U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Pseudanophthalmus troglodytes Krekeler

Common Name:

Louisville cave beetle

Lead region:

Region 4 (Southeast Region)

Information current as of:

07/01/2016

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Endangered Species Act (Act) and, therefore, was not elevated to the Candidate status.

___ New Candidate

___ Continuing Candidate

_X_ Candidate Removal

> _X_ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
> ___ Range is no longer a U.S. territory
> ___ Insufficient information exists on biological vulnerability and threats to support listing
> ___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"
___ Taxon believed to be extinct
___ Conservation efforts have removed or reduced threats
___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

____ Non-Petitioned

_X__ Petitioned - Date petition received: 05/11/2004

90-Day Positive: 05/11/2005

12 Month Positive: 05/11/2005

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted (if yes, see summary threats below) **No**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, formerly precluded the proposed and final listing rules for this species. We continue to monitor populations and will change its status if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories:** Kentucky
- **US Counties:** Jefferson, Kentucky
- **Countries:** United States

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories:** Kentucky
- **US Counties:** Jefferson, Kentucky
- **Countries:** United States

Land Ownership:

The species is known from four privately-owned caves in Jefferson County, Kentucky.

Lead Region Contact:

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Lead Field Office Contact:

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Biological Information

Species Description:

Cave beetles in the genus *Pseudanophthalmus* are small, eyeless, reddish-brown insects. Like most insects, they have six legs and a body that consists of a head, thorax (second, third, and fourth distinguishable body segments, all of which support one pair of legs), and abdomen. Body length ranges from 3.0 to 8.0 millimeters (mm) (0.12 to 0.32 inches (in)). Species within the genus *Pseudanophthalmus*, which includes approximately 255 described species (Barr 1996, p. 3), are differentiated by differences in the shape and size of the various body parts, especially the shape of the male appendages (genitalia) used during reproduction and the arrangement of setae (hairs) on the body. The Louisville cave beetle, *P. troglodytes*, is about 4.5 mm (0.18 in) long and can be distinguished from other *Pseudanophthalmus* species by the shape of the first pair of legs and the shape of the aedeagus

(male copulatory organ) (Krekeler 1973, pp. 65-67).

Taxonomy:

Pseudanophthalmus troglodytes was described by Krekeler (1973, pp. 65-67) based upon 23 specimens collected in 1964 from Highbaugh Cave, Louisville, Kentucky. The species belongs to the family Carabidae (ground beetles), subfamily Trechinae, and is one of two species within the *P. barri* species group in Clark County, Indiana, and Jefferson County, Kentucky (Barr 2004, pp. 22-23).

Habitat/Life History:

Most members of the genus *Pseudanophthalmus* are cave dependent (troglobites) and are not found outside the cave environment. All are predatory and feed upon small cave invertebrates such as spiders, mites, millipedes, oligochaete worms, and diplurans; the larger *Pseudanophthalmus* species also feed on cave cricket eggs (Barr 1996, p. 6). Members of this genus vary in abundance from fairly common, widespread species to uncommon, rare species that are often found in very low numbers and are restricted to only one or two caves. The Louisville cave beetle generally falls within the latter category as it is restricted to four caves in a small portion of Jefferson County, Kentucky.

Little detailed life history information is available for the genus *Pseudanophthalmus*, but the generalized summary that follows is accurate for the more common and more easily studied species and is believed to also apply to the rarer species (Barr 1998, p. 3).

Cave beetles copulate in the fall, and the eggs are deposited in cave soil during late fall.

The eggs hatch and larvae appear in late fall through early winter. Pupation occurs in late winter to early summer with the adult beetles emerging in early summer (Barr 1996, p. 5).

The limestone caves in which the genus *Pseudanophthalmus* are found provide a unique and fragile environment that supports a variety of species evolved to survive and reproduce under the demanding conditions found in cave ecosystems. No photosynthesis takes place within the dark zone of a cave. Therefore, all organisms that are adapted to life within a cave are dependent upon energy from the surface to form the basis of the cave food chain. This energy can be in the form of leaf litter, woody debris, small bits of organic matter that are washed or fall into the cave, or guano deposited by cave-dependent bats that feed on the surface and return to the cave to roost (Barr 1996, pp. 6-7).

Pseudanophthalmus beetles tend to be found in moist, humid habitats, and cold, dry influxes of winter air into caves appear to be detrimental to these species, making any collection of the species difficult during the winter months (Lewis and Lewis 2015, p. 2). Although caves of only a few hundred feet in length can support these beetles, larger caves often have structural complexity that supports moist, humid conditions. *Pseudanophthalmus* cave beetles have been found on moist silt banks along streams that run through many of these caves, among gravel, under small boulders, on decomposing wood, and among areas with organic debris (Barr 2001, p. 3).

Historical Range/Distribution:

The Louisville cave beetle's historical distribution consisted of two localities - Highbaugh Cave and Eleven Jones Cave, both in Jefferson County, Kentucky. The species was discovered

in Highbaugh Cave by N. Whitehead in October 1964, when he collected the type series of 23 specimens (Krekeler 1973, pp. 65-66). According to Barr (1996, pp. 41-42), Highbaugh Cave was located approximately 2.1 kilometers (km) (1.3 miles (mi)) east-northeast of the I-64/I-264 interchange at the intersection of Bedfordshire Way and Cheshire Way (Figure 1). Sometime around 1990, the entrance to Highbaugh Cave was permanently closed during development of Oxmoor subdivision in east Louisville (Barr 1996, p. 41). The cave's former entrance is reported to lie beneath 8102 Cheshire Way (Barr 1996, p. 42), a private residence, but the actual location of the entrance is unknown (Lewis and Lewis 2015, p. 3).

In fall 1994, Dr. Julian J. Lewis visited several potential *P. troglodytes* caves in Jefferson County as part of a Service-funded cave beetle status survey and prelisting study (Barr 1996, pp. 42-44). He observed the species at one locality, Eleven Jones Cave, in October 1994, observing two individuals about 6 meters (20 feet) from the entrance (Barr 1996, p. 42; Lewis and Lewis 2015, p. 3). The entrance to Eleven Jones Cave is situated along a wooded slope on the south side of South Fork Beargrass Creek immediately adjacent to Louisville Cemetery (Lewis and Lewis 2015, p. 3). The cave has been reported to have, at times, dangerously high carbon dioxide levels (Barr 1996, p. 42). Other caves searched by Lewis included Sheffield Cave, Holly Spring Cave, an unnamed cave at E. P. "Tom" Sawyer State Park, Goose Creek Cave, an unnamed cave on Goose Creek, unnamed caves at Kentucky State Children's Home, Ballentine Cave, Seneca Gardens Cave, and Big Rock Cave. Three caves, Sheffield Cave, Ballentine Cave, and Seneca Gardens Cave, were not searched due to obstructions (blocked entrance) or a lack of access (no permission granted). Suitable habitat was sparse at all remaining sites, and no *Pseudanophthalmus* were observed.

Current Range/Distribution:

Currently, the species is known from four Jefferson County caves – one previously known location, Eleven Jones Cave, and three new caves, Sauerkraut Cave, Cave Hill Cave, and Cave Creek Cave (Table 1) (Lewis and Lewis 2015, pp. 3-12). The species may continue to occur in Highbaugh Cave (type locality), but the species' presence there can no longer be verified due to closure of the entrance around 1990 and continued uncertainty regarding the actual location of the former cave entrance.

