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

Scientific Name:

Gyrinophilus gulolineatus

Common Name:

Berry Cave salamander

Lead region:

Region 4 (Southeast Region)

Information current as of:

10/31/2012

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 Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

___ 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: 01/22/2003

90-Day Positive:03/18/2010

12 Month Positive:03/22/2011

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

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

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

Explanation of why precluded:

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower LPNs). During the past 12 months, the majority our entire national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements; meeting statutory deadlines for petition findings or listing determinations; emergency listing evaluations and determinations; and essential litigation-related administrative and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of Progress on Revising the Lists, in the current CNOR which can be viewed on our Internet website (http://endangered.fws.gov/).

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Tennessee
- **US Counties**:County information not available
- **Countries**:Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Tennessee
- **US Counties**:County information not available
- **Countries**:Country information not available

Land Ownership:

The majority of the cave entrances of documented Berry Cave salamander populations are privately owned and access-controlled (Niemiller et al. 2010b, p. 14). Main entrances to the Meades Quarry Cave system

(Meades Quarry, Meades River, and Fifth caves) are managed by Ijams Nature Center and owned by the City of Knoxville. These entrances are gated and only allow authorized entry to the caves. The Berry Cave entrance is under a conservation easement with The Nature Conservancy and is also privately owned. Christian, Mudflats, The Lost Puddle, and Aycock Spring caves are all located on private properties (Niemiller et al. 2010b, p. 14). Blythe Ferry Cave is on land owned by the Tennessee Valley Authority, a federal entity.

Lead Region Contact:

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Biological Information

Species Description:

Members of the Tennessee cave salamander complex are related to the spring salamander (*G. porphyriticus*); however, unlike the spring salamander, they usually are found in caves and are neotenic, meaning that they normally retain larval characteristics as adults. Individuals occasionally metamorphose and lose their larval characters (Simmons 1976, p. 256; Yeatman and Miller 1985, pp. 305-306), and metamorphosis can be induced by subjecting them to hormones (Dent and Kirby-Smith 1963, p. 123). The Berry Cave salamander is differentiated from other members of the group by a distinctive dark stripe on the upper portion of the throat, a wider head, a flatter snout, and possibly a larger size (Brandon 1965, p. 347).

Taxonomy:

Three taxonomic entities have been formally described within the Tennessee cave salamander species complex. The pale salamander (*Gyrinophilus palleucus palleucus*) is the most widely distributed member of the group and is found in middle Tennessee, northern Alabama, and northwestern Georgia. The Big Mouth Cave salamander (*G. p. necturoides*) is restricted to one cave in middle Tennessee, and the Berry Cave salamander (*G. gulolineatus*) (formerly recognized as the subspecies *G. p. gulolineatus*) has been recorded from nine locations in eastern Tennessee. The taxonomic status of the Berry Cave salamander has been debated for some time. The Berry Cave salamander was recognized as a distinct aquatic, cave-dependent taxon of the Tennessee cave salamander complex by Brandon (1965, pp. 346-352), who described it as a subspecies (*G. p. gulolineatus*). The Tennessee Wildlife Resources Agency (TWRA) (2005, p. 50) still uses this subspecific designation. Brandon et al. (1986, pp. 1-2) suggested the Berry Cave salamander be considered separate from the Tennessee cave salamander based on nonadjacent ranges (it is geographically isolated from other members of the complex), dissimilarity in bone structures of transformed adults, and morphology of neotenic adults. Furthermore, Niemiller et al. (2010b, p. 5) found that Berry Cave salamander populations they sampled have three unique alleles when compared to the Tennessee cave salamander. According to Niemiller et al. (2008, p. 2), current taxonomy recognizes the Tennessee cave salamander (*G. palleucus*) and the Berry Cave salamander (*G. gulolineatus*) as two independent species. Because most authorities now assign the Berry Cave salamander species-level status (Brandon 1965, p. 347; Brandon 1986, pp. 1-2; Collins 1991, p. 43; Simmons 1976, p. 276; IUCN 2010; ITIS 2010), we considered the Berry Cave salamander to be a distinct species, *G. gulolineatus*.

Habitat/Life History:

Limited information is available concerning the habitat requirements of the Berry Cave salamander.

According to Miller and Niemiller (2008, pp. 10-11), the Berry Cave salamander is associated with subterranean waters within the Appalachian Valley and Ridge Province in East Tennessee. In general, cave-obligate salamanders require an inflow of organic detritus, aquatic organisms on which to feed, and sufficient cover in the form of rocks and ledges. Studies indicate that the tendency to utilize cover varies between caves, but the Berry Cave salamander often seeks refuge in crevices, cover areas, and overhanging ledges when disturbed (Niemiller et al. 2010b, p. 10; Miller and Niemiller 2006, p. 11).

