habitat more representative of the environment generally present in the stream. A mating pair of Gammarus acherondytes was noted and attests to the fact that the species is reproducing in this site.

Wednesday Cave Entrance (GPS unit for scale above crawlway)

Wednesday Cave transect, notebook for scale

PAUTLER GROUNDWATER BASIN

Pautler Cave

Location: Pautler Cave is found approximately 3 miles WSW of Waterloo.

Description: Pautler Cave is a side passage of the Pautler Cave System main trunk described by Moss et al. (2004). The entrance of Pautler Cave is owned by the Karst Conservancy of Illinois and has been dedicated as an Illinois Nature Preserve. The entrance is in the wall of a climbable open air pit. A crawlway past the entrance room allows access to the large main passage of the cave. The Dog Passage in Pautler Cave apparently receives water from Rose Hole. Following the water in Pautler Cave downstream leads to a tight, barely passable connection with the main Pautler Cave System trunk. An artificial entrance was recently excavated allowing access from the Pautler Cave sink into the downstream continuation of the cave, and the main trunk of the system beyond.

Transect: A 100 foot transect was established with the upstream end at the large breakdown spanning the main stream passage (maps 9-10) with a measured area of 497 square feet.

Community: Pautler Cave was censused on two occasions in 2007, on 7 July (appendix table 10) and 21 November (appendix table 11), both by J. Lewis and S. Lewis. Of note, the floor of the entrance passage was dry on both trips. Drought conditions occurred in the area during the summer of 2007. A precipitous drop in the number of animals present was documented in the July census. Only 28 animals were noted in the quadrats, of which 2 were Gammarus acherondytes and 6 were Gammarus troglophilus. For that reason the transect was re-visited in November to see if perhaps the low numbers demonstrated during July census was a fluke of sampling. The November census was the first time since the cave has been visited that Gammarus acherondytes was not found in the transect. After conducting the census, the upstream riffle area was examined by crawling along and turning stones. This demonstrated the same species found in the census quadrats, but no Gammarus acherondytes.

Previously, in the census of 31 August 2003 the community was dominated by the amphipod Gammarus troglophilus in which 47 were found, followed by Gammarus acherondytes with 18 in the sample. The July 2007 census area was dominated by the stygophilic isopod Caecidotea brevicauda. About 21% of the animals were stygobitic, compared with 27% in 2003. In both years other stygobites found in the transect were the isopod Caecidotea packardi and amphipod Bactrurus brachycaudus. The November 2007 census revealed only 9 animals: 3 Gammarus troglophilus, 2 Caecidotea packardi and 4 Caecidotea brevicauda. The proportion of stygobites in the community in the last census was about 22%. The presence of Bactrurus is sporadic in the transect and of no immediate concern, but the decrease of Gammarus acherondytes to a level below that detectable in the census raises great concerns.

In 2007 a new opportunity was available with the opening of the man-made entrance to downstream Pautler Cave and the main trunk beyond formerly accessible only by a very arduous trip from the Dane's Cave entrance. The artificial entrance is a 23 foot pit in which a culvert has been placed, with a gate at the top. The continuation of the stream from the historic section of

Pautler Cave is visible about 50 feet into the part of the cave referred to here as "Downstream Pautler Cave". The character of the stream is different from that in the Historic section of the cave, characterized by abundant riffles and breakdown strewn habitat. The Illinois cave amphipod was observed in traversing this passage.

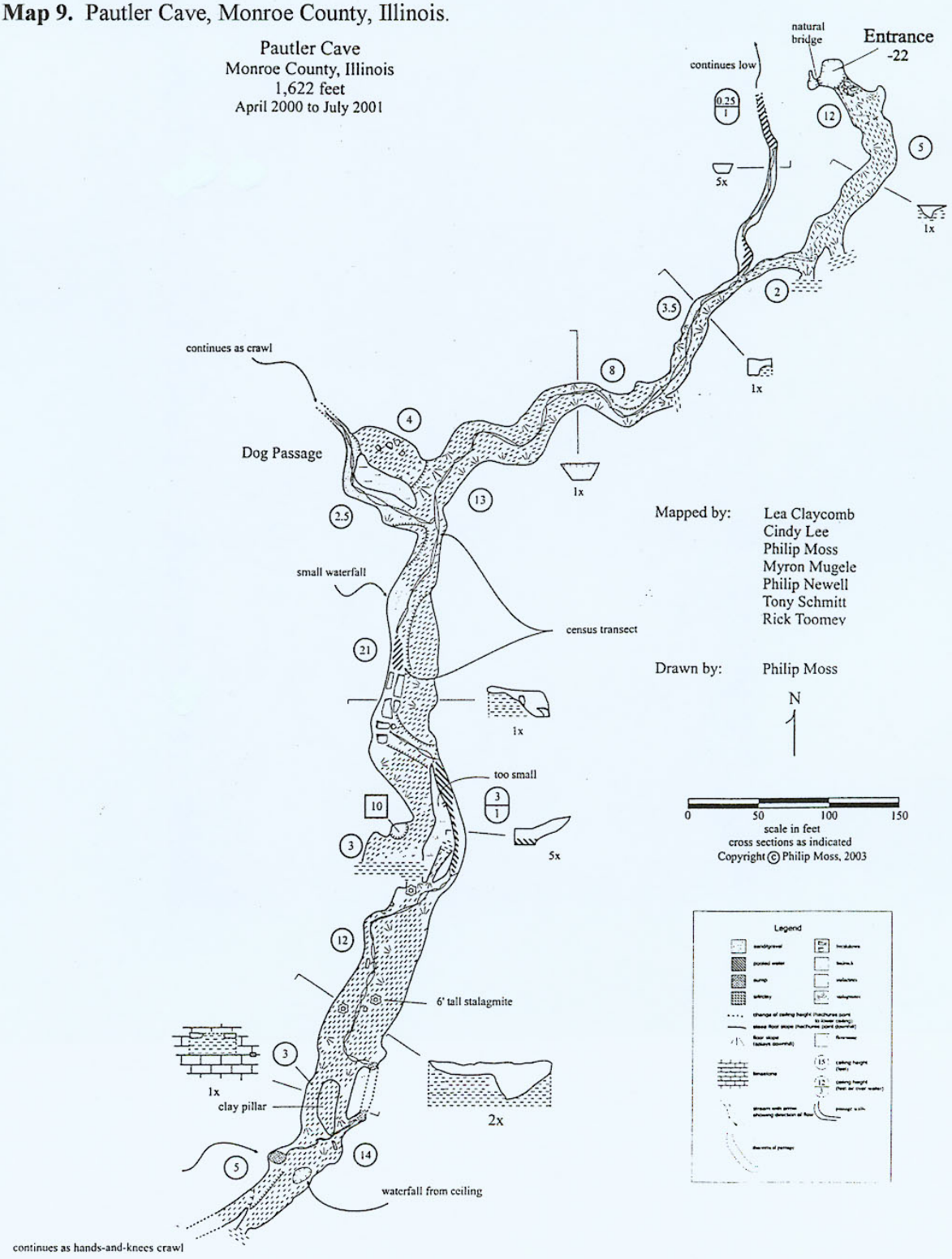
A small separate stream, originating from a ceiling inlet, is present around survey marker D14. This stream is a few inches wide (and deep) with a mud bottom with scattered gravel. We observed an adult Gammarus acherondytes in the company of the isopod Caecidotea packardi, both of which were under a thin layer of calcite ice floating on the surface of the stream pool.

The passage ends at the intersection with the main stream passage, the conduit for waters of the Pautler Cave groundwater basin to the spring at Camp Vandeventer. At the intersection, the stream drops precipitously down Pautler Falls into the much larger main stream passage. The habitat in the upstream end of this stream was qualitatively sampled by J. Lewis and P. Moss (Lewis et al. 2003). At that time the Illinois cave amphipod was easily found and seemed to be common. At the downstream end of the system, Gammarus acherondytes has never been found in Camp Vandeventer Cave.

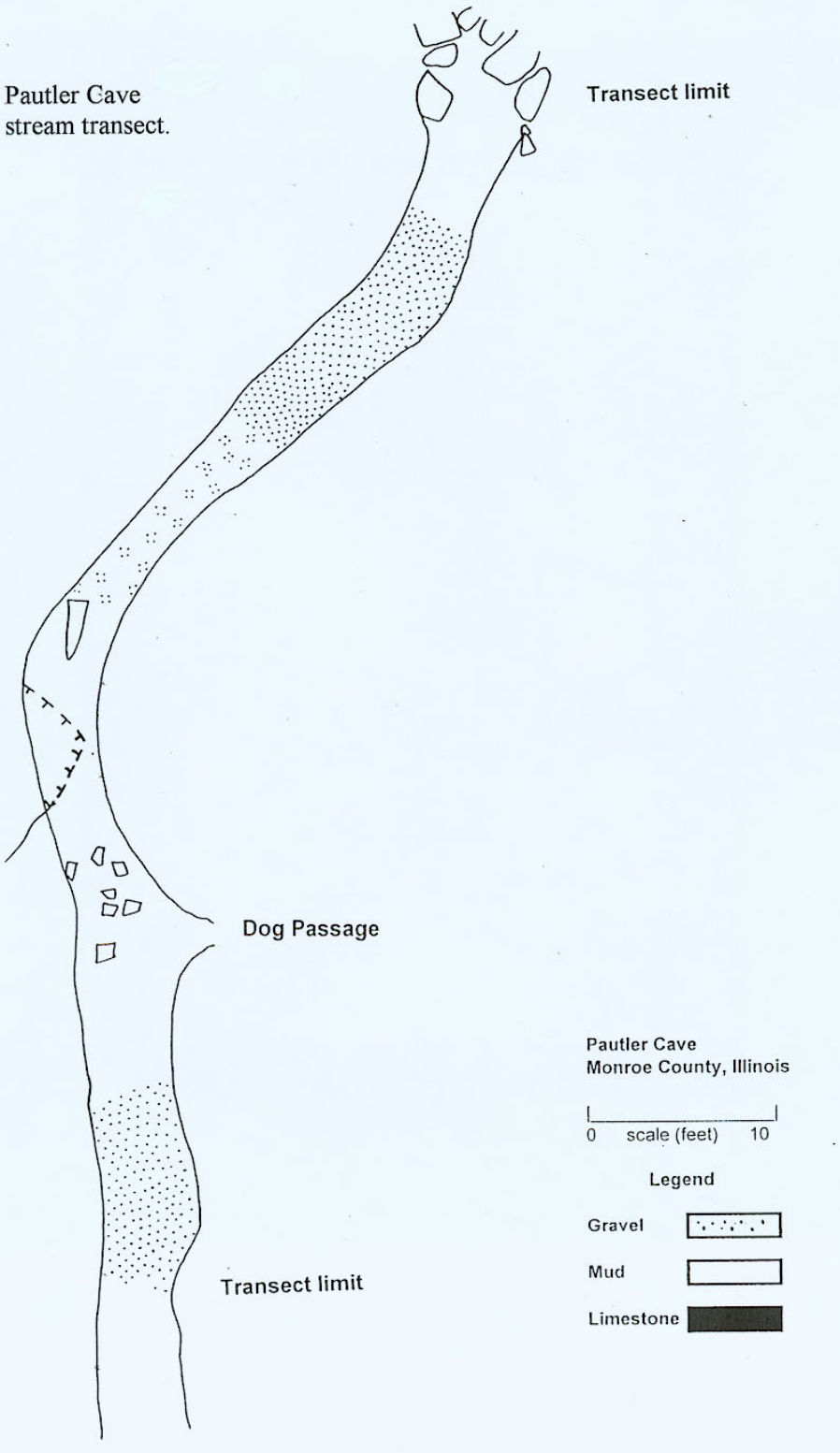
Thus, qualitative sampling in the upstream part of the Pautler system indicates that the Illinois cave amphipod is common, but absent in the downstream end. It stands to reason that the population declines somewhere in between. The habitat in the main stream passage below Pautler Falls appears excellent for the amphipod, with long, broad gravel riffles with intervening pools. On 7 July 2007, several quadrats were taken in subjectively appropriate appearing gravel riffles, but no amphipods were found. At that point exploration was started at the base of the riffle by crawling upstream and turning over gravel and visually scouring the substrate for Gammarus acherondytes. With some difficulty this resulted in finding one individual of the Illinois cave amphipod.

Gammarus acherondytes status: The Illinois cave amphipod was first noted in Pautler Cave by Peck & Lewis (1978). Previous censuses of the stream community in Pautler Cave were conducted on 26 May 2001 and 26 September 2001. Two transects were surveyed during the previous surveys, one in the vicinity of the end of the entrance crawlway with the main passage and the other in the same area as the present transect at the large breakdown. The first (crawlway) transect produced 4 and 6 Gammarus acherondytes, respectively, in each of the two 10 quadrat surveys. The present transect produced 13 Gammarus acherondytes on each of the two surveys in 2001 and 18 in 2003. The increase probably reflects the slight change in the length of the transect, which in 2003 encompassed an additional gravel riffle not included in previous samples. Only 2 Gammarus acherondytes were found in the same census area in July 2007 and none in November 2007. This represents a catastrophic decline.

Map 9. Pautler Cave, Monroe County, Illinois.



Map 10. Pautler Cave stream transect.



FOGELPOLE CAVE GROUNDWATER BASIN

Fogelpole Cave

Location: The main entrance to Fogelpole Cave is approximately 9 1/2 miles south of Waterloo and is marked as Fogelpole Cave on the Renault Quadrangle map. This entrance is a dedicated Illinois Nature Preserve. The Northwest Entrance to Fogelpole Cave is about one mile to the northwest of the main entrance, about 9 miles south of Waterloo.

Description: Fogelpole Cave is the longest cave in Illinois with approximately 16 miles of passages (map 11). Much of the habitat in the part of the cave accessible from the nature preserve entrance is not optimal, consisting of bedrock or flowstone (Lewis 2000, 2001, 2003). The habitat accessible near the Northwest Entrance consists of gravel riffles and deep, mud-bottomed pools. The Northwest Entrance is a vertical pit of about 30 feet in depth and requires vertical gear for entry.

Transect: A 100 foot transect was established that spans the entrance room of the Northwest Entrance area (map 12). The downstream end of the transect is a ceiling ledge at the downstream end of a riffle. The upstream is a breakdown block that bridges the stream creating an underlying crawlway. The measured area of the transect is 870 square feet.

Community: The census done 30 August 2003 (appendix table 12) contained 83 of the stygophilic isopod Caecidotea brevicauda, with 1 each of Gammarus acherondytes, Gammarus troglophilus, and Crangonyx forbesi. Also present in the transect were epigean flatworms Dugesia sp., leeches, clams, frogs Rana palustris, sunfish Lepomis and minnows Notropis. Discussion with the owner revealed that after a torrential rain his pond over-flowed and the water ran into an adjacent sinkhole, with large numbers of fish visibly entering the groundwater system. This presumably accounts for the significant influx of pond organisms in the Fogelpole Cave stream seen in the 2003 census.

The cave was visited on 8 October 2007 by J. Lewis and D. Tecic and the standard transect was censused. Similar to the 2003 census, the predominant animal was the isopod Caecidotea brevicauda with 26, but the Gammarus acherondytes found in the transect increased to 11. Five Gammarus troglophilus were present. No pond organisms were noted and the cave community appeared to have rebounded from the incident four years prior.

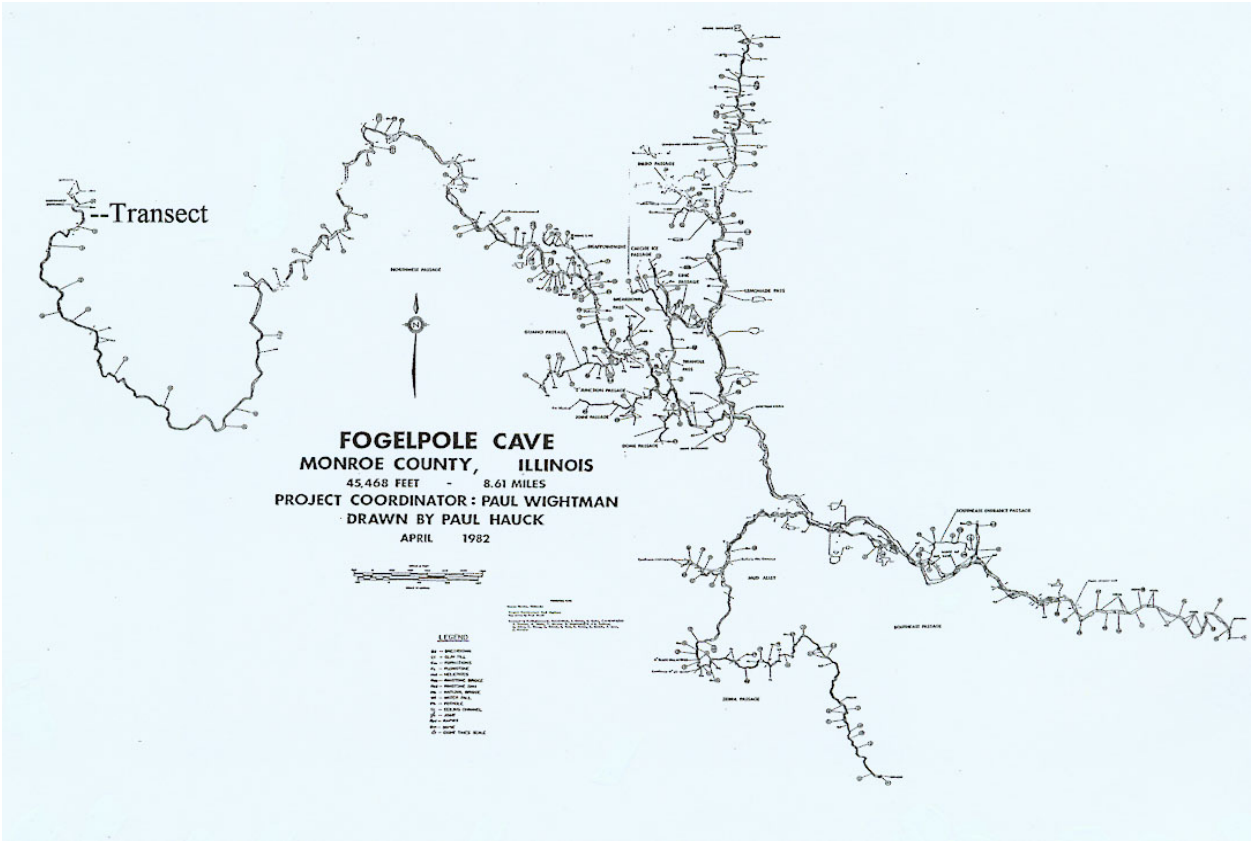
Gammarus acherondytes status: Previous surveys in Fogelpole Cave are available from 2000, 2001 and 2003.

On 2 July 2000 three transects of 10 quadrats each were surveyed. The Triangle Passage transect was primarily flowstone substrate and 1 Gammarus acherondytes was found. Transect two was the large riffle at the intersection of the main entrance passage and the main stream passage. This transect is a mixture of flowstone, gravel and larger chunks of rock, in which 3 Gammarus acherondytes were found. The third transect was near the intersection of the Zebra Passage and was a mixture of flowstone and gravels. Again, 3 Gammarus acherondytes were found.

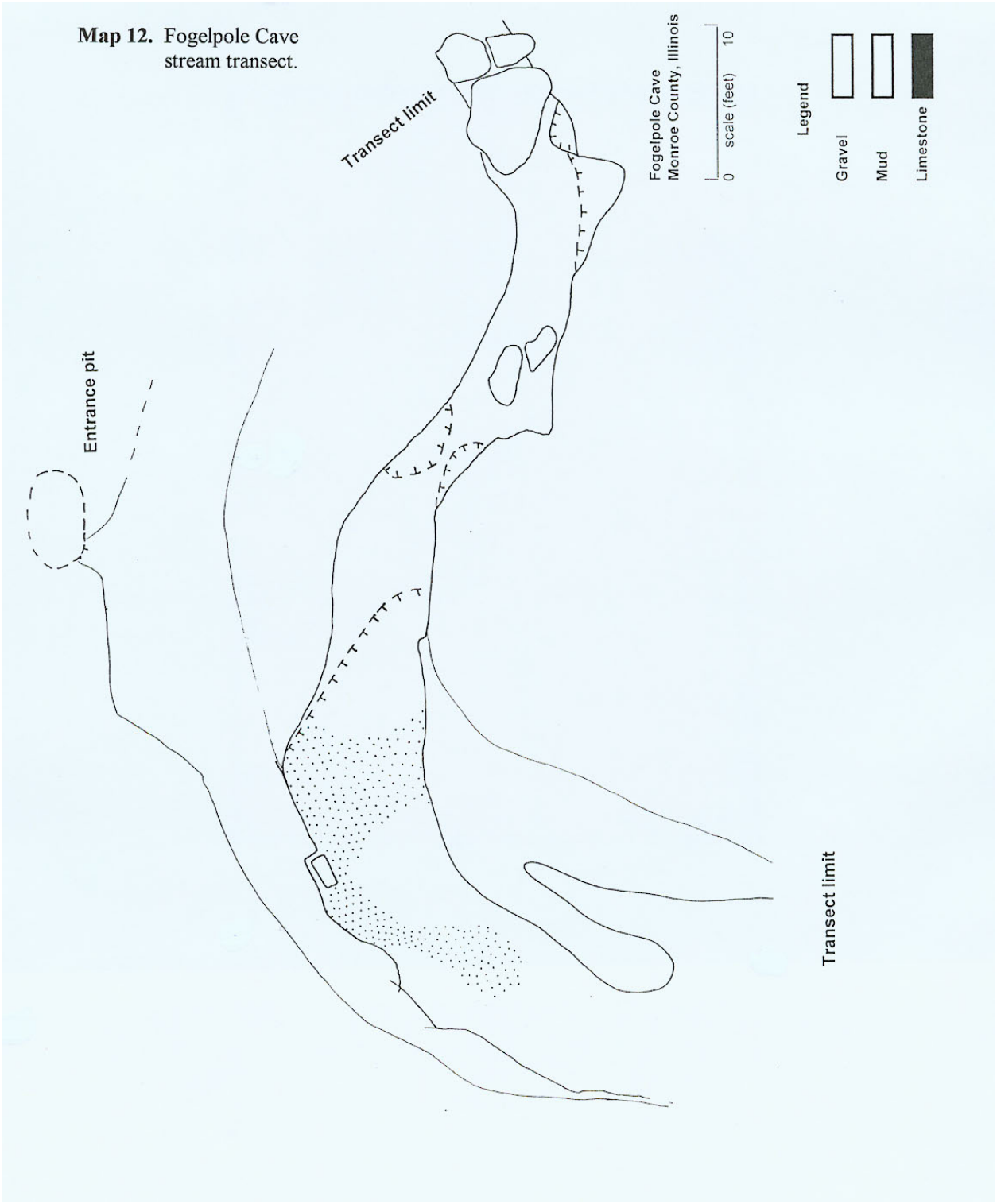
On 5 July 2001 the transects at the main entrance passage intersection and near the Zebra Passage were again surveyed. No Gammarus acherondytes were found, but large numbers of the isopod Caecidotea brevicauda were present. The isopods are favored by the bare flowstone substrate, which they cling to in the brunt of the stream flow.

On 28 September 2001 a transect was placed at the first riffle upstream of the Northwest Entrance. This transect of 10 quadrats produced 17 Gammarus acherondytes. That transect was at the confluence of two passages, each bringing in water. In 2003 the transect was moved to the next riffle downstream to avoid the effects of censusing in an area receiving flow from two different sources. Only 1 Gammarus acherondytes was found in 2003. This decline occurred with an abrupt increase in the number of exotic species in the cave, some of which were amphipod predators.

The census of 8 October 2007 revealed 11 Gammarus acherondytes, an encouraging rebound in numbers from the 2003 census. Most of the amphipods were small, with only two being 10mm or greater. This may reflect repopulation of the area by juveniles.



Map 11. Fogelpole Cave showing the major passages.


Map 12. Fogelpole Cave stream transect.
Transect limit
Entrance pit
Fogelpole Cave
Monroe County, Illinois
0 scale (feet) 10
Legend
Gravel
Mud
Limestone
Transect limit

KRUEGER/DRY RUN GROUNDWATER BASIN

Spider Cave

Location: Spider Cave is found approximately 6 1/4 miles south of Waterloo.

Description: The cave is entered via an 11 foot deep pit. Entry requires vertical gear or a ladder. At the base of the pit is a wide, standing height stream passage, although the ceiling lowers in both directions from the entrance room.

Transect: The downstream end of the 100 foot transect was established starting at a large slab of breakdown that forms a natural bridge across the passage, and extends back to the entrance pit. The habitat consists of a mixture of gravel/cobble riffles and pools with a few areas of bedrock or bare breakdown (map 13).

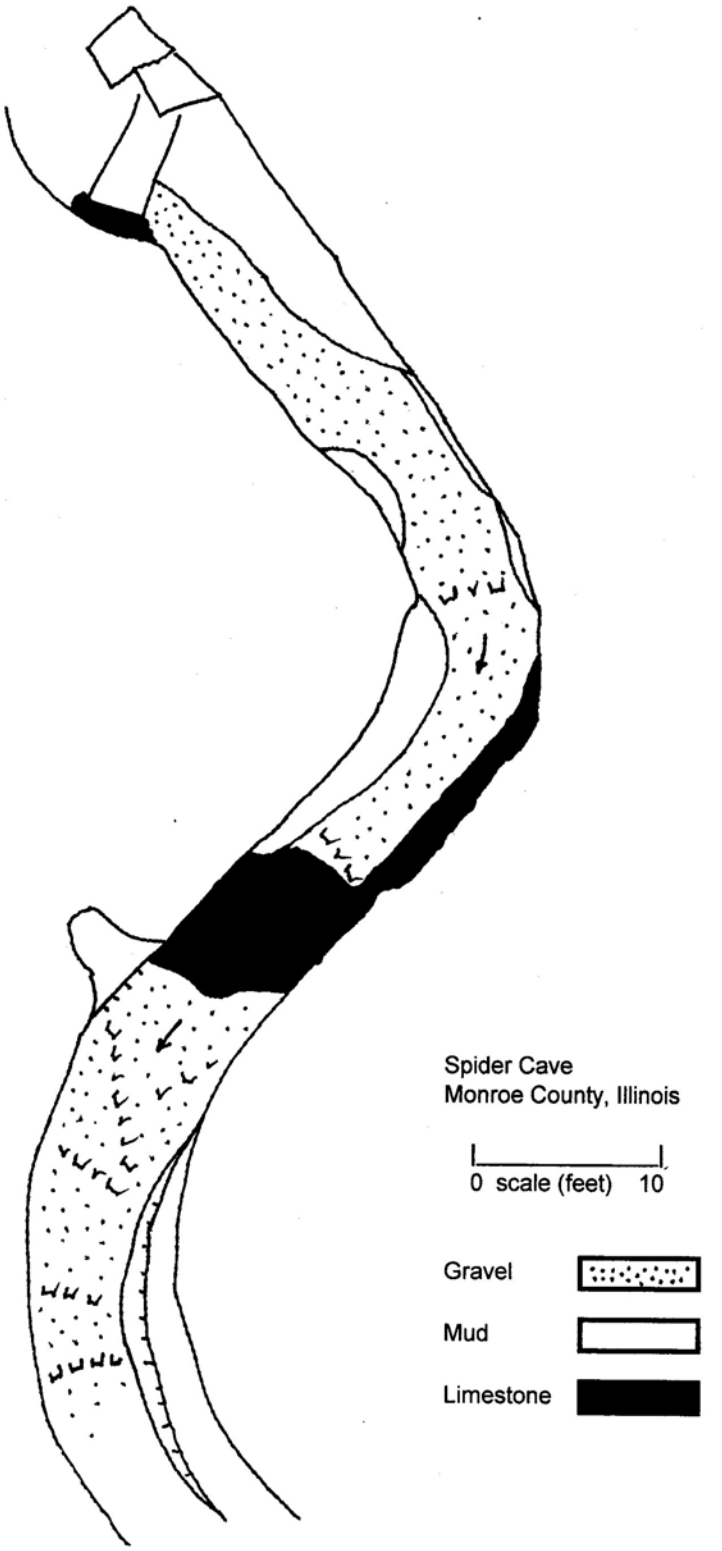
Community: At the time of the discovery of Gammarus acherondytes in Spider Cave the amphipod was common and readily collected. Subsequently a pollution episode, the cause of which was never determined, occurred (Lewis 2000) and the stream substrate was covered with a microbial mat inhabited only by the isopod Caecidotea brevicauda. In a census performed on 11 June 2003 the stygophilic isopod Caecidotea brevicauda was the numerically dominant species with 18 in the sample, followed by the stygophilic amphipod Gammarus troglophilus with 6. Of the 19 animals found in the quadrats, 100% were non-stygobites. As noted below, conditions were poor and results were equivocal.

The transect was again censused on 7 October 2007 (appendix table 13). At that time were found 11 Gammarus troglophilus, 12 Gammarus acherondytes, and 12 Caecidotea brevicauda. Of the 35 animals found, 34% were stygobitic (all G. acherondytes).

Gammarus acherondytes status: None were found in the 2003 survey, but conditions were poor for the census - several inches of rain fell while we were in the cave. The large amount of water coming in the entrance required a five hour delay in exiting the cave by the survey party.

Venarsky (email 23 September 2003) reported that he and Dr. Frank Wilhelm entered Spider Cave on 9 September 2003 and sampled 28 Gammarus acherondytes from the entrance room of the cave, 9 of which were ovigerous females.

The presence of 12 Gammarus acherondytes in the 2007 survey substantiates the repopulation of Spider Cave following the pollution episode.



Map 13. Spider Cave transect.

RESULTS

Trends in Illinois Cave Amphipod Populations

The 2003 and 2007 census results for Gammarus acherondytes (indicated as total number found per transect) are summarized and compared in table 14, along with an interpretation on the status of the population at each site. In table 15 the populations are rank-ordered by the magnitude of the amphipod's population. At Frog, Snow White and Pump House caves the census numbers changed so little as to suggest that the populations are stable. In addition the physical habitats and surface environments appeared to have remained the same.

Three sites showed increases in population: Reverse Stream, Spider, Fogelpole caves and Illinois Caverns. The largest increase occurred in Reverse Stream Cave, for which no obvious cause is discernible. On the other hand, at Spider Cave, the reason is obvious. When the cave was visited on 1 July 2000, the stench was overpowering and a microbial mat covered the stream substrate. The cause of the degradation event was never learned, but it is evident that the community has been recovering.

In the 2003 census at Fogelpole Cave the stream community contained a variety of pond species, including fish, with a precipitous drop in the numbers of Gammarus acherondytes. The owner's farm pond had overflowed into the cave after a large rain. The problem was an acute event and by this year the population had rebounded.

At Illinois Caverns the population has increased in the upstream part of the cave, for which there is a plausible explanation. For many years the area around the main entrance to Illinois Caverns was in agricultural crop production. In 1985 the property was purchased and during the last decade was restored to native prairie plants. Between 2000 – 2003 the Gammarus acherondytes censuses yielded between 0.1 – 0.4 amphipods/ft^2, trending slightly upward. Then the population increased from 0.4 in 2003 to 1.0 in 2007. It appears that the endangered species is responding to the improvement in the surface land management.

Some data exists for other parts of Illinois Caverns. Indications are that the G. acherondytes population has increased beyond the T-junction, also. This year the amphipod was present in the area near the junction with the Cascade Canyon Passage at a level of 0.6amphipods/ft^2. We have been unable to find the Illinois Cave Amphipod downstream of the Rimstone River Passage area and this trend continued this year.

A significant decrease was seen at Pautler Cave this year. In previous years data demonstrated that this cave was one of the most important of the Gammarus acherondytes sites. In 2007 the amphipod has all but vanished. The cause of this decline is unknown, but it was our observation that the riffle gravels had thin layers of mud on the individual stones, and the interstices between them were also filled with sediment.

It should be pointed out that invertebrate populations are variable and may change seasonally or in response to factors that are not necessary bad, nor unnatural. The census data that the above observations are based upon is thin at best. That said, it is all that we have.

Table 14. Trend analysis of Gammarus acherondytes sites censused in 2003 and 2007.

	2007	2003	Interpretation
Frog Spring Groundwater Basin			
Frog Cave	24	20	stable population
Dual Spring Groundwater Basin			
Snow White Cave	1	1	stable population
Luhr Spring Groundwater Basin			
Pump House Cave (Rick's Pit)	6	7	stable population
Illinois Caverns Groundwater Basin			
Illinois Caverns transect 1	10	4	increase in population after purchase of property and change of land management from agriculture to restoration of prairie
Illinois Caverns transect 2	6	n/m*	
Illinois Caverns transect 3	0	n/m	
Pautler Cave Groundwater Basin			
Pautler Cave, July	2	18	decrease in population possibly due to siltation of habitat
Pautler Cave, November	0		
Fogelpole Cave Groundwater Basin			
Fogelpole Cave, Northwest Entrance area	11	1	increase in population due to rebound after release of fish pond into cave after flood event in 2003
Annbriar Spring Groundwater Basin			
Reverse Stream Cave	70	23	increase in population, no changes discernible
Triple Delight Cave	17	n/m	
Wednesday Cave	9	n/m	
Krueger/Dry Run Groundwater Basin			
Spider Cave	12	0	increase in population due to rebound after pollution event in 2000

* n/m denotes no measurement of population that year

Table 15. Gammarus acherondytes localities rank-ordered (from most to least) by the number Illinois Cave Amphipods present per square foot as measured in sampled quadrats.

	ICA quadrat ft^2			
	2007	**2003**	**2001**	**2000**
Reverse Stream Cave	7.0	2.3	n/m*	n/m
Frog Cave	2.4	2.0	1.35 / 2.65	n/m
Triple Delight Cave	1.7	n/m	n/m	n/m
Spider Cave	1.2	0.0 [1]	0.0 [2]	0.0 [2]
Fogelpole Cave, Northwest Entrance area	1.1	0.1	1.7 [3]	n/m
Illinois Caverns transect 1	1.0	0.4	0.3 / 0.4	0.2 / 0.1
Wednesday Cave	0.9	n/m	n/m	n/m
Pump House Cave (Rick's Pit)	0.6	0.7	n/m	n/m
Illinois Caverns transect 2	0.6	n/m	n/m	0.0
Pautler Cave	0.2 / 0.0	1.8	1.3 / 1.3	n/m
Snow White Cave	0.1	0.2	n/m	n/m
Illinois Caverns transect 3	0.0	n/m	n/m	0.0 [4]

*denotes not measured during that year

[1] equivocal census due to flooding

[2] same area, roughly equivalent transects

[3] transect upstream from present one

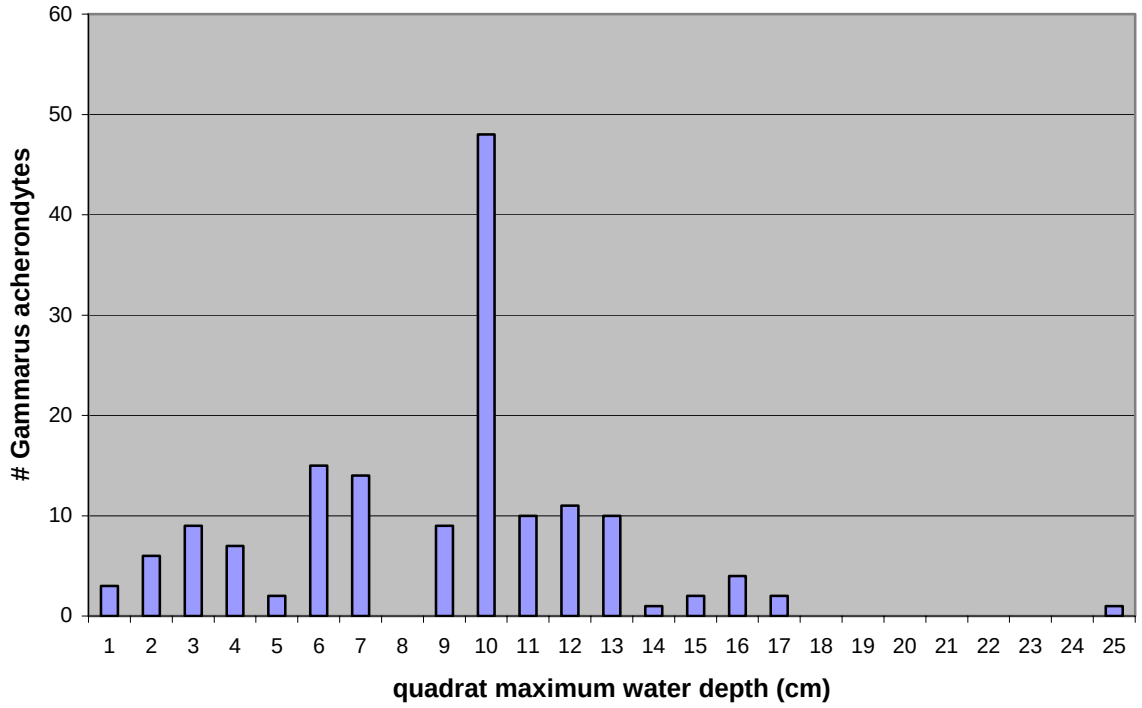
[4] transect placed just upstream of Roaring River Passage

Habitat Analysis

During censusing the minimum/maximum the habitat type (riffle or pool), water depth and substrate of each quadrat was recorded. The data for each occurrence of the 154 Gammarus acherondytes amphipods found this year was entered into an Access database and analyzed as a function of each parameter.

Habitat type—Of 154 amphipods, 117 (76%) were found in riffles, 37 were in pools.

Water depth—The frequency histogram below shows that all but one G. acherondytes was found in water between 1-17 cm in deep (i.e., up to about 7 inches). The single outlier occurred in water 25 cm deep (about 10 inches). The mean maximum depth of the quadrats in which the amphipods occurred was 8.9cm, with a standard deviation of 3.8.



Substrate—The amphipod was found on every substrate type encountered, including mud, silt, sand and limestone bedrock. Of the 154 amphipods, 137 occurred on substrates that were at least 80% covered by gravel or cobbles, and 109 of these were in habitat characterized as being 100% gravel or cobble. Sixteen amphipods were found in habitats having 20% or less gravel coverage, of which 7 of the quadrats were devoid of gravel. The average gravel coverage of quadrats inhabited by Gammarus acherondytes was 83%.

Community Composition

Table 16 summarizes the majority of the animals encountered in the transects censused in 2007. Omitted from the table were one crayfish and a few incidental organisms that were probably accidentals. A total of 657 invertebrates are accounted for in the table, which break down as follows:

Species	Common name	total	% of community
Caecidotea brevicauda	short-tailed isopod	266	41%
Gammarus troglophilus	troglophilic amphipod	171	26%
Gammarus acherondytes	Illinois cave amphipod	168	26%
Caecidotea packardi	Packard's cave isopod	16	2%
Physella sp.	aquatic snail	15	2%
Sphalloplana hubrichti	Hubricht's cave flatworm	14	2%
Crangonyx forbesi	Forbe's amphipod	4	<1%
Bactrurus brachycaudus	groundwater amphipod	3	<1%

The most predominant community constituents, Caecidotea brevicauda and Gammarus troglophilus, are stygophiles. Together these two species comprised two thirds of the animals encountered. In other parts of the eastern U.S. cave stream communities are usually comprised mostly, or entirely, of stygobites. In the western Illinois cave streams censused in 2007 the community composition ranged from 0-57% stygobites.

The question usually asked is "What's normal?". It is probably safe to say that a "normal" stygobite community composition would be more than 0% and less than 100%. After the pollution event in Spider Cave the community was over-run with Caecidotea brevicauda and stygobite composition was zero in the censuses of 1 July and 4 September 2000. The same situation was noted in Tom Moore Cave, Perry County, Missouri, in an area below a septic field outfall emptying into the cave stream.

The presence of Caecidotea brevicauda does not necessarily imply nutrient enrichment. This isopod is adept at clinging to bedrock or flowstone substrates where other animals can not hang on in swiftly flowing water. The relatively large numbers of isopods present in Reverse Stream, Snow White and Pump House caves, as well as the part of Fogelpole Cave accessed through the nature preserve entrance, reflect the presence of unsheltered micro-habitats.

A few observations on other species were noteworthy. The flatworm Sphalloplana hubrichti occurs throughout the project area and is seen sporadically, usually individuals clinging to the underside of a rock. At Pump House Cave the flatworms are common – 8 of the 14 found in quadrats in 2007 were seen at this one cave - and many more were seen outside of the quadrats. Tree root mats are abundant in the stream and some of the worms were noted to come out of them. One flatworm was found during the Wednesday Cave survey and it, too, crawled out of a root mat.

The amphipods Crangonyx forbesi and Bactrurus brachycaudus were rarely seen. Crangonyx forbesi occurs in a broad band from Oklahoma to Pennsylvania, primarily in springs and caves, as well as surface streams and ponds (Zhang and Holsinger, 2003). The only place this species has been seen in appreciable numbers in any of the caves within the range of Gammarus acherondytes was in the nutrient-enriched environment of Stemler Cave (Lewis, 2000). On the other hand, Bactrurus brachycaudus is an obligate subterranean species that is usually found in cave streams under slabs of rock or down in the interstices of gravel bars. It is equally at home in non-cave groundwater habitats.

Table 16. Summary of community composition in caves censused.

	Gammarus troglophilus	Gammarus acherondytes	Crangonyx forbesi	Bactrurus brachycaudus	Caecidotea packardi	Caecidotea brevicauda	Physella	Sphalloplana hubrichti	**Transect Total**
Frog Spring Groundwater Basin									
Frog Cave	5	24	0	1	1	40	0	0	71
Dual Spring Groundwater Basin									
Snow White Cave	4	1	0	0	1	52	2	1	61
Luhr Spring Groundwater Basin									
Pump House Cave (Rick's Pit)	8	6	1	0	5	13	1	8	42
Illinois Caverns Groundwater Basin									
Illinois Caverns transect 1	6	10	0	0	1	3	0	1	21
Illinois Caverns transect 2	13	6	0	0	0	5	6	1	31
Illinois Caverns transect 3	5	0	0	0	0	7	2	0	14
Pautler Cave Groundwater Basin									
Pautler Cave, July	6	2	0	1	3	15	1	0	28
Pautler Cave, November	3	0	0	0	2	4	0	0	9
Fogelpole Cave Groundwater Basin									
Fogelpole Cave, Northwest Entrance area	5	11	0	0	0	26	0	0	42
Annbriar Spring Groundwater Basin									
Reverse Stream Cave	68	70	0	0	2	72	2	0	214
Triple Delight Cave	27	17	3	0	0	6	0	2	55
Wednesday Cave	10	9	0	1	1	11	1	1	34
Krueger/Dry Run Groundwater Basin									
Spider Cave	11	12	0	0	0	12	0	0	35

Recommendations

The Illinois cave amphipod Recovery Plan (USFWS 2002) Recovery Task 3.3.1 states that the population status of the Illinois cave amphipod is to be quantitatively monitored on an annual basis.

Recommendation: Annual quantitative monitoring - census all sites in 2008.

(a) Pautler Cave census should be a priority, to ascertain if the population decline continues. A census transect should be established between the new entrance and Pautler Falls as well as the main stream passage. If the decline continues the cause needs to be established and rectified.

(b) If possible enter Rose Hole (a tributary to the historic section of Pautler Cave) and establish the status of the amphipod.

(c) Establish transects in Illinois Caverns side passages, specifically Cascade Canyon and Rimstone River passages, as well as re-census of the three established transects.

(d) Re-check Stemler Cave for the presence of the Illinois Cave Amphipod. The species has demonstrated resilience to acute habitat degradation and an ability to recolonize from other passages.

Acknowledgments

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Other field assistance was provided by Marty Kemper, District Natural Heritage Biologist (IDNR) and Don Coons, President of the Karst Conservancy of Illinois.

Our children, Alexandra and Geoffrey, accompanied us on two trips and assisted in the censusing. We thank them for their assistance, as well as their patience with their parents' periodic disappearance underground.

Lewis family Thanksgiving dinner, T-junction, Illinois Caverns, 22 November 2007.

Geoffrey Lewis enjoying Thanksgiving afternoon census note taking, transect 3, Illinois Caverns, 22 November 2007.

Salisa Lewis, measuring water depth, quadrat 7, transect 3, Illinois Caverns, 22 November 2007.

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APPENDIX: CENSUS DATA TABLES