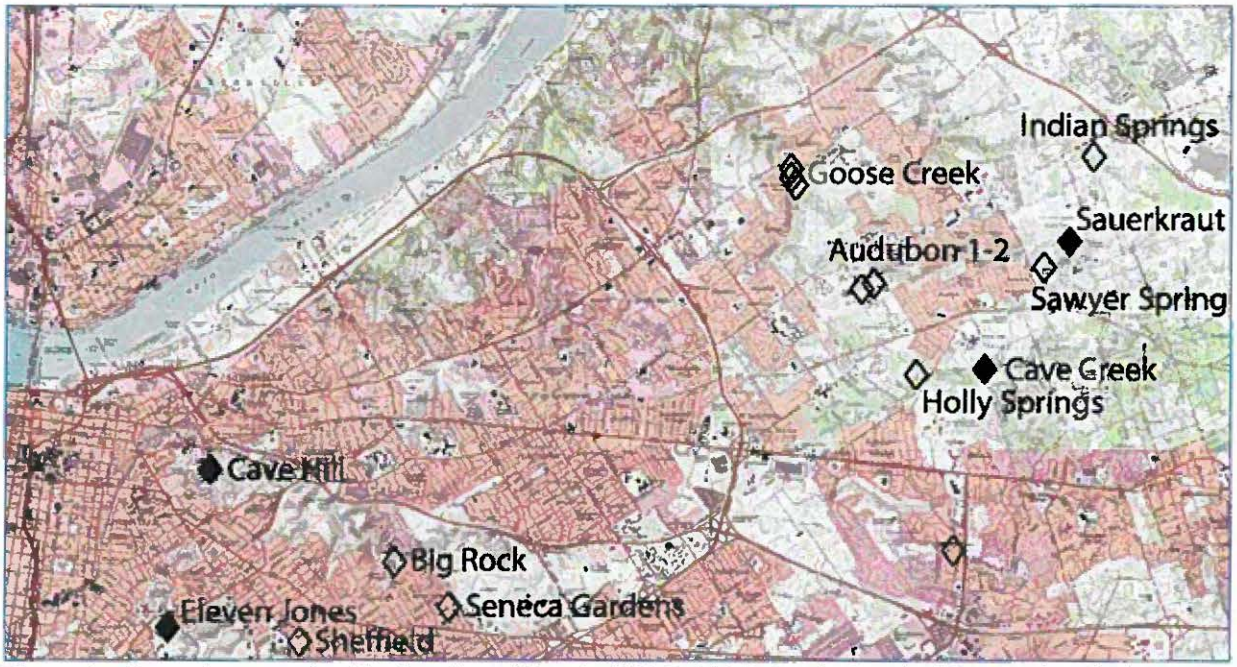


Figure 1. Cave sites searched by Lewis and Lewis (2015, 2016) for the Louisville cave beetle (*P. troglodytes*) in eastern Louisville, Jefferson county, Kentucky (2015- 2016); Species observed (♦), species not observed (◊) (map prepared by Lewis and Associates, LLC).

Table 1. Summary of Louisville cave beetle (*P. troglodytes*) observations.

Cave	# *P. troglodytes* observed	Date	Reference
Highbaugh Cave*	23	October 7, 1964	Krekeler (1973)
Eleven Jones Cave*	2	October 2, 1994	Barr (1996)

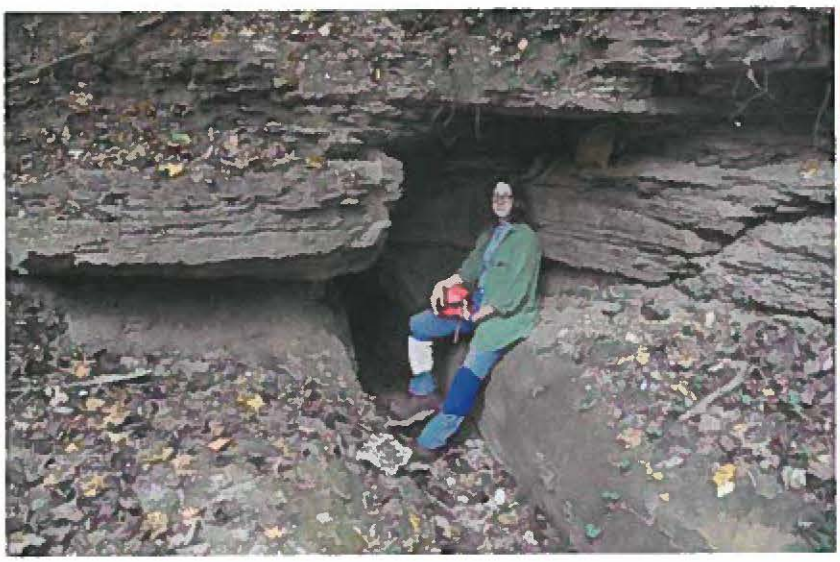
Eleven Jones Cave*	1	September 27, 2015	Lewis and Lewis (2015)
Sauerkraut Cave	3	June 26, 2015	Lewis and Lewis (2015)
Sauerkraut Cave	1	July 3, 2015	Lewis and Lewis (2015)
Cave Hill Cave	1	July 26, 2015	Lewis and Lewis (2015)
Cave Creek Cave	1	October 2, 2015	Lewis and Lewis (2015)

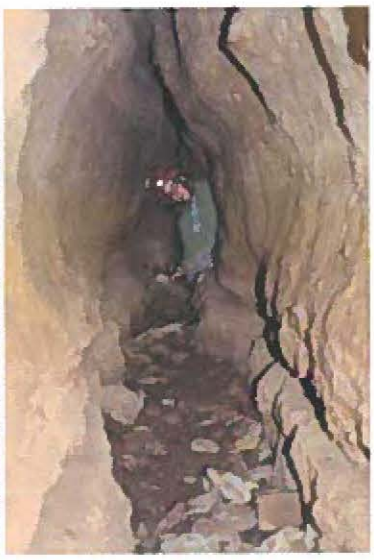
*Historical location

Recent survey efforts for *P. troglodytes* and other Kentucky *Pseudanophthalmus* were completed by Laudermilk (2005, pp. 1-15), Lewis and Lewis (2015, pp. 1-35; 2016, pp. 1-24). Laudermilk (2005, p. 7) conducted surveys for seven *Pseudanophthalmus* species in Kentucky from 2004-2005, but Eleven Jones Cave was not entered or searched due to concerns over air quality in the cave. The Louisville cave beetle's continued presence in Eleven Jones Cave was confirmed in September 2015, when Lewis and Lewis (2015, p. 4) observed one male specimen under a stone on the cave floor in the same approximate location where the species was observed in 1994 (Figures 2-3). This passage was described by Lewis and Lewis (2015, p. 4) as a narrow, hands-and-knees crawlway, with sharp limestone projections extending from the walls. As mentioned previously, the entrance to Eleven Jones Cave is situated above South Fork Beargrass Creek (Figure 4), and much of the cave lies beneath Louisville Cemetery (Figure 5). Barr (1996, p. 42) reported that Eleven Jones Cave sometimes had dangerously high carbon dioxide levels. Due to these concerns, the cave was not searched by Laudermilk (2005, p. 7) during his 2004–2005 study.

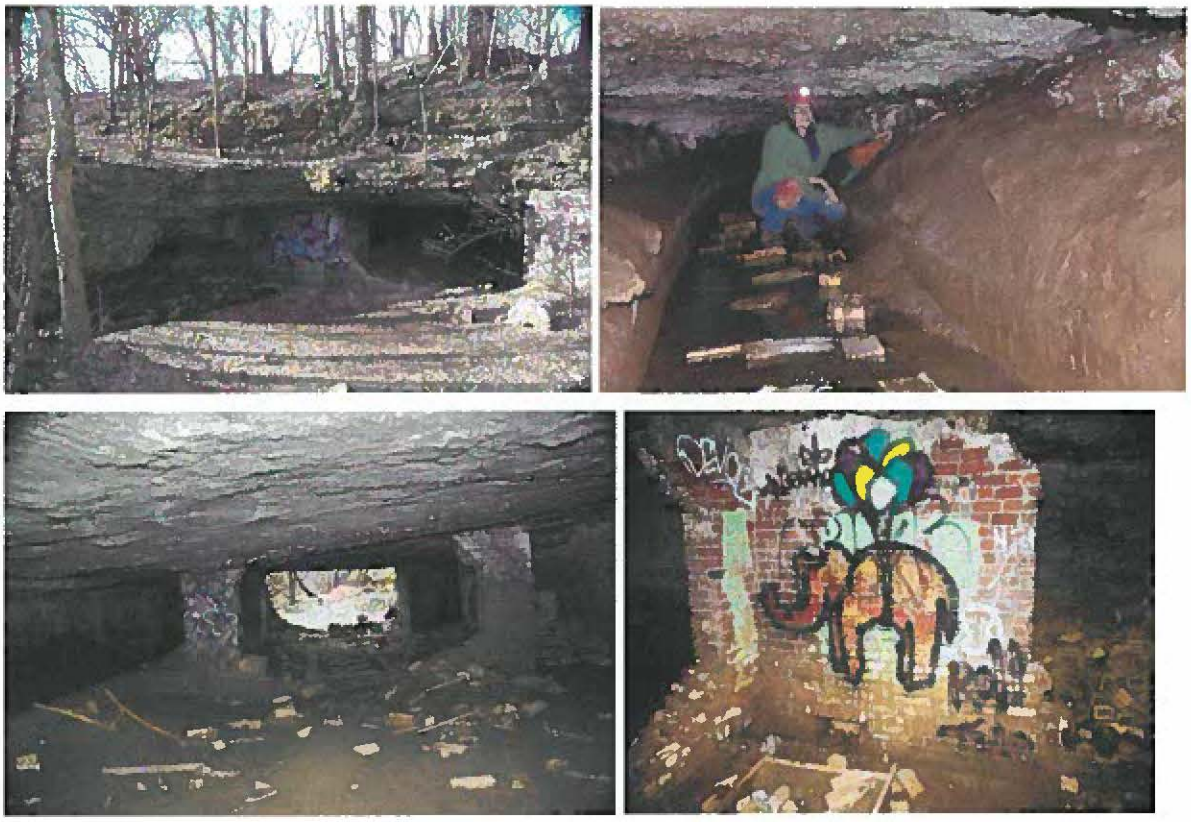
In June 2015, Lewis and Lewis (2015, p. 8) discovered a new population of *P. troglodytes* in Sauerkraut Cave, where they observed three individuals in a rear passage (Figures 6-7). The entrance to Sauerkraut Cave lies on the hillside behind the archery range of E. P. "Tom" Sawyer State Park in Louisville. The spring emanating from the cave flows into Goose

Creek, which then flows into the Ohio River about 9.6 km (6 mi) west-northwest of the cave. The cave entrance is located on the grounds of the former Central State Hospital, where the cave was once reportedly used for food storage (including sauerkraut, hence the cave's name). The cave entrance, passages, and area surrounding the entrance have been subject to severe anthropogenic disturbance, and the area continues to be visited by locals and park visitors. A crumbling brick wall is situated at the entrance, leading to a relatively large entrance room of walking height. The cave stream has been channelized within a brick trough that extends through the entrance room and first section of stream passage. Beyond that point, the cave passage branches into a stream passage and parallel overflow passage, which then later merge and continue as a stream crawlway. Spray-painted graffiti, trash, and debris (bricks) are plentiful within the entrance room and across the cave entrance (Figures 7-8) (Lewis and Lewis 2015, pp. 6-8).





Figures 2-5. Eleven Jones Cave: cave entrance above South Fork Beargrass Creek (top left), cave passage where *P. troglodytes* was observed in September 2015 (top right), South Fork Beargrass Creek (bottom left), and Louisville Cemetery (bottom right) (photographs provided by Lewis and Associates, LLC).



Figures 6-9. Sauerkraut Cave: entrance (top left); rear cave passage near where *P. troglodytes* was observed (top right); and trash, debris, and graffiti observed near entrance (bottom left and right) (photographs provided by Lewis and Associates, LLC).

In July 2015, Lewis and Lewis (2015, pp. 9-11) discovered a single female *P. troglodytes* in Cave Hill Cave, a new locality for the species in historic Cave Hill Cemetery near downtown Louisville (Figures 10-11). According to Lewis and Lewis (2015, pp. 9-10), Cave Hill Cave is about 75 m (246 ft) long, with about 30 m (98 ft) of walking height and the rest consisting of a crawlway. A stream flows through the cave, discharging into a cemetery pond below. The single *P. troglodytes* was discovered about 0.6 m (2 ft) above the cave stream on a moist, bare limestone ledge (Lewis and Lewis 2015, p. 9).

Figures 10-11. Cave Hill Cave, entrance (left) and cave passage where *P. troglodytes* was observed (right) (photographs provided by Lewis and Associates, LLC).

In October 2015, Lewis and Lewis (2015, p. 12) observed one *P. troglodytes* in Cave Creek Cave, another new locality for the species (Figures 12-13). The entrance to Cave Creek Cave is located along a Metropolitan Sewer District (MSD) sewer line right-of-way above Middle Fork Beargrass Creek in the Forest Green subdivision. According to Lewis and Lewis (2015, p. 12), the cave spring entrance is walking height for a short distance, then the passage becomes a tight crawlway along the cave stream. Riparian habitats along the cave stream were described as a mixture of gravel bars, scattered large rocks, mud banks, and bare limestone. The one specimen of *P. troglodytes* was discovered on bare limestone about 30 m (100 ft) from the

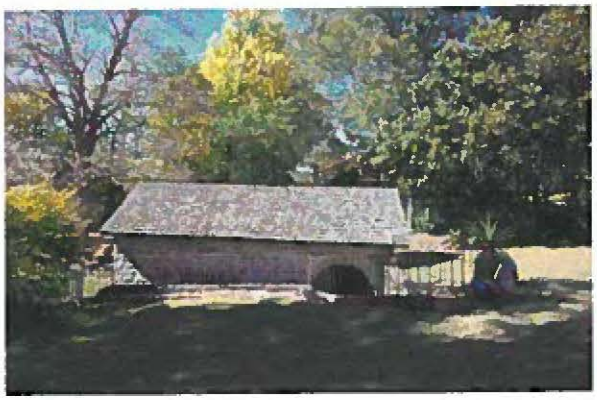
cave entrance at the beginning of the crawlway.

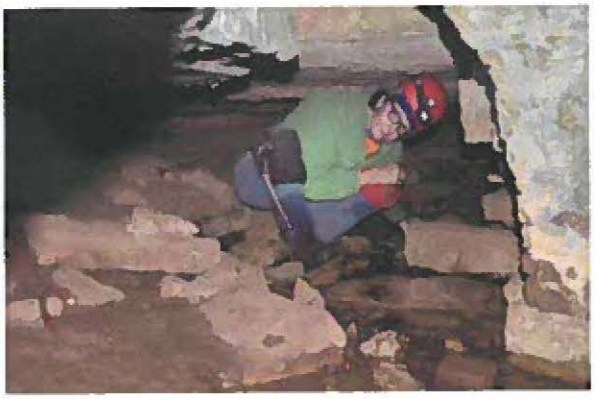
In an attempt to locate additional *P. troglodytes* habitats, Lewis and Lewis (2015, pp. 13-19) visited or surveyed seven other Jefferson County caves in August and October 2015 (Figures 14-24). These sites included Spring Cave (at Highbaugh House), Indian Springs Cave, Seneca Gardens Cave, Goose Creek Cave, an unnamed spring Cave (E. P. "Tom" Sawyer State Park), Big Rock Cave, and Holly Springs Cave. Suitable habitats for *P. troglodytes* were observed within four of these caves, Spring Cave (Highbaugh House), Seneca Gardens Cave, Indian Springs Cave, and Goose Creek Cave, but no *P. troglodytes* individuals were observed. Low relative humidity levels (<90%) could have played in a role in the absence of *P. troglodytes* (Lewis and Lewis 2015, pp. 13-14) – a result of the surveys being completed in the fall. Lewis and Lewis (2015, pp. 13-14) commented that *P. troglodytes* might be found in these caves during summer months when higher humidity conditions prevail.

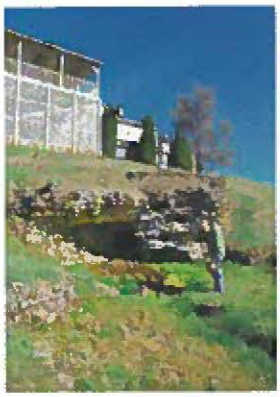
Figures 12-13. Cave Creek Cave, entrance (left) and cave passage where *P. troglodytes* was observed (right) (photographs provided by Lewis and Associates, LLC).

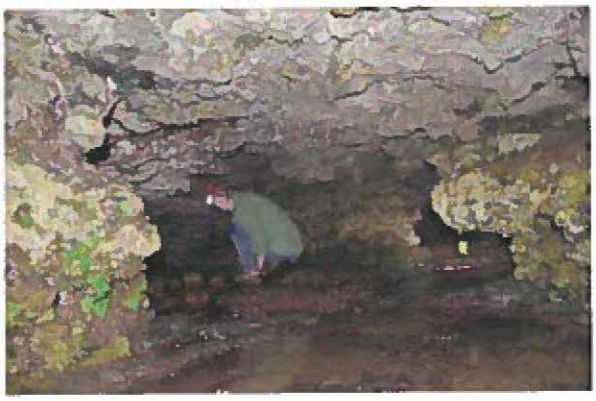
From April–June 2016, Lewis and Lewis (2016, entire) conducted additional surveys for

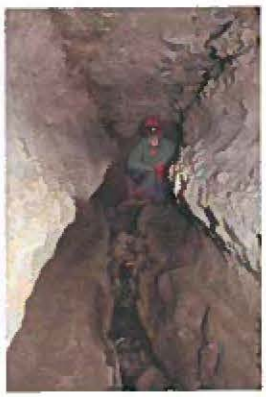
P. troglodytes, including new searches of Sauerkraut Cave, Sheffield Cave, Goose Creek Cave, Goose Creek Annex Cave #1, Goose Creek Annex Cave #2, Goose Creek Annex Cave #3, Holly Springs Cave, an unnamed cave at E. P. "Tom" Sawyer State Park, Indian Springs Cave, and two unnamed caves on property of the Kentucky Children's Home (Figures 25-30). No *P. troglodytes* were observed.



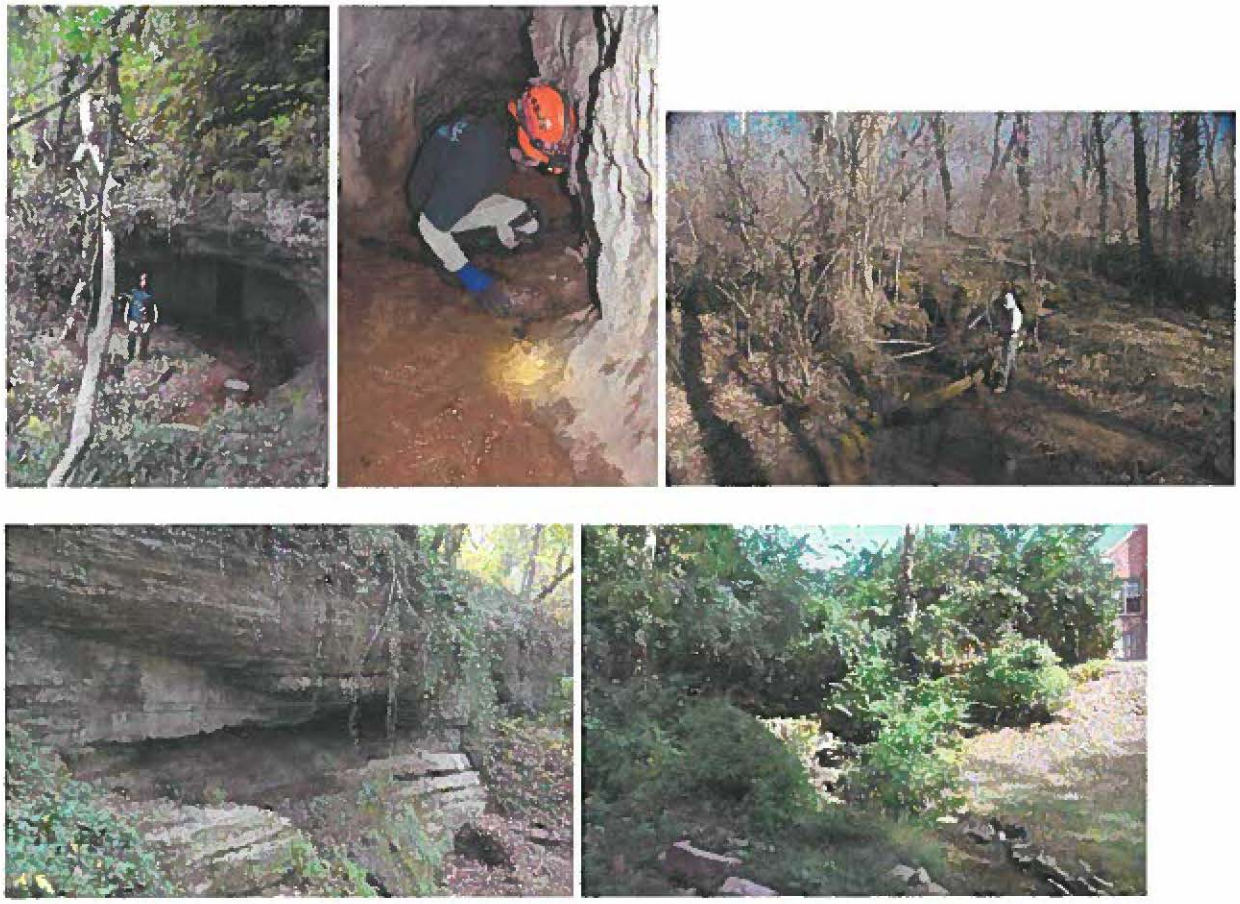




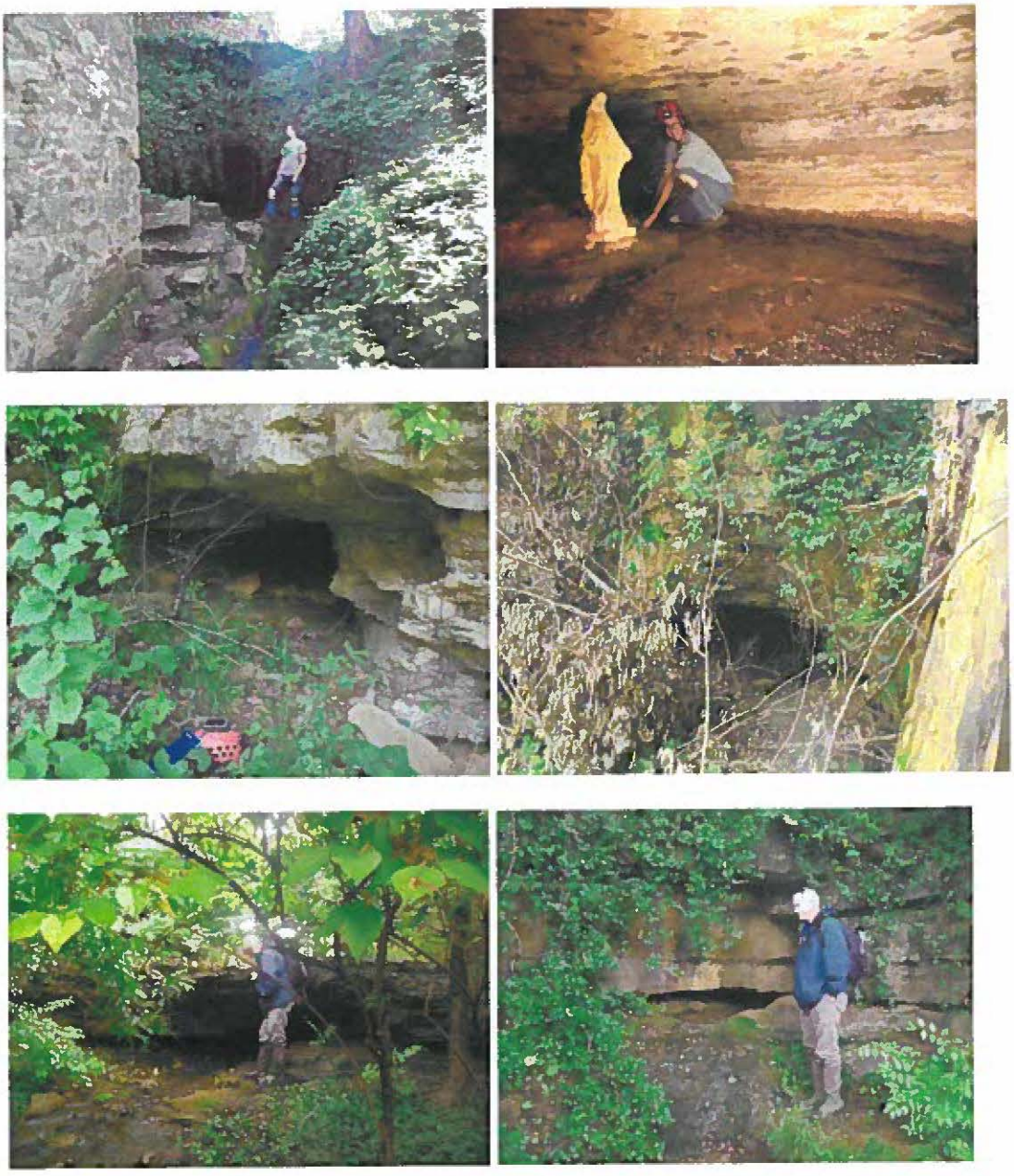




Figures 14-19. Jefferson County caves searched by Lewis and Lewis (2015): Spring cave at Highbaugh House, cave entrance (top left) and cave passage (top right); Indian Springs Cave, entrance (middle left) and cave passage (middle right); Seneca Gardens Cave, cave entrance (bottom left) and cave passage (bottom right) (photographs provided by Lewis and Associates, LLC).



Figures 20-24. Jefferson County caves searched by Lewis and Lewis (2015): Goose Creek Cave, entrance (top left) and cave passage (top middle); spring cave at E. P. Tom Sawyer State Park, entrance (top right); Big Rock Cave, entrance (bottom left); and Holly Springs Cave, entrance (bottom right); (photographs provided by Lewis and Associates, LLC).



Figures 25-30. Selected Jefferson County caves searched by Lewis (2016): Sheffield Cave, entrance (top left) and cave passage (top right); Goose Creek Annex Cave #1 (middle left); Goose Creek Annex Cave #2 (middle right); and unnamed caves and springs at Kentucky Children's Home (bottom, left and right) (photographs provided by Lewis and Associates, LLC).

Population Estimates/Status:

No population estimates for the Louisville cave beetle are available. The entrance to Highbaugh Cave has been closed since the early 1990s, so recent surveys in the cave have not been possible. Population estimates for the four known populations (Eleven Jones Cave, Sauerkraut Cave, Cave Hill Cave, and Cave Creek Cave) have not been possible due to the low number of individuals observed in these habitats (total of nine individuals) and the difficulty in finding specimens during cave surveys. The species appears to occur in low densities in each of these caves; however, this is not unusual for the genus *Pseudanophthalmus* (Service 2015, p. 60850) and may be a reflection of the difficulty in locating such a small animal within these habitats, much of which is difficult to search or is simply inaccessible to surveyors. Despite the lack of population estimates and the species' apparent low densities, it continues to occur in Eleven Jones Cave and was recently discovered in three new caves.

Threats

Section 4 of the Act (16 U.S.C. 1533) and implementing regulations (50 CFR 424) set forth procedures for adding species to, removing species from, or reclassifying species on the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, a species may be determined to be an endangered species or a threatened species based on any of the following five factors:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;

B. Overutilization for commercial, recreational, scientific, or educational purposes;

C. Disease or predation;

D. The inadequacy of existing regulatory mechanisms; or

E. Other natural or manmade factors affecting its continued existence.

When the Louisville cave beetle was first identified as a candidate for protection under the Act in the October 30, 2001, Federal Register (66 FR 54808), we identified two of the five listing factors as threats to the species:

- The present or threatened destruction, modification or curtailment of its habitat or range;
- The inadequacy of existing regulatory mechanisms.

With respect to habitat threats (Factor A), we previously considered the Louisville cave beetle to be vulnerable to toxic chemical spills, discharges of large amounts of polluted water, closure or alterations of cave entrances, and the disruption of cave energy processes by highway construction and industrial, residential, and commercial development. We had also noted the lack of State or Federal regulations to ameliorate those threats (Factor D). During this initial review, the Service's general perception was that these stressors were significant and the species' population trend was likely decreasing. The species was known from only two caves, one of the caves was no longer accessible (Highbaugh Cave), and only two individuals had been observed in the other cave (Eleven Jones Cave). In the 2005 candidate notice of review (CNOR) (70 FR 24879; May 11, 2005), we also noted the species' limited distribution (Factor E) and how that would increase its vulnerability to isolated events that would have only a minimal effect on the more wide-ranging members of the genus *Pseudanophthalmus*.

In making the present finding, information pertaining to the Louisville cave beetle is discussed below in relation to these five factors. We considered and evaluated the best available scientific and commercial information in making our conclusions regarding threats. In considering what factors might constitute threats, we must look beyond the mere exposure of the species to the factor to determine whether the species responds to the factor in a way that causes actual impacts to the species. If there is exposure to a factor, but no response, or only a positive response, that factor is not a threat. If there is exposure and the species responds negatively, the factor may be a threat and we then attempt to determine if that factor rises to the level of a threat, meaning that it may drive or contribute to the risk of extinction of the species such that the species warrants listing as an endangered species or a threatened species as those terms are defined by the Act. This does not necessarily require empirical proof of a threat. The combination of exposure and some corroborating evidence of how the species is likely impacted could suffice. The mere identification of factors that could negatively impact a species is not sufficient to compel a finding that listing is appropriate; we require evidence that these factors are operative threats that act on the species to the point that the species meets the definition of an endangered species or a threatened species under the Act.

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Any review of stressors to caves and cave-dependent species like *Pseudanophthalmus* beetles must consider both the physical environment in which the species is found and the surface components that provide the energy that forms the basis of the cave food chain (Barr 1996, p. 1). Energy sources for cave biota can be in the form of bat guano deposited by cave-

dependent bats, large or small woody debris washed or blown into the cave, tiny bits of organic matter that are carried into the cave by water through small cracks in the rocks overlying the cave, or the bodies of other cave organisms that occupy the same environment (Barr 1996, pp. 6-7). The dependence upon the surface environment increases the vulnerability of cave organisms to actions that take place well outside and away from the cave. Alteration or interruption of these energy inputs can negatively affect cave beetle populations (Barr 1996, pp. 16-17).

Cave beetles in the genus *Pseudophthalmus* face a variety of stressors that have the potential to lead to destruction, modification, or curtailment of their habitat or range (Barr 1996, entire; Laudermilk 2006, entire). Ground disturbance associated with development (e.g., industrial, residential, or commercial construction) or agriculture has the potential to alter or interrupt energy inputs originating from the surface, and these disturbances have the potential to contribute large amounts of sediment into cave systems that smother beetle habitats or disrupt the natural inflow of energy essential to maintaining a cave's sensitive ecology. Caves can also be degraded more directly by vandalism (e.g., excavation, spray painting) and by pollution and chemical contamination associated with polluted stormwater, transportation-related spills, agricultural operations (e.g., livestock, row-crops), and illegal trash dumps. These activities can degrade cave environments through the physical disturbance or alteration of cave habitats and the introduction of harmful chemicals.

Lewis and Lewis (2016, pp. 18-20) identified a number of habitat stressors for *P. troglodytes*. The species' known range (four caves) lies completely within urban and suburban

Louisville (Figure 1), the largest city in Kentucky with a metropolitan population of over 1.2 million (Lewis and Lewis 2016, p. 18). The once forested landscape has been replaced by buildings, roads, parking lots, and residences, which have undoubtedly altered the energy (food) supply from the surface. All food entering the cave ecosystem is dependent upon the surface community and the transfer of organic nutrients to the cave food web via input of plant material, guano from bats or crickets, or the decaying bodies of cave organisms (Lewis and Lewis 2016, p. 18). Increased imperviousness (e.g., hardened surfaces like roads and parking lots) associated with urban watersheds has altered the hydrology of these cave systems, leading to more frequent and intense storm flows that can scour cave habitats or lead to sedimentation of cave passages. These events have the potential to remove or bury gravel/mud substrates used by the beetle for feeding and sheltering. During summer months, these storm flows also have the potential to introduce warm water that may elevate stream temperatures in underground stream systems, potentially causing population declines of semi-aquatic worms, a primary food source for *Pseudanophthalmus* beetles such as this species (Lewis and Lewis 2016, p. 18). The two major streams within the species' range, Beargrass Creek and Goose Creek, are heavily polluted by untreated sewage originating from obsolete septic systems and combined sewer overflows. During periods of heavy rain, these streams can rise and backflow into karst systems, introducing pollutants that may harm cave organisms, including the Louisville cave beetle (Lewis and Lewis 2016, p. 18). All of the aforementioned stressors have the potential to negatively affect cave habitats in which *P. troglodytes* occurs; however, we currently have no evidence that these stressors are acting (operative) on populations of *P. troglodytes*. Recent surveys demonstrate that the species continues to occur within Eleven Jones Cave, and the total number of occupied caves has increased from one to four (Lewis and Lewis 2015, pp. 3-12).

The species has been observed in low numbers (one to four individuals) in each of these caves, but this is not unusual for beetles in the genus *Pseudanophthalmus*, which are often difficult to find and typically observed in low numbers (Service 2015, p. 60850). The species is likely more abundant in these caves than survey results would suggest due to its small size (low detectability) and the inherent difficulties associated with searching cave habitats (e.g., low light conditions, narrow passageways). The best available scientific and commercial information does not indicate that these habitat stressors are negatively affecting populations of *P. troglodytes*.

All four caves known to support *P. troglodytes* remain accessible to humans, so cave vandalism (e.g., excavation, spray painting) and trampling of these habitats represent stressors. The relationship between this stressor and the species' apparent low abundance is unclear. Sauerkraut Cave is the most heavily visited and disturbed cave inhabited by the species, as evidenced by well-defined paths leading to and from the cave and fresh graffiti and debris reported by Lewis and Lewis (2016, pp. 18-20). Human visitation at other caves supporting *P. troglodytes* is possible but appears to occur with less frequency and intensity compared to Sauerkraut Cave. Despite these stressors, the species has persisted within Sauerkraut Cave. The species is difficult to find in the cave and appears to occur in low densities; however, as discussed above, this is not unusual for the genus *Pseudanophthalmus*, which is often observed in low numbers (1-2 specimens) and has demonstrated an ability to persist at these levels over time.

As summarized above, *P. troglodytes* occupies four caves within a heavily modified

urban landscape. Within this landscape, the species faces a number of habitat stressors (e.g., alteration or interruption of energy inputs, pollution, sedimentation, and human disturbance (trampling, vandalism); however, the best available scientific and commercial information does not indicate that these stressors are acting (operative) on the species, either individually or cumulatively, at a level that warrants its listing under the Act. Recent surveys for *P. troglodytes* have resulted in the discovery of three new populations and have demonstrated that, despite various stressors, the species has been documented to persist within Eleven Jones Cave for over 20 years. Therefore, based on the best available scientific and commercial information, we conclude that the present or threatened destruction, modification, or curtailment of its habitat or range does not currently pose a threat to *P. troglodytes* and is not likely to become a threat to the species in the future.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

The Louisville cave beetle is not known to be utilized for commercial, recreational, scientific, or educational purposes. The species is known from only four caves, all of which are located in the Louisville Metropolitan area. Sauerkraut Cave receives a significant amount of recreational visitation, but the other three caves are more difficult to find and are not as heavily visited (Lewis and Lewis 2015, pp. 6-12). Despite heavy visitation within Sauerkraut Cave, the species continues to occur there. The best available scientific and commercial information does not indicate that overutilization has led to the loss of populations or a significant reduction in numbers of individuals for this species. Therefore, we conclude based on the best available scientific and commercial information that overutilization for

commercial, recreational, scientific, or educational purposes does not currently pose a threat to the Louisville cave beetle, nor is it likely to become a threat to the species in the future.

C. Disease or predation:

Some predation by cave crickets or other insects may occur within caves known to support the species, but within the deeper parts of these caves, *Pseudanophthalmus* beetles have few predators and are likely the top carnivore (Barr 1996, p. 6). No other information is available suggesting that disease or predation are threats to the Louisville cave beetle. Therefore, we conclude, based on the best available scientific and commercial information, that disease or predation do not currently pose a threat to the Louisville cave beetle, and they are not expected to become threats to the species in the future.

D. The inadequacy of existing regulatory mechanisms:

The Louisville cave beetle is not afforded protection by any existing Federal statute or regulation.

The Kentucky Cave Protection Act of 1988 (KRS 433.871-885) is an existing State regulatory mechanism that provides some protection to the Louisville cave beetle and its habitat. The statute provides for protection of cave habitats from wrongful disturbance or damage, and it protects cave organisms, including troglobitic species such as the Louisville cave beetle, from wrongful harm, killing, disturbance, or removal (unless for the purpose of scientific collecting). The Louisville cave beetle has been identified as an endangered species within Kentucky (KSNPC 2014, p. 40), although this State designation conveys no legal protection for the species

or its habitat.

The best available scientific and commercial information does not indicate that existing regulatory mechanisms are themselves inadequate or that any lack of enforcement has led to the loss of populations or a significant reduction in numbers of individuals for this species. As discussed elsewhere, the species' persistence within Eleven Jones Cave for over 20 years and its recent discovery in three new caves suggests that the absence of regulatory mechanisms has not increased any of the stressors to the level of threats. Therefore, we conclude based on the best available scientific and commercial information that the inadequacy of existing regulatory mechanisms does not currently pose a threat to the Louisville cave beetle, nor is it likely to become a threat to this species in the future.

E. Other natural or manmade factors affecting its continued existence:

Small Population Size

The Service previously identified small population size as a threat to *P. troglodytes* and other *Pseudanophthalmus* beetles because these species are often found in low numbers. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift (e.g., random loss of allele frequency leading to a loss in genetic variation), potentially increasing their susceptibility to inbreeding depression (e.g., the reduction in fitness of progeny from matings between related individuals compared to progeny from unrelated individuals), decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soulé 1980, pp. 157–158; Hunter 2002, pp. 97–101; Allendorf and Luikart 2007, pp. 117–146). Recent surveys demonstrate that the species is more

widespread and abundant than previously believed, with the total number of occupied caves increasing from one to four (Lewis and Lewis 2015, pp. 3-12). The species has been observed in low numbers (one to four individuals) in each of these caves, but this is not unusual for beetles in the genus *Pseudanophthalmus*, which are often difficult to find and typically observed in low numbers (Service 2015, p. 60850). The species is likely more abundant in these caves than survey results would suggest due to its small size (low detectability) and the inherent difficulties associated with searching cave habitats (e.g., low light conditions, narrow passageways). These species often go undetected for many years, but then suddenly reappear in subsequent survey efforts (Lewis and Lewis 2015, p. 26). As discussed above, we have no recent information on population estimates for any of the caves occupied by the species. Therefore, the best available scientific and commercial information does not suggest that small population size is a threat to *P. troglodytes*.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2014, p. 3). Numerous long-term climate changes have been observed, including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns, and aspects of extreme weather, including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014, p. 4). Species that are dependent on specialized habitat types, that are limited in distribution, or are at the extreme periphery of their range may be most susceptible to the impacts of climate change (Byers and Norris 2011, p. 18); however, while continued change is certain, the magnitude and rate of change is unknown in many cases.

Estimates of the effects of climate change using available climate models lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the Louisville cave beetle (i.e., there are no "downscaled" projections available that are useful for predictions of cave microclimates) (Girvetz et al. 2009, pp. 1-19; USGS 2015, entire). Climate has changed in recent decades in the southeastern United States, and the rate of change will likely continue to increase into the future with potential effects on the microhabitats of caves and their hydrologic regimes. Generally, cave microclimates are influenced by factors such as cave length, complexity of passages, and elevational juxtaposition of surface openings. The best available scientific and commercial information does not project how changes in temperature and precipitation will affect the Louisville cave beetle or its habitat and how the species will respond to these changes. Therefore, we cannot conclude that climate change is a threat to the species.

We conclude based on the best available scientific and commercial information that natural or manmade factors do not currently pose a threat to the Louisville cave beetle and are not likely to become a threat to this species in the future.

Conservation Measures Planned or Implemented:

In the mid-1990s, the Kentucky Department of Fish and Wildlife Resources (KDFWR), in cooperation with the Service, funded a status survey for the rarer cave beetles that occur in Kentucky (Barr 1996, entire). These efforts included conversations with landowners and

searches of numerous caves in the Louisville area. For the results, see the **Historical Range/Distribution** discussion above. As a result of this survey, Barr (1996, p. 23) recommended (1) gating of Eleven Jones Cave (to prevent human disturbance), (2) completion of a hydrologic study to delineate the cave's watershed and identify potential sources of contaminants, and (3) completion of additional cave surveys in Jefferson County. Barr's first two recommendations have not been completed, but additional surveys were completed in 2015 and 2016 by Lewis and Lewis (2015, pp. 3-12; 2016, entire).

Summary of Threats:

When the Louisville cave beetle was first identified as a candidate for protection under the Act in 2001, our general perception was that it was vulnerable to habitat stressors (Factor A), such as toxic chemical spills, discharges of large amounts of polluted water, closure or alterations of cave entrances, and the disruption of cave energy processes by development. We also noted the lack of State or Federal regulations to ameliorate those threats (Factor D). In the 2005 CNOR, we noted the species' limited distribution (Factor E) and how that would increase its vulnerability to isolated events that would have only a minimal effect on the more wide-ranging members of the genus *Pseudanophthalmus*. We suspected that all of these stressors were significant and the species' overall population trend was likely decreasing. At that time, the species was known from only two caves, and one of those caves, Highbaugh Cave, was no longer accessible.

Over the last two years, field surveys for *P. troglodytes* have provided new information

on the species' distribution and the magnitude and imminence of potential stressors (Lewis and Lewis 2015, pp. 3-19; 2016, entire). Lewis and Lewis (2015, pp. 3-19) confirmed the continued presence of *P. troglodytes* in Eleven Jones Cave and observed the species in three new caves – Sauerkraut Cave, Cave Hill Cave, and Cave Creek Cave, demonstrating that the species is more abundant and widespread than previously believed. The species was difficult to find in each of these caves (one to four individuals observed), but this is not unusual for the genus *Pseudanophthalmus*, which is often difficult to find and is typically observed in low numbers. Population estimates or discernable trends for these populations have not been possible due to the low number of individuals observed and the difficulty in finding specimens during repeat visits. We acknowledge that caves within the species' range continue to be impacted by many of the same stressors identified by previous investigators – reduced energy inputs, sedimentation, pollution, and human visitation (Barr 1996, pp. 42-44); however, we currently lack evidence that these stressors are negatively affecting populations of *P. troglodytes*. Based on our analysis of these stressors and our review of the species' current status, we conclude that *P. troglodytes* is not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

Foreseeable Future

On January 16, 2009, the Solicitor for the Department of the Interior issued a memorandum (M-37021), which was intended to provide prospective guidance as to how the Secretary can best explain how a determination under section 4(a)(1) addresses the concept of foreseeable future. In the memorandum, the Solicitor concluded that, as used in the ESA, Congress intended the term "foreseeable future" to describe the extent to which the Secretary can

reasonably rely on predictions (a prediction is reliable if it is reasonable to depend upon it in making decisions) about the future in making determinations about the future conservation status of the species. Those predictions can be in the form of extrapolation of population or threat trends, analysis of how threats will affect the status of the species, or assessment of future events that will have a significant new impact on the species. The Secretary's ability to rely on predictions may significantly vary with the amount and substance of available data. For the Louisville cave beetle, we do not anticipate or foresee previously identified stressors such as physical habitat disturbance, cave vandalism, or trampling acting upon the species in the future. Presently, we have insufficient information to suggest that these potential stressors rise to the level of a threat, and there is no evidence that the magnitude of these potential stressors will increase in the near future, so we do not expect the species' status to change significantly in the foreseeable future.

Significant Portion of the Range

Under the Act and our implementing regulations, a species may warrant listing if it is an endangered or a threatened species throughout all or a significant portion of its range. The Act defines "endangered species" as any species which is "in danger of extinction throughout all or a significant portion of its range," and "threatened species" as any species which is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The term "species" includes "any subspecies of fish or wildlife or plants, and any distinct population segment [DPS] of any species of vertebrate fish or wildlife which interbreeds when mature." We published a final policy interpreting the phrase "Significant Portion of its Range" (SPR) on July 1, 2014 (79 FR 37578). The final policy states that (1) if a

species is found to be an endangered or a threatened species throughout a significant portion of its range, the entire species is listed as an endangered or a threatened species, respectively, and the Act's protections apply to all individuals of the species wherever found; (2) a portion of the range of a species is "significant" if the species is not currently an endangered or a threatened species throughout all of its range, but the portion's contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range; (3) the range of a species is considered to be the general geographical area within which that species can be found at the time the Service or National Marine Fisheries Service (NMFS) makes any particular status determination; and (4) if a vertebrate species is an endangered or a threatened species throughout an SPR, and the population in that significant portion is a valid DPS, we will list the DPS rather than the entire taxonomic species or subspecies.

The SPR policy is applied to all status determinations, including analyses for the purposes of making listing, delisting, and reclassification determinations. The procedure for analyzing whether any portion is an SPR is similar, regardless of the type of status determination we are making. The first step in our analysis of the status of a species is to determine its status throughout all of its range. If we determine that the species is in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range, we list the species as an endangered (or threatened) species, and no SPR analysis will be required. If the species is neither an endangered nor a threatened species throughout all of its range, we determine whether the species is an endangered or a threatened species throughout a significant portion of its range. If it is, we list the species as an endangered or a threatened species, respectively; if it is not, we

conclude that listing the species is not warranted.

When we conduct an SPR analysis, we first identify any portions of the species' range that warrant further consideration. The range of a species can theoretically be divided into portions in an infinite number of ways. However, there is no purpose to analyzing portions of the range that are not reasonably likely to be significant and either endangered or threatened. To identify only those portions that warrant further consideration, we determine whether there is substantial information indicating that (1) the portions may be significant and (2) the species may be in danger of extinction in those portions or likely to become so within the foreseeable future. We emphasize that answering these questions in the affirmative is not a determination that the species is an endangered or a threatened species throughout a significant portion of its range; rather, it is a step in determining whether a more detailed analysis of the issue is required. In practice, a key part of this analysis is whether the threats are geographically concentrated in some way. If the threats to the species are affecting it uniformly throughout its range, no portion is likely to warrant further consideration. Moreover, if any concentration of threats applies only to portions of the range that clearly do not meet the biologically based definition of "significant" (i.e., the loss of that portion clearly would not be expected to increase the vulnerability to extinction of the entire species), those portions will not warrant further consideration.

If we identify any portions that may be both (1) significant and (2) endangered or threatened, we engage in a more detailed analysis to determine whether these standards are indeed met. The identification of an SPR does not create a presumption, prejudgment, or other determination as to whether the species in that identified SPR is an endangered or a threatened

species. We must go through a separate analysis to determine whether the species is an endangered or a threatened species in the SPR. To determine whether a species is an endangered or a threatened species throughout an SPR, we will use the same standards and methodology that we use to determine if a species is an endangered or a threatened species throughout its range.

Depending on the biology of the species, its range, and the threats it faces, it may be more efficient to address the "significant" question first, or the status question first. Thus, if we determine that a portion of the range is not "significant," we do not need to determine whether the species is an endangered or a threatened species there; if we determine that the species is not an endangered or a threatened species in a portion of its range, we do not need to determine if that portion is "significant."

We evaluated the current range of the Louisville cave beetle to determine if there is any apparent geographic concentration of potential threats for this species. This species has a relatively small range that is limited to the four cave systems where it is currently found. We examined potential stressors including human visitation, commercial and residential development, disease, predation, and sources of water quality impairment. We concluded that we have insufficient information regarding the species' current status and threats to suggest that it is warranted for listing throughout all of its range. Without knowing the species' current status or the significance of potential threats, we have insufficient information to suggest that potential threats are significantly concentrated or substantially greater in one portion than in other portions of its range. Therefore, we find that factors affecting the species are essentially uniform throughout its range, indicating no portion of the range is likely to be in danger of extinction or

likely to become so. Therefore, no portion warrants further consideration to determine whether the species may be endangered or threatened in a significant portion of its range.

Conclusion:

Based on our analysis of these stressors and our review of the species' current status, we conclude that listing of this species is not warranted. Therefore, we no longer consider it to be a candidate species for listing. We will continue to monitor the status of the Louisville cave beetle and to accept additional information and comments concerning this finding. We will reconsider our determination in the event that new information indicates that the stressors to the species are of a considerably greater magnitude or imminence than identified through assessments of information contained in our files, as summarized in this assessment.

For species that are being removed from candidate status:

No Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions (PECE)?

Recommended Conservation Measures:

Recommended conservation measures include the following:

- Maintain landowner contacts and continue to evaluate potential threats;
- Monitor population levels once every five years in known habitats;
- Construct metal gates to control human access if needed; and
- Search for additional populations in Jefferson County.

Emergency Listing Review: Is Emergency Listing Warranted?

Emergency listing is not warranted. Based on a detailed review of the best available scientific and commercial information, we have determined that listing of this species under the Act is not warranted.

Description of Monitoring:

Surveys for the Louisville cave beetle and other *Pseudanophthalmus* species in Kentucky were completed by Barr (1996, entire), Laudermilk (2005, entire), Lewis and Lewis (2015, entire), and Lewis (2016, entire). Most recently (June – October 2015), Lewis and Lewis (2015, pp. 3-19) observed a total of nine specimens from four Jefferson County caves – Eleven Jones Cave, Sauerkraut Cave, Cave Hill Cave, and Cave Creek Cave. Currently, there is no future monitoring planned for the Louisville cave beetle.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

None

Indicate which State(s) did not provide any information or comment:

Kentucky

State Coordination:

In the mid-1990s, KDFWR, in cooperation with the Service, funded a status survey for

the rarer *Pseudanophthalmus* beetles that occur in Kentucky (Barr 1996, entire). These efforts included surveys of Eleven Jones Cave and several other Jefferson County caves. Service funds supported a second statewide beetle survey by the Kentucky State Nature Preserves Commission (KSNPC) in the mid-2000s (Laudermilk 2006, entire). Kentucky has not included insects in its Wildlife Action Plan (KDFWR 2013); the only invertebrates included in the plan have been freshwater mussels and crayfishes.

Literature Cited:

Allendorf, F.W. and G. Luikart. 2007. Conservation and the genetics of populations. Malden, Massachusetts, Blackwell Publishing. 642 pp.

Barr, T. C., 1996. Cave beetle status survey and prelisting recovery project. Unpublished report to Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky, and the U.S. Fish and Wildlife Service, Asheville, North Carolina. 63 pp.

Barr, T. C. 1998. Study of potentially threatened or endangered species of cave beetles in Tennessee, Alabama, and Georgia. Interim progress report to the Tennessee Wildlife Resources Commission. 11 pp.

Barr, T.C. 2001. Cave beetles in Tennessee, Alabama, and Georgia, potentially threatened or endangered species of *Pseudanophthalmus* (Coleoptera: Carabidae). Final report to U.S. Department of Interior, Office of Endangered Species and Tennessee Wildlife Resources Agency. 36 pp.

Barr, Thomas C. 2004. A classification and checklist of the genus *Pseudanophthalmus* Jeannel (Coleoptera: Carabidae: Trechinae). Virginia Museum of Natural History Special Publication 11. 52 pp.

Barr, Thomas C. 2010. Personal communication, email from Tom Barr regarding potential conservation efforts for Tatum Cave, Clifton Cave, and Icebox Cave. Nashville, Tennessee.

Byers, E. and S. Norris. 2011. Climate change vulnerability assessment of species of concern in West Virginia. Project report, West Virginia Division of Natural Resources, Elkins, West Virginia. 69 pp.

Girvetz, E.H., C. Zganjar, G. T. Raber, E. P. Maurer, P. Kareiva, and J. L. Lawler. 2009. Applied Climate-Change Analysis: The Climate Wizard Tool. PLoS ONE 4:1-19. e8320. doi:10.1371/ journal.pone.0008320.

Hunter, M.L., Jr. 2002. Fundamentals of conservation biology, second edition. Blackwell Science, Inc. Malden, Massachussetts. 547 pp.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014 synthesis report. Available at *http://ipcc.ch/report/ar5/.*

Kentucky Department of Fish and Wildlife Resources (KDFWR). 2013. Kentucky's Comprehensive Wildlife Conservation Strategy. KDFWR, Frankfort, Kentucky. Available from: *http://fw.ky.gov/WAP/Pages/Default.aspx* (Date updated 2/5/2013).

Kentucky State Nature Preserves Commission (KSNPC). 2014. Endangered, threatened, and special concern plant, animals, and natural communities of Kentucky with habitat description. (PDF file available at: *http://naturepreserves.ky.gov/pubs/publications/ksnpc_specieshabitat.pdf*). 50 pp.

Krekeler, C. H. 1973. Cave beetles of the Genus *Pseudanophthalmus* (Coleoptera: Carabidae) from the Kentucky Bluegrass and vicinity. Fieldiana 62(4):35-83.

Laudermilk, Ellis L. 2006. A survey for Kentucky *Pseudanophthalmus* (Coleoptera: Carabidae: Trichinae) species considered candidates for listing by the U. S. Fish and Wildlife Service. Kentucky State Nature Preserves Commission, Frankfort, Kentucky. 15 pp.

Lewis, J. J. and S. L. Lewis. 2015. Pre-listing evaluation of populations and habitats of four species of Kentucky cave beetles (*Pseudanophthalmus*). Unpublished technical report submitted to U.S. Fish and Wildlife Service, Frankfort, Kentucky. 38 pp.

Lewis, J. J. and S. L. Lewis. 2016. Louisville cave beetle (*Pseudanophthalmus troglodytes*) draft report. Unpublished technical report submitted to U.S. Fish and Wildlife Service, Frankfort, Kentucky. 24 pp.

Lewis, J. J. and T. P. Sollman. 1998. Groundwater monitoring in significant aquatic caves that lie beneath impending residential developments in the Blue River basin of southern Indiana. Final report, Ohio River Valley Ecosystem Team, U. S. Fish and Wildlife Service and Indiana Karst Conservancy. 89 pp.

Soulé, M.E. 1980. Threshold for survival: maintaining fitness and evolutionary potential. Pages 151-169 In M.E. Soule and B.A. Wilcox, eds. Conservation biology. Sinauer Associates, Inc., Sunderland, Massachusetts.

U.S. Fish and Wildlife Service (Service). 2015. Endangered and threatened wildlife and plants; 12-month findings on petitions to list 19 species as endangered or threatened species. Federal Register 80:60834-60850.

Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: _____ 8-15-16
Acting Regional Director — Date

Concur: _____ 9/26/16
Acting Director — Date

Did not concur: _____
Date

Director's Remarks: