5-YEAR REVIEW
Lee County cave isopod (*Lirceus usdagalun*)

Photo by Wil Orndorff, VDCR NHP

GENERAL INFORMATION:

Species: Lee County cave isopod (*Lirceus usdagalun*)
Date listed: November 20, 1992
FR citation(s): 57 FR 54722-54726
Classification: Endangered

BACKGROUND:

Most recent status review: U.S. Fish and Wildlife Service. 2014. Lee County cave isopod (*Lirceus usdagalun*) 5-year review. Abingdon, VA.

FR Notice citation announcing this status review: 85 FR 64527-64529, Initiation of 5-Year Reviews of 10 Northeastern Species, October 13, 2020.

ASSESSMENT:

Information acquired since the last status review: This 5-year review was conducted by the U.S. Fish and Wildlife Service's (Service) Southwestern Virginia (VA) Field Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on October 13, 2020. We also contacted State agencies, Federal agencies, species

experts, universities, and nongovernmental organizations (NGOs) to request any data or information we should consider in our review. Additionally, we conducted a literature search and a review of information in our files.

We received correspondence from the VA Department of Conservation and Recreation (VDCR) Natural Heritage Program (NHP) and other species experts in response to our *Federal Register* Notice initiating this 5-year review. Wil Orndorff, VDCR, reviewed the draft document. The information received indicates that the Lee County cave isopod (LCCI) is still present at previously documented locations and that extant populations remain stable. Information provided also suggests that the species has likely been detected at a new location within the existing range. The species distribution remains the same as described in the Service's 2014 status review (Service 2014) and the additional information does not alter our understanding of the species' current distribution or viability.

The LCCI range occurs entirely within autogenic zones and includes 9 known site occurrences: (1) Thompson Cedar Cave; (2) Masons Cave; (3) a small spring tributary to and northwest of Sims Creek; (4) Flanary Bridge Springs; (5) Golf Course Cave No. 3; (6) Gallohan Cave No. 1; (7) Gallohan Cave No. 2; (8) Surgener Cave in Lee County, VA (Service 2014). (9) Hamblin Porthole, Lee County, VA is an additional site in the Flanary Bridge system discovered in 2021 (J. Lewis, Smithsonian Institution, email to W. Orndorff and T. Malabad, VDCR, May 3, 2021).

These sites occur within four discrete subterranean basins and associated caves that flow to four resurgence springs. For consistency with the recovery plan and other related documentation, these subterranean basins are as follows:

1. Surgener-Gallohan Cave system – culminates at Surgener cave spring and includes Surgener Cave, Gallohan Caves #1 and #2
2. Thompson Cedar Cave system – culminates at Batie West Spring and includes Thompson Cedar and Mason Caves
3. Sims Creek system – includes Little Sims Spring and Sims Spring
4. Flanary Bridge Springs system – includes Golf Course Cave #3 and the Hamblin Porthole

The Sims Spring population was considered extirpated after development of the Lee County Airport eliminated the recharge area for the system; however, there are currently no known stream caves that can be accessed to verify if LCCI is absent from the system. The Service (2014) stated that numerous dye traces from karst features (caves, sinkholes, sinking streams) to the east and northeast of Sims Spring verify the presence of blind tributaries, and suggested that the species may be present in blind subterranean tributaries to the main underground stream that ultimately resurges at Sims Spring. Future sampling at this site will help determine if LCCI is present or extirpated from this system.

Batie Creek was listed on VA's 303(d) list of impaired waters in 1998 due to low dissolved oxygen levels caused by inflows of anoxic leachate from the Russell sawmill property. The low dissolved oxygen levels negatively affected the population of LCCI in Thompson Cedar Cave, which is associated with Batie Creek, and the LCCI was considered extirpated from the

Thompson Cedar Cave system when the species was listed and the recovery plan was written (Service 1992, Service 1997). LCCI re-established itself and was detected in 2002 after many of the impacts resulting from the sawmill were remediated and water quality had subsequently improved, and in 2006 Batie Creek was removed from the 303(d) list of impaired waters (Service 2014, USEPA 2007). Although the numbers of individuals do not appear to have recovered to levels that were described historically, the existing population continues to remain stable, and has been recovering for nearly 20 years (Holsinger and Bowman 1973, Estes 1978, Service 2014). Orndorff stated that qualitative observations indicate that the cave habitat occupied by LCCI appears to have increased and that LCCI is now the dominant asellid in the Thompson Cedar Cave (W. Orndorff, VDCR, email to R. Agbalog, Service, May 3, 2021).

Two additional cave locations, Masons Cave and Golf Course No. 3, inhabited by the LCCI have been documented since the recovery plan was written (Service 1997). Masons Cave was documented in November 2002 and is part of the Thompson Cedar Cave system. The Golf Course No. 3 population was discovered in May 2011 and belongs to the Flanary Bridge Springs subterranean system.

Specimens from the Hamblin Porthole, a tiny karst window approximately 1 meter deep, were recently discovered by VDCR NHP staff and were confirmed to be LCCI (W. Orndorff, VDCR, email to R. Agbalog, Service, April 27, 2021; J. Lewis, Smithsonian Institution, email to W. Orndorff and T. Malabad, VDCR, May 3, 2021). Earlier hydrological studies had suggested this site is connected to both the Flanary Bridge and Thompson Cedar populations. This discovery provides evidence that the species exists in smaller caves and epikarst streams upstream of the larger caves, which had been hypothesized given recolonization of Thompson Cedar Cave by LCCI in the early 2000s. Despite these recent discoveries, spatial distribution and the historical range of the LCCI populations remain as defined in the recovery plan (Service 1997).

Significant insights have been gained on the population biology and ecology of the species since the species was listed and the recovery plan was completed, although many aspects of knowledge about LCCI life history remain rudimentary. Previous efforts to monitor populations of LCCI and habitat parameters, including water quality, within cave systems were summarized in Orndorff and Hanlon (2014). They performed multiple surveys at extant sites to quantify populations and better understand population demographics. Although monitoring was extensive and occurred over multiple years, the population estimates and size classes present varied considerably depending on time of year and hydrological conditions. Quantitatively assessing the status of populations over time remains a significant challenge for this and other cryptic species with inaccessible habitat. Previous surveys and more recent qualitative surveys have consistently documented that the species is always present, and all extant populations are considered stable (J. Lewis, Smithsonian Institution, email to R. Agbalog, Service, November 20, 2020; W. Orndorff, VDCR, email to R. Agbalog, Service, May 3, 2021).

Recent work has validated the taxonomy of LCCI. In a report to the Service and VDCR, Lewis (2017) suggested that LCCI, *L. culveri*, and *L. hargeri* may all represent different variants of the same species, and suggested reclassifying the three to subspecies. He had found that the morphology of the tip of the endopod of the second pleopod in males, a trait that typically helps define the taxonomic status of freshwater-dwelling isopods, was indistinguishable between the

LCCI, *L. culveri*, and *L. hargeri*. However, in a follow-up study applying next generation sequencing of transcriptomes, also known as RNA-Seq, Fong and Carlini (2018) found sufficient sequence divergences to justify maintaining the status of the LCCI, *L. culveri*, and *L. hargeri* as separate species and thus validated the existing taxonomy for LCCI and *L. culveri*, although they detected divergence among different populations of *L. hargeri*, which indicated those populations may represent distinct species.

Ongoing research by Dr. Lewis and researchers at the Université Lyon 1 in Lyon, France have led to significant improvements in the understanding of the taxonomic and evolutionary context of LCCI. They have been performing molecular phylogenetic analyses of *Lirceus* specimens across the range of this North American genus as part of a more extensive project investigating asellid isopods worldwide. Results are already helping to inform our understanding of the genetic relationships within the genus *Lirceus*, and in and amongst species, populations, and congeners (Lewis et al. 2019). Preliminary results of an analysis of four genes indicates that LCCI is in fact not in the same clade *L. culveri* as previously thought, and is most closely related to an assemblage of nontroglomorphic *Lirceus* species occurring in springs in the Powell River watershed in Lee and Wise Counties. An undescribed species occurring in Young-Fugate Cave and its resurgence spring is the most closely related to LCCI (J. Lewis, Smithsonian Institution, email to R. Agbalog, Service, November 20, 2020). Upon reexamination of specimens prompted by the molecular results, Dr. Lewis has been able to distinguish and separate these genetic clades also on the basis of morphology, lending further support to recognizing numerous species within what was once considered a single, wide-ranging epigean species (*Lirceus hargeri*). Lewis is in the final stages of a taxonomic revision of the genus *Lirceus* and his findings during this process, which will continue to further our understanding of the genus.

Since the 2014 status review (Service 2014), there have been continued efforts from partners to protect land within the range of the LCCI, which overlaps with the VDCR Cedars Natural Area Preserve. The VDCR owns 2,100 acres within the Cedars karst region of Southwestern VA (*https://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/thecedars* accessed May 5, 2021). In May 2021, the VDCR Natural Heritage Program in coordination with the VA Department of Wildlife Resources acquired additional tracts totaling 10 acres with LCCI habitat at Flanary Bridge Spring with Service Section 6 Recovery Land Acquisition grant funding (R. Evans, VDCR, email to R. Agbalog, Service, May 21, 2021), which will afford protection to the downstream end of a subterranean drainage in which the isopod occurs and direct protection to the fringe population in the spring. Other properties within the species' range containing the Golf Course Caves, and the Rabjansee tracts, which contain the Hamblin Porthole, are also included in this grant. Acquisition of these properties by conservation partners will provide increased protection of LCCI habitat, which is an objective identified in the species' recovery plan (Service 1997), other karst species, and species within the Powell River drainage. According to Orndorff (W. Orndorff, VDCR, email to R. Agbalog, Service, April 24, 2021), all extant sampling sites for the LCCI are currently owned by or under contract for purchase by either the VDCR or The Nature Conservancy for inclusion in the Cedars Natural Area Preserve and will be protected in perpetuity from land development threats. The spring along Sims Creek, south of the Lee County Airport, is not in conservation ownership, and the VDCR considers the LCCI extirpated from the site.

Conclusion:

The LCCI had been documented from sites that occur within four discrete subterranean basins. The species is currently considered extant at nine sites within three basins including the Surgener-Gallohan Cave system, the Thompson Cedar Cave system, and the Flanary Bridge Springs system. The Sims Spring population is likely extirpated. The recovery plan (Service 1997) states that reclassification to threatened may be considered when recovery criteria A and B have been met, when C and D have been underway for at least 5 years with positive results, and when E is accomplished for at least two sites. Criteria A, B, and E of the reclassification criteria have been met, while the intent of Criteria C has been met and Criteria D has been partially met.

After reviewing the best available scientific information and information from the Service's 2014 5-year review, we conclude that the LCCI should be downlisted from an endangered species to a threatened species as previously recommended in the 2014 review. The evaluation of threats affecting the species under the factors in section 4(a)(1) of the Act and analysis of the status of the species in the Service's 2014 status review remain an accurate reflection of the species current status, and additional information provided by partners for this review confirms progress has continued towards recovery of the species.

RECOMMENDATIONS FOR FUTURE ACTIONS:

To address recovery Criterion D and continue recovery efforts, which include protection of habitat (Criterion E), in order to delist the LCCI, we continue to endorse recommendations 1 and 2 from our 2014 5-year review with modifications to 1. Two new recommendations (3 and 4) will provide additional information to help inform our understanding of the species' status:

1. Continue implementing recovery actions 1.1, 2.1, 5.4, 6.2 and 9 to monitor water quality and populations of the LCCI, and track recovery progress with additional focus on the following:

    - Conduct a presence/absence assessment of the LCCI to verify presence/extirpation at Little Sims Spring, or develop a method to test for presence in blind tributaries to Sims Spring proper.

    - Continue to monitor the Thompson Cedar Cave population and water quality. *Recovery actions 1.1, 5.4 and 6.2*

    - Continue to monitor Flanary Bridge Springs system water quality. *Recovery action 5.4*

    - Conduct qualitative monitoring of extant populations. *Recovery actions 2.1*

2. Continue to pursue permanent land protection for key autogenic areas. *Recovery action 6.2*

3. Coordinate with Dr. Julian Lewis and the 1'Université Lyon in France to analyze additional specimens from all basins, and specifically individuals from Thompson Cedar

(east of Hardy Creek) and Surgener-Gallohan (west of Hardy Creek), for the ongoing molecular phylogenetics project.

4. If the Sims Spring population is extirpated, reassess the species' status using our current understanding of the populations, threats, and viability across the range.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Lee County Cave Isopod (*Lirceus usdagalun*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

__X_ Downlist to Threatened
____ Uplist to Endangered
____ Delist
____ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Recovery Priority: _14_

Brief Rational: The Lee County cave isopod has a low degree of threats and a high recovery potential.

Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number:____
Reclassification (from Endangered to Threatened) Priority Number: _6__
Delisting (removal regardless of current classification) Priority Number:____

Brief Rational: Nonpetitioned action. Low management impact.

Review Conducted By: Rose Agbalog
Fish and Wildlife Biologist
Southwestern Virginia Field Office

REGIONAL OFFICE APPROVAL:

Approve SHARON MARINO Digitally signed by SHARON MARINO Date: 2021.08.03 14:31:39 -04'00' Date _____

Assistant Regional Director, Ecological Services, North Atlantic-Appalachian Region

Literature cited

Estes, J.A. 1978. The comparative ecology of two populations of the troglobitic isopod crustacean *Lirceus usdagalun* (Asellidae). M.S. Thesis. Old Dominion University, Norfolk, VA. 85 pp.

Fong, D.W. 2009. Within and between site analysis of molecular variation in the Lee County Cave isopod, *Lirceus usdagalun*. Report to U.S. Fish and Wildlife Service, Abingdon, VA. 13 pp.

Fong, D.W. and D.B. Carlini. 2018. Molecular genetic variation among *Lirceus usdagalun, L. culveri*, and *L. hargeri* populations using next generation sequencing methods. Report to U.S. Fish and Wildlife Service, Abingdon, VA. 16 pp.

Holsinger, J.R. and T.E. Bowman. 1973. A new troglobitic isopod of the genus *Lirceus* (Asellidae) from southwestern Virginia, with notes on its ecology and additional cave records for the genus in the Appalachians. International Journal of Speleology 5:261-271.

Lewis, J.J. 2017. Examination of the taxonomic status of the Lee County cave isopod *Lirceus usdagalun*. Report to Virginia Department of Conservation and Recreation and U.S. Fish and Wildlife Service, by Lewis and Associates LLC, Biological Consulting, 37 pp.

Lewis, J.J., S.L Lewis, W.D. Orndorff, F. Malard, C. Douady, and L. Konecy. 2019. Endangered species management in an era of ever-increasing biodiversity: A case study of the molecular phylogenetics of *Lirceus hargeri*. Pages 49-55 *in* W.D. Orndorff, J.J. Lewis, K. Kosič Ficco, M.H. Weberg, and Z.W. Orndorff, eds. Proceedings of the 2019 National Cave and Karst Management Symposium, Bristol, VA.

Orndorff, W.D, and S. Hanlon. 2014. Monitoring and status survey of the Lee County Cave Isopod (*Lirceus usdagalun*) across its range, 2009-2013: Final Report. Natural Heritage Technical Report 14-12. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 103 pp.

U.S. Environmental Protection Agency. 2007. Section 319 Nonpoint source program success story, Virginia: Batie Creek restoration helps protect unique karst habitats. Report EPA 841-F-07-001O September 2007. Office of Water, Washington, DC.

U.S. Fish and Wildlife Service. 1997. Lee County cave isopod (*Lirceus usdagalun*) recovery plan. Hadley, MA.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants: Determination of endangered status for the Lee County cave isopod (*Lirceus usdagalun*). Federal Register 57(225):54722-54726.

U.S. Fish and Wildlife Service. 2014. Lee County cave isopod (*Lirceus usdagalun*) 5-year review summary evaluation. Southwestern Virginia Field Office, Abingdon, VA.

Virginia Department of Conservation and Recreation. 2021. Natural Heritage. The Cedars Natural Area Preserve. [Internet]. Richmond, VA [cited May 5, 2021]. Available from: *https://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/thecedars.*