Life requirements of the Tennessee cave salamander complex are poorly documented due to their reclusive nature and the obscurity of subterranean environments (Niemiller 2006, p. 9). Animals found in the same location during mark-recapture studies indicate that Berry Cave salamander territories are diminutive (Miller and Niemiller 2008, p. 11).

Little is known in general about breeding habits, life spans, or numbers comprising individual populations within the Tennessee cave salamander complex (Miller and Niemiller 2005, p. 92). Transition time from larval stage to reproductive adult is currently undocumented. Members of the Tennessee cave salamander complex are paedomorphic (retain juvenile characteristics as an adult) and become sexually mature without metamorphosing into an adult form (Brandon 1966, in Niemiller et al. 2008, p. 2). Female salamanders in the Tennessee cave salamander complex are believed to be gravid from late autumn to early winter (Niemiller et al. 2010a, p. 39). Gyrinophilus species are generalist feeders and cannibalization of other conspecifics (belonging to the same species) may cause females of some species to seek isolation from main cave streams for oviposition (laying eggs) (Niemiller et al. 2010a, pp. 38-39). To date, neither eggs nor embryos have been described (Niemiller and Miller 2010, p. 1).

Historical Range/Distribution:

Until recently, only eight populations of the Berry Cave salamander were documented: seven from caves and one from a roadside ditch in McMinn County, Tennessee, where three individuals were collected (presumably washed into the ditch from a cave). Salamanders in Cruze Cave, formerly considered to be Berry Cave salamanders, are now thought to be spring salamanders (Miller and Niemiller 2008, p. 14). A closer analysis of Cruze Cave animals revealed the presence of an iris (absent in the Berry Cave salamander), a high propensity to metamorphose (23 percent of individuals collected), and relatively large eye size when compared to Berry Cave salamanders (Miller and Niemiller 2008, p. 14). Furthermore, genetics indicated that Cruze Cave individuals shared the spring salamander's haplotype (closely linked genetic markers present on a single chromosome) and group (having a common ancestor) (Niemiller 2006, p. 41). Therefore Cruze Cave is no longer thought to contain a population of Berry Cave salamanders. The species was discovered in The Lost Puddle Cave in Knox County, Tennessee, in May of 2012.

Current Range Distribution:

Recent population surveys (April 2004 through May 2012) resulted in the discovery of Berry Cave salamanders in three new Knox County caves (Aycock Spring, Christian, and The Lost Puddle caves). According to Miller and Niemiller (2008, p. 10), the Berry Cave salamander is recorded from ten localities within the Appalachian Valley and Ridge Province in East Tennessee. These include nine caves within the Upper Tennessee River and Clinch River drainages (Niemiller et al. 2009, p. 243) and one unknown cave in McMinn County, Tennessee (Brandon 1965, p. 348). The Berry Cave salamander is currently known from Berry Cave, which is located south of Knoxville, Tennessee (in Roane County) (Niemiller 2006, p. 96); from Mud Flats, Aycock Spring, Christian, Meades Quarry, Meades River, and Fifth caves in Knox County (Niemiller and Miller 2010, p. 2), the latter three being part of the larger Meades Quarry Cave System (Brian Miller, Middle Tennessee State University, pers. comm., 2010); from Blythe Ferry Cave (in Meigs County) (Niemiller and Miller 2010, p. 2); and from an unknown cave in Athens, McMinn County, Tennessee. The Athens record is based solely on the three specimens collected in a roadside ditch during a flooding of Oostanaula (Eastanollee) Creek (Brandon 1965, pp. 348-349). The species has not been observed in the

Athens area since 1953. Niemiller (pers. comm., 2012) reported a newly discovered Berry Cave salamander population at The Lost Puddle Cave in Knox County as a result of a survey effort in May of 2012. Berry Cave salamanders are now known from ten localities and nine caves.

Miller and Niemiller (2008, p. 11) suggested that populations of the Berry Cave salamander could occur throughout the Valley and Ridge Province in interconnected subterranean waters associated with the Tennessee River. Distribution studies are limited due to inaccessibility of smaller cave systems, but Miller and Niemiller (2006, p. 15) suggest that cave salamander populations are likely small. Western dispersal appears to be prohibited by a fault zone located west of the East Tennessee Aquifer System (Miller and Niemiller 2008, p. 10).

Population Estimates/Status:

Historical estimates of Berry Cave salamander densities and population trends are lacking. Miller and Niemiller (2006, p. 44) provided numbers of Berry Cave salamanders observed in Berry and Mudflats caves by decade, but the information has gaps and is insufficient for analysis. Miller and Niemiller (2005, p. 93) planned to implant salamanders with tags for population estimates on return cave visits, comparing marked to unmarked individuals captured. However, in an unpublished report to TWRA (Miller and Niemiller 2006, p. 15), the authors state that time constraints did not allow for mark-recapture studies to be performed in each cave and that population estimates were based on the number of salamanders found during the surveys. These surveys concluded that Berry Cave salamander populations are robust at Berry and Mudflats caves where population declines had been previously reported (Miller and Niemiller 2008, p. 1; Miller and Niemiller 2006, p. 44). According to Miller and Niemiller (2008, pp. 1, 17-20), a total of 113 caves in Middle and East Tennessee were surveyed from the time period of April 2004 through June 2007, resulting in observations of 63 Berry Cave salamanders. Three Berry Cave salamanders were spotted during a cursory May, 2012, survey of The Lost Puddle. Population trends for the Berry Cave salamander are unknown.

Distinct Population Segment(DPS):

Not applicable

Threats

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

According to Caldwell and Copeland (1992, pp. 3-4), the greatest threats to the Tennessee cave salamander complex are derived from agricultural runoff, pesticide use in residential and agricultural settings, over-collection, increased water flow into and through cave systems following timber operations, and siltation caused by the removal of trees from riparian zones. Although standard best management practices (BMPs) for timber harvesting require intact riparian buffers and prohibit instream operation of heavy equipment, these BMPs are not always followed and may not fully prevent sediment from entering streams. Siltation may adversely affect reproduction by filling crevices used for egg deposition or covering the eggs themselves (Miller and Niemiller 2006, p. 22). Niemiller and Miller (2006, p. 10) believe that Berry Cave salamander populations, specifically, are most vulnerable to habitat degradation associated with urbanization, over-collecting, and poor silvicultural and agricultural practices.

Boone and Bridges (2003) (in Miller and Niemiller (2006, p. 22)) found that water contamination caused by pesticide and roadway runoff poses a considerable threat to cave systems. Hayes et al. (2006, p. 40) suggest that amphibians are particularly vulnerable to pesticides due to their highly permeable skin combined with the fact that their critical reproductive and developmental stages occur while they are in aquatic

environments. Some persistent pesticides are active at low environmental concentrations and act as endocrine disrupters in amphibians, causing delayed metamorphosis, developmental retardation, and stunted larval growth (Hayes et al. 2006, p. 40).

According to Miller and Niemiller (2008, p. 13), there are few water quality data available for caves where the Berry Cave salamander is documented, and the source of the streams is not well understood. Niemiller (2006, p. 96) observed three individuals in Meades Quarry Cave and three in Mudflats Cave, caves that are heavily silted and prone to flooding (Miller and Niemiller 2006, p. 22). The Mudflats Cave system is thought to be affected by residential pollution (e.g., herbicides, pesticides, exhaust runoff, and silt load) from a nearby housing development (Miller and Niemiller 2008, p. 13), although no studies have been done to substantiate this (Miller, pers. comm., 2005). Caldwell and Copeland (1992, p. 3) suggest that increased "through flow" (water passing through the cave) can flush salamanders and their aquatic invertebrate food base from caves as well as introduce contaminants into them at a quicker rate. Miller and Niemiller (2006, pp. 22-23) cite Boone and Bridges (2003) as evidence of adverse effects to amphibian species from pesticide contamination, but note that regular flooding of caves appears to wash silt from the systems and that data on the long-term effects to the species from "through flow" fluctuations are lacking.

Meades Quarry Cave continues to be greatly impacted by past quarrying activities. Niemiller et al. (2010b, p. 11) indicate that cave passages were destroyed by quarrying and that lye leaching continues to alkalize the system near the main entrance to the cave. Water pH tests reveal fluctuations in pH levels from 8.4 to 12.7 downstream of the cave entrance, and Berry Cave salamanders have been observed with chemical burns (Niemiller et al. 2010b, p. 11). Matthew Niemiller (University of Tennessee, pers. comm., 2010) suggested that removal of larger lye deposits would reduce alkalinity input if the main point source could be located.

There are substantial concerns for the seven documented Knox County caves where Berry Cave salamanders are known to occur (Mud Flats, Aycock Spring, Christian, Meades Quarry, Meades River, The Lost Puddle, and Fifth caves) due to growth of metropolitan Knoxville (Miller and Niemiller 2008, p. 1). Construction activities, such as residential and business developments, land clearing, and highway projects, frequently result in stream siltation, toxic runoff (e.g., solvents, chemical spills, road salt oil and grease), and urban pollution. Stream temperatures are elevated by removal of trees from riparian zones (forested land along streams and rivers), and hydrologic fluctuations result from increased silt load; elevated stream temperatures and hydrologic fluctuations both potentially affect the quantity and quality of organic matter available to cave systems. Data are currently lacking on long-term effects of hydrologic fluctuations on salamander population size, but it is thought that an increase in siltation affects reproduction (Miller and Niemiller 2006, pp. 22-23). While Berry Cave salamander populations have persisted, development is known to be occurring and affecting the salamander in all seven Knox County caves. Heavy siltation is present in Mudflats Cave, believed to be associated with the Gettysvue housing development (Niemiller et al. 2010b, p. 11). Miller and Niemiller (2008, p. 13) and Niemiller (pers. comm., 2012) indicate that residential housing developments and roads are being constructed near Aycock Spring, Christian, and The Lost Puddle caves. Development of a major roadway known as the James White Parkway (South Knoxville Boulevard) has potential to impact Berry Cave salamander populations in the Meades Quarry Cave system (Meades Quarry, Meades River, and Fifth caves) by increased siltation from construction, the creation or closures of cave openings by blasting and excavating activities which could affect organic input into the system, and an increase in impervious surface runoff that may contain various environmental contaminants (e.g., oil, herbicides, salt). Meades Quarry Cave contains the largest population of Berry Cave salamanders documented and is currently impacted by hybridization with the spring salamander and lye leaching associated with past quarrying activities (Niemiller and Miller 2010, p. 3; M. Niemiller, pers. comm., July 2010).

Due to the proximity of the Meades Quarry Cave system to the proposed James White Parkway, the Service requested, during a March 4, 2003, meeting with the Tennessee Department of Transportation (TDOT), that a study be prepared to determine whether the potential alignments would impact the surface area that recharges the Meades Quarry Cave system. As a result, TDOT contracted ARCADIS to perform a dye trace study of the affected watershed. ARCADIS (2009, p. 1-2) conducted a hydrogeologic dye trace study from April

through June 2009 to determine which karst features within the Toll Subwatershed (i.e., a surface watershed overlying Meades Quarry and Cruze caves) are connected to the Meades Quarry Cave system. A positive trace from a large sinkhole, just north of Sevierville Pike, indicates that it directly recharges the Meades Quarry Cave system, and it is likely that four smaller sinkholes, in proximity to this one, also drain into the Meades Quarry Cave (ARCADIS 2009, pp. 5-1, 5-2). Dye trace results demonstrated a general southwest to northeast orientation of groundwater flow (ARCADIS 2009, p. 5-1) and appeared to substantiate the hypothesis (based on surface flow) that Cruze Cave and Meades Quarry Cave systems were not hydrologically connected.

TDOT, in cooperation with the Federal Highway Administration, is preparing an EIS for the James White Parkway project (John Hunter, TDOT Project Manager, pers. comm., June 2009; Luke Eggering, Parsons Consulting, pers. comm. October 2010). The concerns for potential impacts to the Meades Quarry Cave system and the Berry Cave salamander are being addressed by substantial changes in project design. In an effort to satisfy the purpose and need of the project while minimizing environmental impacts, TDOT is now proposing to construct a fully access-controlled facility (South Knoxville Boulevard EIS 2010, p. 10). Furthermore, the alignments under consideration have been purposefully designed to avoid or minimize impacts to the recharge area for the Meades Quarry Cave system (South Knoxville Boulevard EIS 2010, p. 43). If direct impacts are unavoidable, TDOT is proposing to install filtration systems at sinkholes that recharge the Meades Quarry Cave system and to suggest that local planners control growth by implementing development buffers around environmentally sensitive areas (South Knoxville Boulevard EIS 2010, pp. 43-44).

Ogden (2005) conducted a dye trace study on the watershed contributing groundwater to the Berry Cave system in Roane County, Tennessee. As determined by Ogden (2005, p. 4), five first-order streams contribute to surface recharge of the Berry Cave system. The recharge area was delineated following two dye traces and is comprised of first-order streams that join the main sinking stream at the cave entrance (Ogden 2005, p. 19). The cave stream is believed to receive year-round input from Lawhon and Schommen springs and empties into a spring on the bank of the Watts Bar Lake (Ogden 2005, p. 4). Water quality results indicated normal conductivity levels and low nitrate levels despite extensive cattle grazing within the recharge area. Sulfate, iron, and phosphate levels were also determined to be low, and pH measured at approximately 7.0 at the time of sampling (Ogden 2005, p. 14). According to The Nature Conservancy (2006, Table 2), current threats to Berry Cave include bacteriological loading in the form of fecal coliform from agricultural runoff, disruption of organic flow due to a lack of cattle exclusion, and erosion/sedimentation caused by cattle access to streams that feed into Berry Cave. However, water quality tests conducted in conjunction with the dye trace study indicate that the system is uncontaminated (Ogden 2005, p. 14), and we have no evidence to suggest that any of these impacts are occurring.

The Federal Government’s Clean Water Act (CWA) of 1972 (33 U.S.C. 1251 et seq.) sets standards for releasing pollutants into waters of the United States and regulates water quality standards for surface water. Projects that could impact waters having a "significant nexus" to "navigable waters" are required under this law to apply for a National Pollutant Discharge Elimination System (NPDES) permit prior to construction. The Tennessee Department of Environment and Conservation’s Division of Water Pollution Control under the Tennessee Water Quality Control Act requires that the applicant perform compensatory mitigation for loss of linear feet of stream or pay into the Tennessee Stream Mitigation Program. While these laws are designed to protect water quality, impacts from projects are seldom viewed cumulatively, and compensatory mitigation might not involve reparation activities within the affected watershed. Therefore, degradation of habitat for this species is ongoing, and these laws have not been adequate to fully protect this species from water quality impacts associated with increasing development and urbanization.

In summary, Knox County populations are believed to be highly susceptible to habitat degradation from surrounding development (Miller and Niemiller 2008, p. 13). Residential pollutants, increased silt load from construction activities, and runoff of impervious surfaces associated with urban development are ongoing threats to Berry Cave salamander populations in seven caves within metropolitan Knoxville. Three of these

populations (Meades Quarry, Meades River, and Fifth caves) are part of the larger Meades Quarry Cave system (Miller, pers. comm., 2010) and could be impacted by development of the proposed James White Parkway Project. Past quarrying activities have resulted in high water pH levels within the Meades Quarry Cave and observations of Berry Cave salamanders with chemical burns. Residential housing developments and road construction are occurring in proximity to Aycock Spring, Christian and The Lost Puddle caves (Miller and Niemiller 2008, p. 13; Niemiller pers. comm., 2012). The Mudflats Cave population is believed to be impacted by a nearby housing development and associated water quality impacts (Miller and Niemiller 2008, p. 13). Water samples indicate that Berry Cave is uncontaminated, and cattle access to streams that recharge the system is evidently not impacting the cave system at this time. However, because of the overall vulnerability of the Berry Cave salamander to impacts associated with urbanization and the extent of overlap between current and projected urbanization and Berry Cave salamander populations, we find the present or threatened destruction, modification, or curtailment of its habitat or range to be a significant threat of moderate magnitude. Further, the information available to us at this time does not indicate that the magnitude or imminence of this threat is likely to be appreciably reduced in the foreseeable future.

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

Most caves containing Berry Cave salamander populations are privately owned, and visits to some of these caves are unsupervised (Miller and Niemiller 2006, p. 24; Niemiller et al. 2010b, p. 12), making the Berry Cave salamander vulnerable to recreational harvest. The most robust Berry Cave salamander populations occur in caves that are either gated or owned by conscientious landowners who monitor access, but the threat of harvesting individuals for the pet trade exists in unmonitored caves (M. Niemiller, pers. comm., 2010). Because populations are considered to be small (Miller and Niemiller 2006, p. 15) and reproductive rates are low, unregulated take of individuals could severely deplete breeding populations of Berry Cave salamanders (Niemiller et al. 2010b, p. 12). However, we currently have no evidence to suggest that recreational harvesting of Berry Cave salamander populations is occurring.

The Tennessee Cave salamander is listed as Threatened by the State of Tennessee. This listing provides protection for the Berry Cave salamander as a State-classified subspecies of the Tennessee cave salamander under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated sections 70-8-101-112). Take of a listed species, as defined by this State legislation, is unlawful, and potential collectors are required to possess a State permit. However, many cave visitors and recreational cavers are likely unaware of the protected status of the Berry Cave salamander. Moreover, Miller and Niemiller (2005, p. 93) find that most recreational cavers are unable to properly identify salamander species, and even biologists misidentify larval spring salamanders as Tennessee cave salamanders. Thus, the State listing of the Berry Cave salamander as a subspecies of the Threatened Tennessee cave salamander may not alone provide adequate protection for this species.

In summary, although the potential for harvesting of individuals exists in unmonitored caves, we have no information to indicate that collection for the pet trade or other purposes is occurring. Furthermore, the Tennessee State law discussed above is designed to provide State protection to the Berry Cave salamander as a classified subspecies of the Tennessee cave salamander, although a general lack of public knowledge with regard to State wildlife laws and common species misidentification may limit the State law’s protectiveness. Because we have no evidence to believe otherwise, we find that overutilization for commercial, recreational, scientific, or educational purposes is a low and nonimminent threat.

C. Disease or predation:

In a June 20, 2005, email to the Service, Dr. Brian Miller of Middle Tennessee State University communicated concerns for parasitic infections in Gyrinophilus species in two caves. Miller and Niemiller (2006, p. 24) observed pervasive, raised nodules on the skin of all Berry Cave salamanders collected within the Berry Cave system. The population appeared otherwise healthy, and no individuals were taken for

analysis (Miller and Niemiller 2006, p. 15). Crayfish are believed to be predators of the Tennessee cave salamander complex and were numerous in caves where injured individuals were found, but Miller and Niemiller (2006, p. 23) did not consider crayfish predation to be a serious threat to cave salamanders.

In summary, we are uncertain as to whether disease or predation constitutes a demonstrable threat to Berry Cave salamander populations at this time. Because of the otherwise healthy appearance of individuals, we find disease or predation to be a minimal threat of low magnitude.

D. The inadequacy of existing regulatory mechanisms:

The Berry Cave salamander and its habitats are afforded some protection from water quality and habitat degradation under the Federal Clean Water Act and the Tennessee Department of Environment and Conservation's Division of Water Pollution Control under the Tennessee Water Quality Control Act. However, as demonstrated under Factor A, degradation of habitat for this species is ongoing despite the protection afforded by these laws. These laws alone have not been adequate to fully protect this species from water quality impacts associated with increasing development and urbanization.

The Tennessee Cave salamander was listed as Threatened by the State of Tennessee in 1994. This listing provided protection for the Berry Cave salamander as a classified subspecies of the Tennessee cave salamander. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated sections 70-8-101-112), "[I]t is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered or Threatened Species state the following: "Except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna." Under these regulations, potential collectors of this species are required to have a State collection permit, although the effectiveness of this permit is uncertain (see Factor B analysis above).

In summary, degradation of Berry Cave salamander habitat is ongoing despite the protection afforded by State and Federal laws and corresponding regulations. Development and associated pollution continue to adversely affect the species. Because of the vulnerability of Knox County populations of the Berry Cave salamander and the imminence of these threats, we find the inadequacy of existing regulatory mechanisms to be a significant threat of high magnitude. Further, the information available to us at this time does not indicate that the magnitude or imminence of this threat is likely to be appreciably reduced in the foreseeable future.

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

According to M. Niemiller (pers. comm., July 2010), molecular and morphological evidence exists of hybridization between the Berry Cave salamander and the spring salamander in Meades Quarry Cave. Hybridization between the two species may be a natural threat to pure Berry Cave salamander populations as it affects the genetic integrity of the species. Studies are underway by Ben Fitzpatrick (Assistant Professor, Department of Ecology and Evolutionary Biology, University of Tennessee) and Niemiller to determine the extent of hybridization that is occurring between taxa in this system. It is debatable as to whether this phenomenon is anthropogenically induced or a natural process (M. Niemiller, pers. comm., July 2010). Currently, the Berry Cave salamander maintains its species distinctiveness in spite of ongoing interbreeding and range overlap with spring salamanders (Niemiller et al. 2010b, p. 5), and hybridization is only known to

be occurring in Meades Quarry Cave (M. Niemiller, pers. comm., July 2010). Research indicates that there is low gene flow between the two species (Niemiller et al. 2008, p. 2), and Berry Cave salamanders and spring salamanders are infrequently observed in the same cave systems (Niemiller et al. 2010b, p. 13).

The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2007a, p. 30). Numerous long-term climate changes have been observed, including changes in arctic temperatures and ice, and 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 2007b, p. 7). While continued change is certain, the magnitude and rate of change is unknown in many cases. Species that are dependent on specialized habitat types, that are limited in distribution, or that have become restricted to the extreme periphery of their range will be most susceptible to the impacts of climate change. As previously mentioned, the Berry Cave salamander is known only from the Appalachian Valley and Ridge Province in East Tennessee within the Upper Tennessee River and Clinch River drainages in Knox, Roane, Meigs, and McMinn Counties, Tennessee. The species is believed to be confined to subterranean aquatic environments (Niemiller et al. 2010, p. 5), and has been documented in only eight caves and a roadside observation where individuals were presumably washed from a cave. Western dispersal is prohibited by a fault that occurs along the west of the East Tennessee Aquifer System (Miller and Niemiller 2008, p. 10). Data on recent trends and predicted changes for the Southeast United States (Karl et al. 2009, pp. 111-116) provide some insight for evaluating the threat of climate change to the species. Since 1970, the average annual temperature of the region has increased by about 2 degrees Fahrenheit (^{o}F) (1.1^{o} Celsius (^{o}C)), with the greatest increases occurring during winter months. The geographic extent of areas in the Southeast region affected by moderate to severe drought has increased by 12 percent in the spring and 14 percent in the summer over the past three decades (Karl et al. 2009, p. 111). These trends are expected to increase.

Rates of warming are predicted to more than double in comparison to what the Southeast has experienced since 1975, with the greatest increases projected for summer months. Depending on the emissions scenario used for modeling change, average temperatures are expected to increase by 4.5 oF to 9 ^{o}F (2.5 ^{o}C to 5 ^{o}C) by the 2080s (Karl et al. 2009, p. 111). While there is considerable variability in rainfall predictions throughout the region, increases in evaporation of moisture from soils and loss of water by plants in response to warmer temperatures are expected to contribute to increased frequency, duration, and intensity of droughts (Karl et al. 2009, p. 112). If these rainfall predictions are accurate, streams that feed karst systems could experience significant decreases in flow volumes, lower dissolved oxygen content, and warmer temperatures. These variables could influence the amount and quality of organic input to cave systems essential in sustaining healthy prey populations for the Berry Cave salamander.

Application of continental-scale climate change models to regional landscapes and even more local or "step-down'' models projecting habitat potential based on climatic factors, is informative but contains a high level of uncertainty when predicting future effects to individual species and their habitats. This is due to a variety of factors including regional weather patterns, local physiographic conditions, life stages of individual species, generation time of species, and species' reactions to changing carbon dioxide levels. Therefore, the usefulness of models in assessing the threat of climate change on the Berry Cave salamander within its range is also limited. Due to variety of factors, e.g., variability surrounding regional rainfall predictions and how these precipitation events would affect the species, uncertainty remains regarding whether cave systems would maintain current ambient temperatures and how climate changes might affect inflow of organic detritus and availability of invertebrate food sources; we are therefore unable to confidently identify climate change threats (or their magnitude) to the Berry Cave salamander. We have no evidence that climatic changes observed to date have had any adverse impact on the species or its habitat.

In summary, hybridization is occurring between the Berry Cave salamander and the spring salamander in Meades Quarry Cave (Niemiller et al. 2010b, p. 5), although there appears to be low gene flow between the two species (Niemiller et al. 2008, p. 2). Because Meades Quarry Cave is still believed to house the healthiest population (Niemiller and Miller 2010, p. 3) and hybridization is not known to be impacting Berry Cave

salamander populations in other caves, we find this natural or manmade factor affecting the species' continued existence to be a threat of low magnitude. Although climate change may affect the species in the future, we lack adequate information to make reasonable predictions regarding the extent of the impact at this time. The available information does not indicate that climate change is a significant threat to the Berry Cave salamander, or that it is likely to become a significant threat in the foreseeable future.

Conservation Measures Planned or Implemented :

None described

Summary of Threats :

This status review identified threats to the Berry Cave salamander attributable to Factors A, B, C, D, and E. However, ongoing threats are from habitat modification, inadequacy of existing regulatory mechanisms, and other natural and manmade factors (Factors A, D, and E). These are in the form of lye leaching in the Meades Quarry Cave as a result of past quarrying activities, a proposed roadway with potential to impact the recharge area for the Meades Quarry Cave system, urban development in Knox County, water quality impacts despite existing State and Federal laws, and hybridization between spring salamanders and Berry Cave salamanders in Meades Quarry Cave. Because the available evidence would suggest that the Berry Cave salamander exists in relatively low population densities (Miller and Niemiller 2006, p. 15) and distribution is confined to subterranean waters within the Tennessee River and Clinch River watersheds (Miller and Niemiller 2008, p. 10), the species cannot readily tolerate losses of populations or even many individuals.

Development is largely responsible for pollution entering cave systems where Berry Cave salamanders occur and could additionally cause fluctuations in organic matter input and hydrologic levels as a result of sediment deposition, higher temperatures in streams that recharge systems when trees are removed from riparian zones (forested land along streams and rivers), and an increase in toxic runoff. The proposed James White Parkway project has the potential to directly impact Berry Cave salamander populations within the Meades Quarry Cave system (Meades Quarry, Meades River, and Fifth caves) by increased siltation from construction, creation or closures of cave openings by blasting activities that would affect organic input into the system, and toxic roadway runoff into sinkholes that recharge the Meades Quarry Cave system. We have determined that these factors could lead to a decline in Berry Cave salamander abundance because the majority of documented populations are located within the urban growth boundary of metropolitan Knoxville, and Meades Quarry Cave houses the largest population known.

For species that are being removed from candidate status:

_____ 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 :

According to Niemiller et al. (2010b, pp. 13-14), conservation would be best achieved by protecting drainage basins of cave systems inhabited by the species. More specifically, the Meades Quarry Cave population should be buffered in case of a catastrophic lye release from the main formation. The authors suggest that captive propagation might be possible and provide the example of endangered species taken from the Edwards Aquifer to San Marcos National Fish Hatchery (http://www.fws.gov/southwest/fisheries/sanmarcos.html). Currently, a few Berry Cave salamanders are housed at the Knoxville Zoo and the University of Tennessee (Niemiller et al. 2010b, p. 14).

Niemiller et al. (2010b, pp. 13-14) believe that population estimates and trends should be studied for Berry

Cave salamanders in the Meades Quarry Cave system. Furthermore, the extent of hybridization and competition with spring salamanders should be examined and determined whether these are natural factors or human-induced. The authors point to the hundreds of smaller caves in the southern Valley and Ridge Province of Tennessee that have never been surveyed as a possibility to expand species distribution. In addition, genetic work and mark-recapture studies might aid in quantifying population sizes within Berry Cave, Meades Quarry Cave, and Mudflats Cave. Finally, they appeal for any future studies that would contribute to an enhanced understanding of the species' natural history. In particular, those that shed light on reproductive behavior and age at maturity would be beneficial (Niemiller et al. 2010b, p. 14).

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	**Imminent**	Monotypic genus	7
		Species	**8**
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

We consider the threats facing the Berry Cave salamander to be moderate in magnitude. Several of the threats to the species (roadway construction, development in proximity to populations, and impacts to water quality) occur across the majority of the species' range. Due to its limited geographic range within subterranean waters of the Tennessee and Clinch River systems, impacts to these systems could have a detrimental effect on Berry Cave salamander populations. Habitat degradation associated with residential, business, and commercial development has high potential to adversely affect Berry Cave salamander populations by impacting water quality. While water quality regulations such as the Clean Water Act and the Tennessee Water Quality Control Act are designed to protect aquatic systems, stream mitigation practices only provide for loss of linear feet of stream and do not consider water quality concerns or impacts to affected species. Six of the eight caves where the species has been documented are within Knoxville's urban boundary (Niemiller and Miller 2010, p. 2) and are highly susceptible to future development activities. While the threats facing the species are numerous and in some cases widespread, we decided they were of moderate, rather than high, magnitude because the salamander still occurs in several different cave systems, and existing populations appear stable. Nonetheless, intensification of these threats could threaten the long-term viability of the species.

Imminence :

The threats to the Berry Cave salamander are imminent because we have factual information that the threats are identifiable and on-going, and that they often overlap or occur throughout most of the species' range. These actual, identifiable threats are covered in detail under the discussion of Factors A and D of this finding and currently include chronic lye leaching in the Meades Quarry Cave due to past quarrying activities, highway development and urban growth in Knox County, and water quality impacts despite existing State and Federal laws.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

Description of Monitoring:

A request for new and relevant information on behalf of the annual candidate assessment for the Berry Cave salamander was distributed to known species authorities and the State wildlife agency via an email dated March 16, 2012. Two responses were received, but neither provided any new species information. Experts suggest population studies in Meades Quarry, Mudflats, and Berry caves (Niemiller et al. 2010b, p. 13). Studies are currently underway by Ben Fitzpatrick (Assistant Professor, Department of Ecology and Evolutionary Biology, University of Tennessee) and Niemiller to determine the extent of hybridization that is occurring between taxa in Meades Quarry Cave (M. Niemiller, pers. comm., July 2010).

On May 14, 2012, we received an email from Matthew Niemiller outlining the survey of two Knox County Caves: Brent Cave and The Lost Puddle. No salamanders were spotted in Brent Cave but three adult Berry Cave salamanders were sighted in The Lost Puddle. Additional surveys are being planned.

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:

Tennessee

State Coordination:

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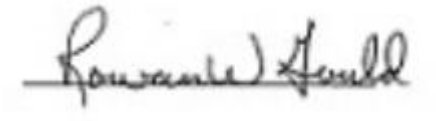
Approval/Concurrence:

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:  06/12/2012
Date

Concur:  11/06/2012
Date

Did not concur: _____ _____
Date

Director's Remarks: