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

SCIENTIFIC NAME: *Pseudanophthalmus parvicollis, Pseudanophthalmus hubbardi, Pseudanophthalmus praetermissus, Pseudanophthalmus limicola, Pseudanophthalmus cordicollis, Pseudanophthalmus holsingeri, Pseudanophthalmus hubrichti, Pseudanophthalmus sericus*

COMMON NAME: Hupp's Hill cave beetle, Hubbard's cave beetle, overlooked cave beetle, Shenandoah cave beetle, Little Kennedy cave beetle, Holsinger's cave beetle, Hubricht's cave beetle, silken cave beetle

LEAD REGION: Region 5

LEAD REGION CONTACT: Matthew Hinderliter, 601-720-6531, matthew_hinderliter@fws.gov

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DATE INFORMATION CURRENT AS OF: JUNE 14, 2023

STATUS/ACTION

_X__ Species petitioned for listing which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species)

_X__Nonlisted species for which we have not received a petition but for which we have undertaken a species status assessment on our own initiative and which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species) (Hupp's Hill cave beetle and Holsinger's cave beetle)

Petition Information:
_X__ Nonpetitioned
_X__ Petitioned; Date petition received: April 20, 2010
    90-day "substantial" finding FR publication date; citation: September 27, 2011 (76 FR 59836)
    12-month "warranted but precluded" finding FR publication date; citation: n/a

PREVIOUS FEDERAL ACTIONS:

On April 20, 2010, we received a petition from the Center for Biological Diversity, Alabama Rivers Alliance, Clinch Coalition, Dogwood Alliance, Gulf Restoration Network, Tennessee Forests Council, and West Virginia Highlands to list 404 aquatic, riparian, and wetland species, including 15 cave beetle species that occur in Virginia: *Pseudanophthalmus hubbardi* (Hubbard's cave beetle), *Pseudanophthalmus praetermissus* (overlooked cave beetle), *Pseudanophthalmus limicola* (Shenandoah cave beetle), *Pseudanophthalmus cordicollis* (Little Kennedy cave beetle), *Pseudanophthalmus hubrichti* (Hubricht's cave beetle), *Pseudanophthalmus sericus* (silken cave beetle), *Pseudanophthalmus avernus* (Avernus cave beetle), *Pseudanophthalmus intersectus* (crossroads cave beetle), *Pseudanophthalmus hirsutus* (Cumberland Gap cave beetle), *Pseudanophthalmus virginicus* (maiden spring cave beetle), *Pseudanophthalmus egberti* (New River Valley cave beetle), *Pseudanophthalmus pontis* (natural bridge cave beetle), *Pseudanophthalmus sanctipauli* (St. Paul cave beetle), *Pseudanophthalmus potomaca* (South Branch Valley cave beetle), *Pseudanophthalmus thomasi* (Thomas' cave beetle), as endangered or threatened species under the Act. On September 27, 2011, we published in the *Federal Register* (76 FR 59836) a 90-day finding that the petition provided substantial information indicating 374 of those species may warrant listing, including the 15 species listed above.

In a letter dated September 12, 2022, the petitioner withdrew their petition for nine of the Virginia cave beetle species citing new information indicating the species no longer merit consideration for listing (CBD 2022, entire). These nine species are Avernus cave beetle, crossroads cave beetle, Cumberland Gap cave beetle, maiden spring cave beetle, New River Valley cave beetle, natural bridge cave beetle, St. Paul cave beetle, South Branch Valley cave beetle, and Thomas' cave beetle.

This document constitutes our 12-month finding on the April 20, 2010, petition to list Hubbard's, overlooked, Shenandoah, Little Kennedy, Hubricht's, and silken cave beetles under the Act. We also assessed two additional Virginia cave beetle species (*Pseudanophthalmus holsingeri,* "Holsinger's cave beetle" and *Pseudanophthalmus parvicollis,* "Hupp's Hill cave beetle") identified by the Service and partners as species of concern as discretionary actions. We refer to these species as "the eight cave beetles" throughout this document.

ANIMAL GROUP AND FAMILY: Insects, Carabidae

ANALYTICAL FRAMEWORK

To assess the cave beetles' viability, we conducted a species status assessment (SSA) using the three conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 306–311). Briefly, resiliency supports the ability of the species to withstand environmental and demographic stochasticity (for example, wet or dry, warm or cold years, variation in demographic rates), redundancy supports the ability of the species to withstand catastrophic events (for example, droughts, large pollution events), and representation supports the ability of the species to adapt to both near-term and long-term changes in its physical and biological environment (for example, climate change, disease). A species with a high degree of resiliency, representation, and redundancy is better able to adapt to novel changes and to tolerate environmental stochasticity and catastrophes. In general, species viability will increase with increases in resiliency, redundancy, and representation (Smith et al. 2018, p. 306). Using these principles, we identified the species' ecological requirements for survival and reproduction at the individual, population, and species levels, and described the beneficial and risk factors influencing the species' viability.

BIOLOGICAL INFORMATION

Species Descriptions and Taxonomy

Cave beetles are eyeless, wingless beetles generally reddish/brown in color. The eight cave beetle species are insects in the Carabidae Family (ground beetles) under the Order Coleoptera. More specifically, they fall under the subfamily Trechinae which includes numerous genera, including *Pseudanophthalmus*. Genus *Pseudanophthalmus* beetles (within which the eight species fall) are typically 3–9 mm in size (Service 2023, pp. 2–4).

Within the genus, there are over 145 species with approximately 80 species currently undescribed (Ober 2019, slide 6). Currently, there are at least 31 described *Pseudanophthalmus* species in Virginia (Holsinger *et al*. 2013, p. 33; Malabad *et al*. 2021, p. 93). Species are differentiated primarily based on several morphological characteristics, the most informative of which are the shape, size, and features of the male reproductive appendage or aedeagus (Service 2023, p. 2–3). We have carefully reviewed the available taxonomic information to reach the conclusion that each species is a valid taxon.

<u>Habitat/Life History</u>

The eight cave beetle species are troglobites, meaning they are obligate cave dwellers and complete all phases of their life cycle within caves (Service 2023, p. v). Caves are a natural opening in solid rock with areas of complete darkness and larger than a few millimeters (mm) in diameter (Culver and Pipan 2019, p. 4–5). Caves typically form in karst landscapes that are defined as areas in which dissolution by weak acids is the primary agent shaping the landscape, as opposed to erosion, volcanoes, and earthquakes (Culver and Pipan 2019, p. 4–5). Most solution caves form in carbonate (limestone or dolostone) bedrock.

Caves tend to have fairly stable environments (constant temperature, humidity, etc.) when compared to surface environments but they are not entirely static; seasonal fluctuations in parameters like airflow and water levels provide temporal variability in food introduction rates and may act as cues for reproduction in cave species (Hawes 1939, entire). Most cave and other subsurface communities must therefore rely on food that is transported in from the surface environment. Primary mechanisms for the introduction of organic matter, nutrients, and energy into caves include water percolating from the surface, flowing water from sinking streams, wind, and gravity (i.e., leaves blowing into entrances or animals falling into entrances or sinkholes and dying), and active movement of animals in and out of caves (Culver and Pipan 2019, p. 25).

Pseudanophthalmus cave beetles typically inhabit riparian mudbanks and other moist areas within limestone caves (Lewis 2001a, p. 5). Sediment deposits on which cave beetles are found in Virginia often exhibit bioturbation, or evidence of the sediment having been processed through the digestive tract of other animals like millipedes, centipedes, and earthworms. Other notable habitat features where *Pseudanophthalmus* have been collected in Virginia include mud cracks, fine silt, woody debris, cobbles, and rocks. It is difficult to interpret these microhabitat features in terms of individual needs because we know so little about the life history of these species. It is common for other carabid beetles to prefer areas where they may seek shelter (hence the mudcracks, rocks, cobbles, and woody debris) and it is likely, again based on other carabid beetles, that females lay eggs in moist silty areas. The combination of moisture and organic material also likely presents the right circumstances for their prey items to be available. The individual needs that seem clear are that karst environments with water or moisture are necessary for beetles to be present; they have not been observed outside of caves or in completely dry caves.

Cave beetles are generally predatory and carnivorous, most likely feeding on mites, springtails, and opportunistic items, including beetle eggs and larvae. Several USDA reports on cave beetle species report that "The primary food source of *Pseudanophthalmus* is enchytraeid and tubificid worms found associated with cave mudbanks" (Lewis 2001a, b, and c, p. 4; Lewis 2002, p. 5). Two species of cave beetle in Kentucky have been documented with different and specific prey preferences including cave cricket eggs and nymphs (*Neaphaenops tellkampfii*) and Collembola (*Pseudanophthalmus menetriesii*) (Kane and Poulson 1976, entire). While it is not clear exactly what each species eats, experts are confident that they forage at a higher trophic level than some other cave invertebrates; they have not been observed associated with mammal scat like some other troglobites that feed on the associated bacterial and fungal growth (Service 2023, p. 2–5).

Because we have no information regarding the reproductive cycle of *Pseudanophthalmus* beetles directly, we assume that life history information for other surface-dwelling carabid beetles is a reasonable surrogate. Carabid beetles typically have four life stages: egg, pupae, larvae, and adult. After internal fertilization, females lay one egg at a time, multiple times during the breeding season, most likely in moist, silty areas. Carabid beetles generally have three larval instars and then pupate to adults (Lovei and Sunderland 1996, p. 234). Larvae are undescribed for the entire *Pseudanophthalmus* genus. It is unclear how long cave beetles remain in the larval stage but close relatives that are surface-dwelling have a life cycle of approximately 1 year (Lovei and Sunderland 1996, p. 234). Several U.S. Department of Agriculture (USDA) conservation assessment reports for cave beetle species report that nothing is known of the life history of *Pseudanophthalmus* beetles; however, one expert explains that "in most of the troglobitic carabid beetles of eastern North America egg laying is timed for the fall, because food is generally more prevalent then. Larvae appear in the winter, pupae in the late winter and early spring, then tenerals [freshly molted adults that are not yet sclerotized] start appearing in June and July. The beetles are almost all fully sclerotized by fall. Although this is a typical life history, the availability of food can change the cycle" (Lewis 2001a, b, and c, p. 4; Lewis 2002, p. 5). Differences may exist between species as well as between populations of the same species in terms of egg production; one species in a study showed clear seasonality in egg production with a sharp peak of gravid females in the fall, whereas the two other species did not display any clear seasonal pattern in egg production (Kane and Ryan 1983, entire). Closely related species and even different populations of the same species can exhibit significantly different reproductive characteristics. In the absence of this information specific to the eight species in this assessment, we cannot reliably assume what these life history details may be for any population of any species based on proxy information (Service 2023, p. 2–5).

<u>Range/Distribution</u>

Cave beetles in the genus *Pseudanophthalmus* range throughout the karst systems from southern Indiana to northern Georgia and Alabama, and from western Kentucky to northern Virginia (see figure 1). *Pseudanophthalmus* species occur primarily in two geomorphic provinces that underlie this geographic range: the Interior Lowland Plateau (ILP) and the Appalachian Valley and Ridge (AVR). The two systems result in different implications for the speciation and subsequent ecology of *Pseudanophthalmus* beetles in the two regions (Service 2023, p. 2–2).
The eight focal cave beetle species are found in Virginia throughout the AVR's geologically unique limestone formations. Uplift, erosion, and dissolution of the faulted and folded strata of the AVR have produced isolated belts of karst topography with numerous caves, where carbonate bedrock is exposed in the valleys and flanks of ridges capped with non-cave forming rocks.

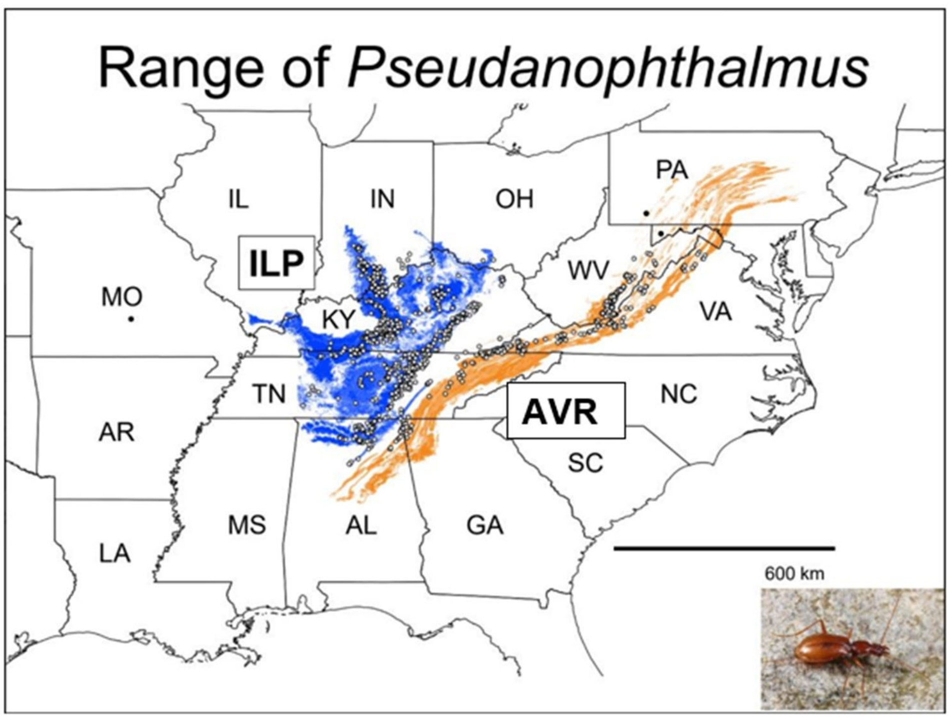

Figure 1. Range map for the genus *Pseudanophthalmus* (Ober 2019, slide 7). Appalachian Valley and Ridge (labeled "AVR") is the geomorphic province in which the eight focal cave beetle species are located in Virginia.

Karst experts at Virginia Division of Conservation and Recreation (VADCR) delineated ranges for the eight cave beetle species individually using a consistent approach. They included the extent of contiguous karst surrounding known cave locations for each species, with the assumption that caves within contiguous belts of karst may be interconnected via subterranean pathways not discernable by researchers. The borders of the ranges were determined by several factors including physical features likely to be barriers to further dispersal (nonkarst geology, large water bodies, etc.) and the nearest observations of a different species, assuming that for the most part the species are allopatric and do not co-occur. In some cases, species ranges include nonkarst areas between known species locations and these cases are noted in the species sections. The species ranges represent the best data available on potential suitable habitat, but in many cases, range maps would likely change with additional survey effort over time (Malabad *et al*. 2021, entire) (see figures 2 through 9).

We have no direct information regarding population structure or connectivity for all eight species. The VADCR NHP keeps element occurrence (EO) records for all species observations in Virginia. For cave beetles, EOs often consist of a single cave site, but when caves are known or likely to be connected in some way allowing for potential dispersal between sites for cave-obligate species, sites are grouped together into a single EO (Service 2023, p. 5–2). The spatial area delineated for each cave beetle EO is essentially the footprint of the cave (or caves) where the species has been recorded (see figures 2 through 9). Given the lack of information regarding population structure or connectivity for each species, we rely on EOs as delineated by VADCR and consider them to be the most appropriate representation of discrete analysis units for each species.

VADCR also delineates conservation sites that are associated with EOs and represent the area surrounding the EO within which activities or events have the potential to impact the habitat or species associated with each EO. Conservation sites are assigned a biodiversity significance rank (Service 2023, p. 5–2). The cave footprints/species EOs are used as anchors to delineate cave conservation sites, and then geology, topography, and drainage characteristics are considered, along with dye tracing results where available (T. Malabad, VADCR, email to K. Maison, Service, 4/5/2022). We use cave conservation sites delineated by VADCR as the geographic areas of analysis of impacts to each species (see figures 2 through 9). In summary, analysis units are the EOs and represent our best estimation of "populations" or ecologically meaningful units that are separate from one another. Conservation sites are the geographic areas of analysis for threats that may be affecting each EO.

Hupp’s Hill Cave Beetle

Since its discovery and description, Hupp’s Hill cave beetle has been recorded from two cave locations within one contiguous belt of limestone spanning Shenandoah and Frederick Counties. The belt of limestone runs northeast under Cedar Creek. At Battlefield Crystal Caverns, Hupp’s Hill cave beetle was first collected in 1928 and the most recent observation of the species at this site is listed in the EO record as “pre-1981” despite eight visits to the cave between 2016 and 2021 by VADCR (Service 2023, p. 6–1). The species is assumed to have been extirpated from Battlefield Crystal Caverns as a result of commercial cave operations’ ventilation fans altering habitat (Service 2023, p. 6–1) so that it is no longer suitable for the species. Additionally, the peninsular extension of limestone where Battlefield Crystal Caverns occurs is bound to the southeast by U.S. Route 11 and associated commercial development and to the northwest by limestone quarrying that intersects the water table. Battlefield Crystal Caverns is no longer connected to the rest of the karst belt due to quarrying activity; thus, quarrying, development, and roads have been potential stressors in the Battlefield Crystal Caverns vicinity (Service 2023, p. 6–3).

At the second location, Ogden's Cave, a single specimen of Hupp's Hill cave beetle was first collected in 2005, prior to which the species was thought to be extinct by VADCR biologists (Service 2023, p. 6–1). Another single specimen was collected at this location in 2014 (Service 2023, p. 6–1). There were five additional cave visits between 2016 and 2018 that yielded no collections. Ogden's Cave is located in the 131-acre VADCR-managed Ogden's Cave Natural Area Preserve (NAP) (Service 2023, p. 6–1).

The two locations for the Hupp's Hill cave beetle are treated as two separate EOs (Service 2023, p. 6–3). Currently, the total species range, including both locations, as delineated by VADCR, consists of 25.37 square kilometers (km^2) (9.80 square miles [mi^2]) (figure 2) (Service 2023, p. 6–1). Hupp's Hill cave beetle may be extant at other caves that have not been surveyed to the northwest of its current location (Service 2023, p. 6–2). VADCR suggests future surveys and conservation should focus on areas northwest of quarrying on both sides of Cedar Creek (Service 2023, p. 6–3). We use the Ogden's (8.55 km^2, 3.30 mi^2) and Hupp's Hill (0.46 km^2, 0.18 mi^2) conservation sites as the geographic areas to evaluate threats that may be impacting the species and its habitat currently and in the future (figure 2).

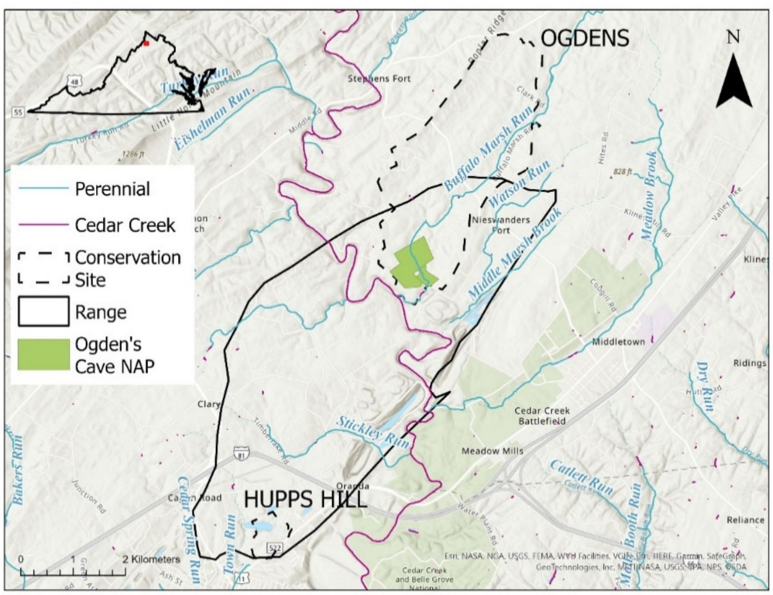

Figure 2. Hupp's Hill Cave Beetle Range and Conservation Sites

Hubbard's Cave Beetle

Hubbard's cave beetle has historically been collected from one location and as such is currently considered a single site endemic. Hubbard's cave beetle has a range of 0.2 km^2 (0.08 mi^2) (figure 3) (Service 2023, p. 6–8). The confirmed location for this species is Luray Caverns in Page County, VA. The first discovery and collection of the species in Luray Caverns was in 1884, when a single specimen was collected (Service 2023, p. 6–8). An unknown number of specimens were collected again in 1980 and the most recent collection of a live specimen of Hubbard's cave beetle was in 1996 (Holsinger *et al*. 2013, p. 36). No additional live specimens were collected in four site visits to the known location between 2016 and 2021 (Service 2023, p. 6–8). Despite not collecting any live specimens of Hubbard's cave beetle during survey efforts from 2016-2021, VADCR biologists still consider the species likely to be extant (because of abundant suitable habitat for the species in non-commercial sections of Luray Caverns) and recommend additional surveys efforts to confirm the species at Luray Caverns and potentially other unsurveyed caves within the contiguous belt of limestone (Service 2023, p. 6–8, Malabad *et al*. 2021, p. 40).

The majority of land within the species range and the Luray-Ruff conservation site is owned by the Luray Caverns Corporation (Service 2023, p. 6–8). Within the conservation site, there are several additional privately owned parcels on the southern end of the site (Service 2023, p. 6–8).

We use the Luray-Ruff conservation site (2.02 km^2 or 0.78 mi^2) as the geographic area to evaluate threats that may be impacting the species and its habitat currently and in the future (figure 3).

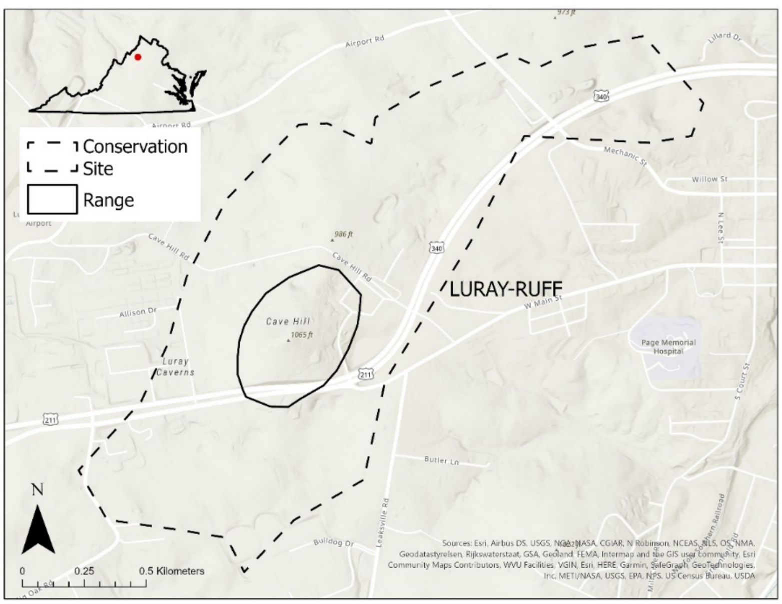

Figure 3. Hubbard's Cave Beetle Range and Conservation Site

Overlooked Cave Beetle

The overlooked cave beetle has historically been collected from one location and as such is currently considered a single site endemic with a range of 0.12 km^2 (0.05 mi^2) (figure 4) (Service 2023, p. 6–12). The species was described based on collections on two separate occasions (1969 and 1979) from Kerns Cave No. 1 (on private property) in Scott County, VA (Service 2023, p. 6–8). In the original species collections, a total of four individuals were collected (Barr 1981, p. 88). VADCR visited Kerns Cave No. 1 four times between 2015 and 2020 and did not collect additional specimens (Service 2023, p. 6–8). Despite not collecting any specimens of the overlooked cave beetle during 2015-2020 survey efforts, VADCR biologists consider the species likely to be extant and recommend additional surveys to confirm the species at the known location and potentially other unsurveyed caves within the contiguous belt of limestone (Malabad *et al*. 2021, p. 74–75).

Land surrounding the cave is entirely privately owned in forested residential parcels. The upper slopes of the watershed that drain toward the cave are largely in U.S. Forest Service (National Forest) or private ownership, with predominantly forested land use (Service 2023, p. 6–13).

The Kerns conservation site (1.03 km^2 or 0.40 mi^2) is the single geographic area for our current and future threats analyses (figure 4).

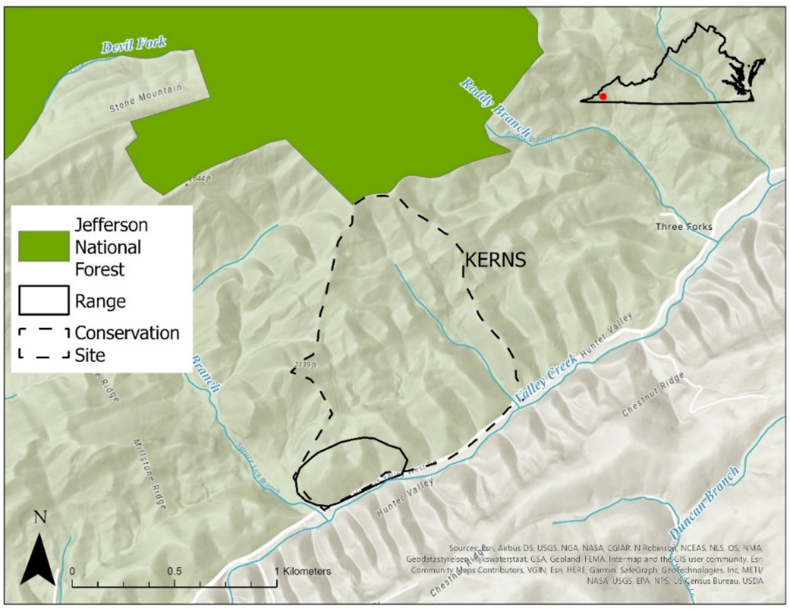

Figure 4. Overlooked Cave Beetle Range and Conservation Site

Shenandoah Cave Beetle

Shenandoah cave beetle has historically been collected from four caves: Shenandoah Caverns, Shenandoah Wild Cave, and Madden's Cave in Shenandoah County, VA and Bakers Cave in Rockingham County, VA (figure 5) (Service 2023, p. 6–17). The species was first collected from Shenandoah Caverns in 1962, in unknown quantity; no surveys have been carried out since at this location. The species was first collected at Shenandoah Wild Cave in 1962 (in unknown quantity) which represents the most recent observation at this site despite five visits between 2015 and 2021 by VADCR (Malabad *et al*. 2021, p. 53–54). The species was first collected from Madden's Cave (in unknown quantity) prior to its description in 1931 and no known surveys have been conducted at Madden's Cave since (Service 2023, p. 6–17). The species was first collected from Bakers Cave in 1994 with two individuals collected and confirmed extant in Bakers Cave with the collection of two individuals in 2016 (Service 2023, p. 6–17). In summary, during survey efforts between 2015 and 2021, VADCR biologists were able to survey only two of the four caves; Madden's Cave could not be located, and Shenandoah Caverns is a commercial operation that could not be accessed for sampling (Service 2023, p. 6–17).

Currently, the known species range as delineated by VADCR consists of 33.89 km^2 (13.08 mi^2); land use within the species range is largely agricultural (Service 2023, pp. 6–17, 6–18). This range lies within a 300-mile-long exposure of limestone and VADCR biologists indicate it is likely that the Shenandoah cave beetle's range is larger than what current sampling efforts suggest (Malabad *et al*. 2021, p. 54).

We consider the Shenandoah cave beetle to have three analysis units (Service 2023, p. 6–18): Shenandoah Wild Cave/Shenandoah Caverns, Madden's Cave, and Bakers Cave (Service 2023, p. 6–18).

VADCR has established conservation sites associated with these analysis units (EOs) that delineate the area of influence surrounding each cave (Service 2023, p. 6–18). We use three conservation sites (Shenandoah Parade, 0.55 km^2 or 0.21 mi^2; Dove Maddens, 1.64 km^2 or 0.63 mi^2; and Bakers, 3.16 km^2 or 1.22 mi^2) as the geographic areas for our current and future threats analyses (figure 5) (Service 2023, p. 6–18).

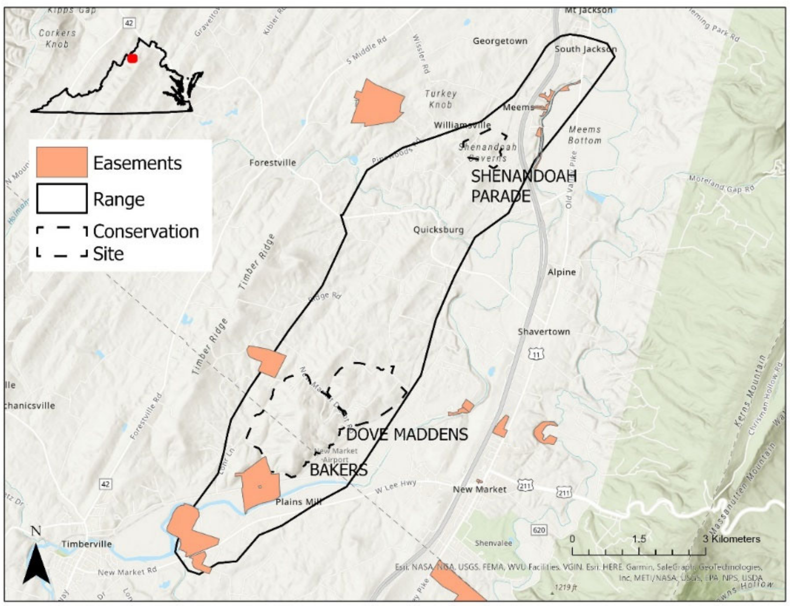

Figure 5. Shenandoah Cave Beetle Range and Conservation Sites

Little Kennedy Cave Beetle

The Little Kennedy cave beetle has been collected from eight caves all within Wise County, VA (Service 2023, p. 6–23). Currently, the known species' range as delineated by VADCR consists of 89.3 km^2 (34.48 mi^2) (figure 6) (Service 2023, p. 6–24). The eight caves are grouped into five EOs:

- Little Kennedy and Big Kennedy Caves -- Little Kennedy cave beetle was first observed in Little Kennedy cave in 1970, observed again in the mid-1990s, and most recently collected in 2017 (Service 2023, p. 6–23). The species was collected for the first time from Big Kennedy Cave in 2017 (Service 2023, p. 6–23). The most recent survey at both locations in 2020 yielded no specimens (Service 2023, p. 6–23).
- Omega and Parsons Caves -- The species was first collected from Omega Cave in 2003,

and again in 2016 and 2017 (Service 2023, p. 6–23). The species was collected from Parsons Cave in 2018 (Service 2023, p. 6–23).
- Wildcat Cavern and Wildcat Saltpetre -- The first collection of the species from Wildcat Saltpetre cave was likely prior to 2004 and may have actually included observations in both caves (T. Malabad, VADCR, email to K. Maison, Service, 11/21/22). There have been no new surveys in Wildcat Saltpetre cave. The species was collected from Wildcat Cavern in 2016 (Service 2023, p. 6–23).
- Kelly Cave -- The species was collected from this site in 2017 (Service 2023, p. 6–23).
- Abe's Abyss -- The species was collected from this site in 2021 (Service 2023, p. 6–23).

A proportion of the land within the Greenbriar limestone part of the species' range is in the Jefferson National Forest (see figure 6) (Service 2023, p. 6–25). The portion of the species' range in the Hancock limestone formation consists of privately owned lands with a combination of forested and agricultural land uses (Service 2023, p. 6–25).

We used VADCR-established conservation sites as the geographic areas of threats analysis for each analysis unit; Wildcat (2.91 km^2, 1.12 mi^2), Kennedy (0.56 km^2, 0.22 mi^2), Cracker Neck (10.49 km^2, 4.05 mi^2), East Stone Gap (3.63 km^2, 1.40 mi^2), and Kelly (1.12 km^2, 0.43 mi^2) conservation sites were analyzed for this species (Service 2023, p. 6–25).

In 2015-2021 survey efforts, 14 individuals were collected from seven caves (Table 1) (Service 2023, p. 6–25).

Table 1. Little Kennedy cave beetle survey visits and total species counts (2015-2021).

Cave (Grouped into EOs)	No. of Visits	Total No. Confirmed Individuals
Little Kennedy	3	2
Big Kennedy	3	1
Kelly*	4	1
Omega*	4	4
Parsons	6	1
Abe's Abyss	1	2
Wildcat Cavern	1	3
Wildcat Saltpetre*	0	N/A

*Kelly Cave and Omega Cave have additional collections that are pending identification and were not included in these calculations. Wildcat Cavern and Wildcat Saltpetre caves are grouped into one EO. Records for the Wildcat caves are unclear as the names of the caves have sometimes been confused in the field notes (T. Malabad, VADCR, email to K. Maison, Service, 11/21/22).

Caves with Little Kennedy cave beetle records are split between two separate belts of limestone. Big Kennedy, Little Kennedy, Omega, and Kelly Caves lie within a single belt of Greenbrier limestone (Service 2023, p. 6–23). Wildcat Cavern, Wildcat Saltpetre Cave, and Abe's Abyss are in a Hancock Formation (Service 2023, p. 6–23). A significant talus pile (collection of rocks at the base of a cliff, slope, etc.) occupies the space between the two limestone exposures, providing a possible migration route for the subterranean species (Malabad *et al*. 2021, p. 23).

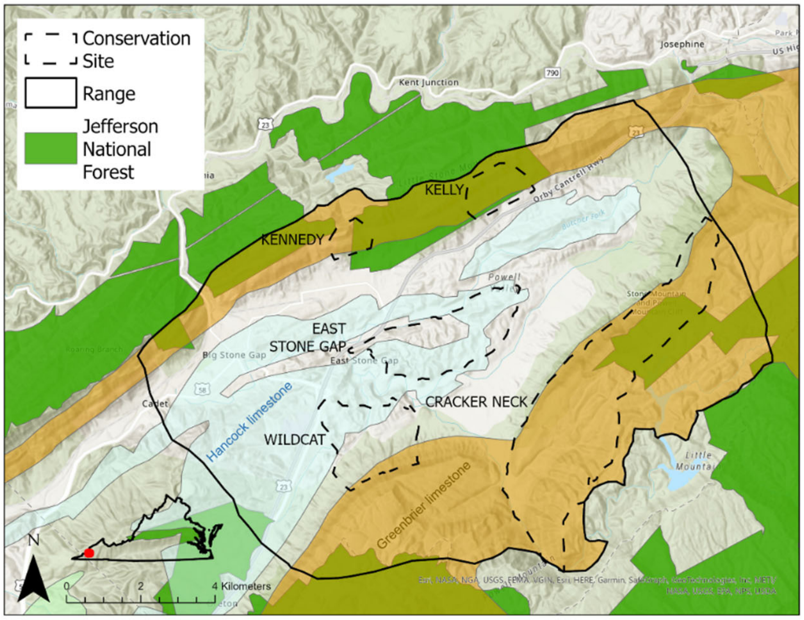

Figure 6: Little Kennedy Cave Beetle Range and Conservation Sites

Holsinger's Cave Beetle

Holsinger's cave beetle has been collected from Young-Fugate Cave in Lee County, VA (Service 2023, p. 6–29). It was first collected in 1962, and the collection totaled eight individuals (Service 2023, p. 6–29). In 1965 10-20 beetles were observed, one individual was observed in 1999, and 13 individuals were observed in 2000 (Hobson 2001). During 2015-2019 survey efforts, VADCR biologists confirmed the species is extant with the collection of 13 individuals and observation of 36 additional beetles (Malabad *et al*. 2021, p. 35). Currently, the known species range as delineated by VADCR consists of the 0.26 km^2 (0.1 mi^2) footprint of a single cave (Young-Fugate Cave) (figure 7) (Service 2023, p. 6–29). The species' range may extend beyond this area; however, the best available information indicates it is a single site endemic (Malabad *et al*. 2021, p. 37).

We used the VADCR-established Young Fugate conservation site (4.58 km^2 or 1.77 mi^2) as the geographic area for threats analysis for Holsinger's cave beetle; the Young Fugate conservation site (figure 7) (Service 2023, p. 6–30). The cave entrance is located on private land, and the landowners strictly prohibit entry into the cave (Service 2023, p. 6–30).

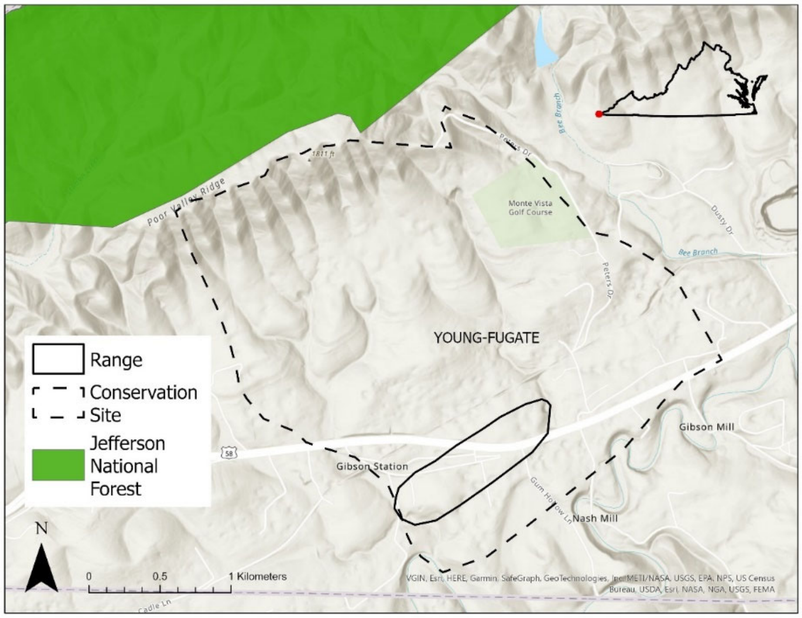

Figure 2: Holsinger's Cave Beetle Range and Conservation Site

Hubricht's Cave Beetle

Hubricht's cave beetle was historically known from Daugherty Cave in Russell County, VA and then collected from Bundy's Cave No. 2 (within the same county) in 2020 (Service 2023, p. 6–34). The known species range as delineated by VADCR consists of 19.18 km^2 (17.41 mi^2; figure 8) (Service 2023, p. 6–34). Additional caves in the Sinking Creek/Grays Water Cave basin (Russell County, VA) should be considered likely locations for additional populations of Hubricht's cave beetle (Service 2023, p. 6–34). Bundy's Cave No. 2 represents a site near the upstream end of the drainage, and Daugherty Cave is at the downstream end of the drainage of that basin (Service 2023, p. 6–34).

Private ownership with agricultural land use dominates within the range of Hubricht's cave beetle. A large portion of the species' range consists of open pastures used for livestock and hay production.

Daugherty Cave and Bundy's Cave No. 2 are identified as two individual EOs. VADCR has established a single conservation site associated with these two EOs that delineates the area of influence surrounding the caves. We use the VADCR-established Lebanon Sinking conservation site (12.37 km^2 or 4.78 mi^2), which encloses both EOs, as the geographic area for our current and future threats analysis (figure 8).

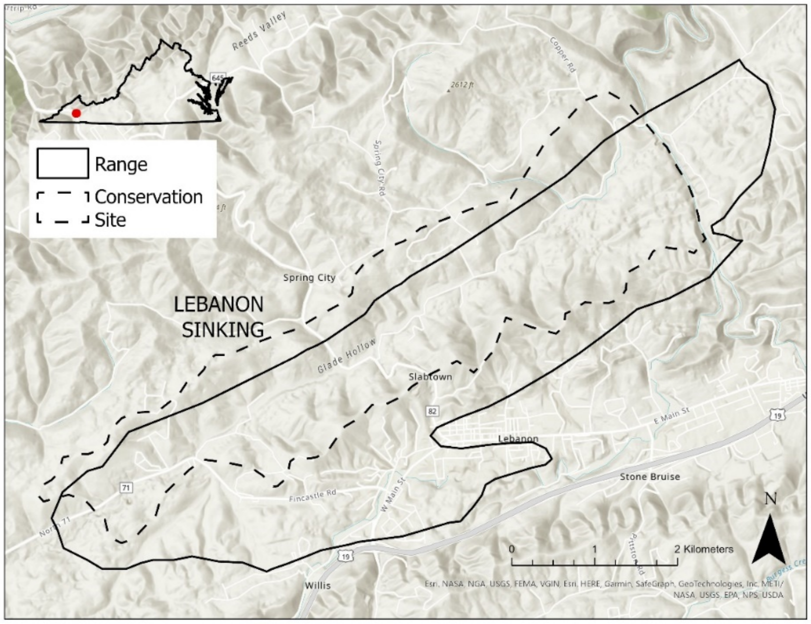

Figure 3: Hubricht's Cave Beetle Range and Conservation Site

Silken Cave Beetle

The silken cave beetle has historically been collected from Lane Cave in Scott County, VA (Service 2023, p. 6–38). VADCR biologists made two visits to Lane Cave (August 2016 and October 2019) and collected or observed a total of 22 beetles (Service 2023, p. 6–38). The estimated area of the known range is 0.24 km^2 (0.09 mi^2) (figure 9) (Service 2023, p. 6–38). The outcrop belt of contiguous limestone within which the species exists continues over 80.5 km (50 mi) in each direction (northeast and southwest) (Service 2023, p. 6–38).

The best available information indicates the silken cave beetle is a single site endemic within a single analysis unit (Service 2023, p. 6–39). VADCR has established the Coley Herron conservation site (5.31 km^2 or 2.05 mi^2) that delineates the area of influence surrounding the cave; this site is our geographic area for threats analyses (figure 9) (Service 2023, p. 6–39).

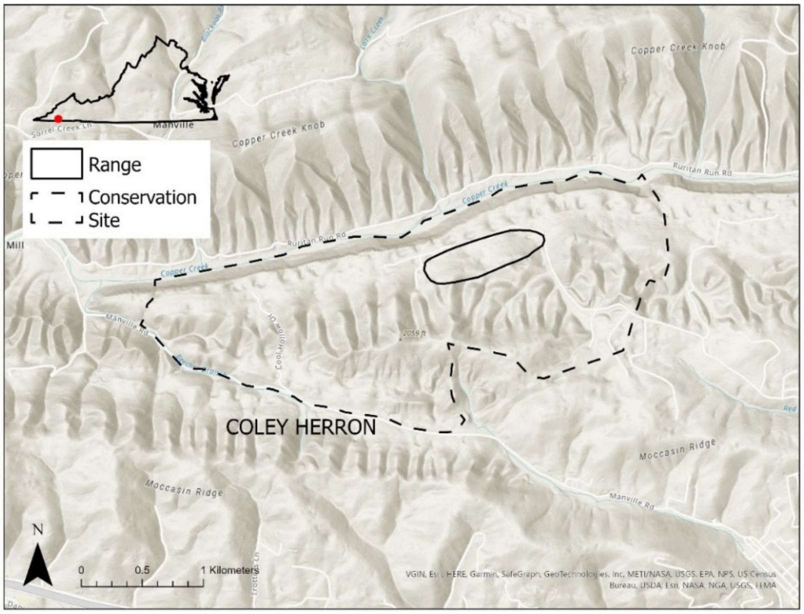

Figure 9: Silken Cave Beetle Range and Conservation Site

<u>Population Estimates/Status</u>

No direct data are available to estimate population size or structure for any of the eight cave beetle species. Available data on occurrences provide some insight into presence and absence of the species but cannot reliably be used to infer current population condition. Cave beetles are cryptic species that can be hard to locate within their habitats.

Most caves likely undergo seasonal fluctuations in moisture that may influence the distribution of cave fauna within the system, and potentially impact ease of survey detection at certain times. Moreover, the nature of caves and karst systems is that there is presumed to be a large portion of area that is accessible to cave beetles (but not to humans), including cracks and crevices that may extend long distances and connect to unknown caves.

For these reasons, it is generally anticipated that cave beetles continue to persist at known sites when habitat remains healthy and suitable. Even if a species has not been observed after numerous surveys at a given site, experts are unwilling to surmise that it has been extirpated from that site if their observations reveal that suitable habitat still exists within the cave (Service 2023, p. 5–1). As such, it is not possible to reliably assess abundance for any of these species.

It is important to note that in most cases, karst areas between known localities have not been adequately sampled and the true extent of each species range is a major source of uncertainty, impacting estimates of the number of populations, the potential for genetic connectivity between localities, and our understanding of both current representation and redundancy for these species (Service 2023, p. 5–6).

For additional information on the species description, taxonomy, habitat/life history, historical and current range/distribution please refer to the SSA report. For additional information on population and species needs, please refer to pp. 3–1 to 3–2 of the SSA report.

FACTORS INFLUENCING THE STATUS

The Act directs us to determine whether any species is an endangered species or a threatened species because of any factors (or threats) affecting its continued existence (i.e., whether it meets the definition of a threatened species or an endangered species). We use the term "threat" to refer in general to actions or conditions that are known to or are reasonably likely to negatively affect individuals of a species. The term "threat" includes actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The term "threat" may encompass—either together or separately—the source of the action or condition, or the action or condition itself.

However, the mere identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In determining whether a species meets either definition, we must evaluate all identified threats by considering the expected response by the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Secretary determines whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and (if evaluating whether a species is a threatened species) in the foreseeable future.

<u>Threats, Conservation Measures, and Existing Regulatory Mechanisms</u>

THREATS

Potential threats for *Pseudanophthalmus* cave beetles in Virginia include quarries/mining, cave visitation, timbering, urbanization, agriculture, and climate change (figure 10). While we evaluated the magnitude and significance of each of these potential influences for each species, it is unclear whether certain environmental changes, like changes in water quality for example, may have an impact on individuals, and if so, what magnitude of change would rise to the level of a response, or what that response may be (Service 2023, p. 4–5). The magnitude of various stressors that *Pseudanophthalmus* individuals or populations can withstand represents a critical source of uncertainty in the assessment process. These uncertainties severely limit our ability to estimate the relative impacts of various threats on species' conditions using an empirical approach. Because the SSA framework seeks to characterize the current and future conditions by explicitly considering species' responses to potential stressors (Smith *et al.* 2018, entire) and few empirical data are available on species' historical or current condition, our assessment relied on expert knowledge to evaluate uncertainty in future viability and how threats may impact populations of the eight Virginia cave beetles. As such, we have focused our assessments on influencing factors that we have reasonable confidence may rise to the level of negative effects on analysis units, if impacting the site, while including additional discussion of other impacts for which there is high uncertainty in terms of their potential to affect viability (Service 2023, p. 4–6).

There is support in scientific literature that physical alterations to cave structure and changes to established hydrologic patterns within caves can have significant impacts to the cave environment and associated biological communities (Simoes *et al*. 2015, p. 104). As such, we have identified alterations to the physical structure of caves and changes to the water table and/or hydrology of cave systems as the primary factors to assess for their potential to impact the viability of cave beetle species. Because most cave beetle species are associated with riparian habitat, we make the conservative assumption that compromised water quality may result in indirect impacts to cave beetle species (Service 2023, p. 4–6). We identified the causes associated with these factors to include quarrying, commercial operations inside the cave, and urbanization/development (Service 2023, p. 4–6). Accordingly, we consider these to be the primary factors potentially affecting the viability of the eight cave beetle species. These potential threats are summarized below, and any evidence of these threats acting on the eight cave beetles is summarized in the CURRENT CONDITION section, below. Protection, management, and conservation measures that may improve the species' viability are also summarized below.

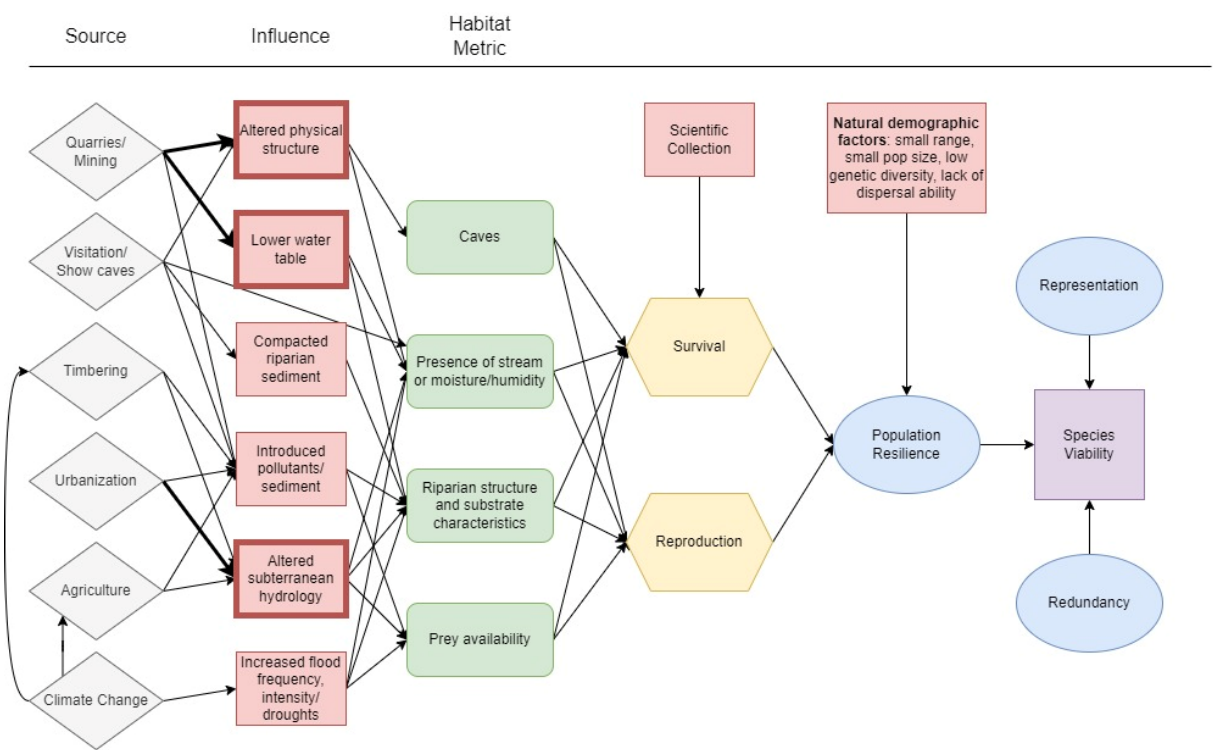

Figure 10: Conceptual Model Influence Diagram for Cave Beetles in Virginia

Quarrying

Quarrying is a type of open-pit mining where stone, minerals, or other materials are extracted from the ground (Service 2023, p. 4–1). Limestone deposits are typically quarried to supply materials for the building and construction industry (Service 2023, p. 4–1). Quarrying is analyzed for the eight cave beetles species; Hupp's Hill cave beetle range includes quarrying activity. The three primary ways that quarrying may affect cave environments are physical alterations to the cave's structure, changes to the cave's established hydrological system, and impacts to water quality. Every cave is unique but even small physical alterations have the potential to change long-established stable habitat parameters including temperature or light (e.g., through opening enclosed spaces), air flow or humidity (e.g., using industrial fans), or water flow (e.g., diverting streams), all of which, in turn, can affect the biological community (Langer 2001, p. 13). Groundwater flows through a network of underground conduits and caves in karst systems (Service 2023, p. 4–1). Altered flow may result from physical changes to caves like new cracks that divert a stream from its established flow path (Service 2023, p. 4–1). Quarrying also has the potential to affect water quality by introducing pollutants into the groundwater system, and to remove vegetation and soil overlying the system that serves as a zone of filtration and water purification for surface water that percolates into the cave environment (Hobbs and Gunn 1998, p. 147).

Development/Urbanization

As human populations increase and developments expand into previously rural areas, there can be a variety of significant impacts to the natural environment. Impermeable surfaces (pavement for example) can lead to changes in hydrology of surface water and increased runoff with contaminants that enters groundwater systems. Development is often associated with changes to the water table as drinking water is either sourced from groundwater aquifers or surface water recharge gets routed to subterranean aquifers for storage and extraction. In karst systems, changes to surface and groundwater hydrology can result in significant impacts to the biological communities that depend on long-established and fairly stable habitat conditions within caves (Service 2023, p. 4–1). Development also typically coincides with road construction which can have physical impacts to cave systems from blasting, and also can bring traffic into previously inaccessible areas. Increasing the proximity of roads to cave environments can result in potential spills, run-off, trash, and introduction of other contaminants that may wash in from new surface roads and run-off patterns (Service 2023, p. 4–2).

The metric we use for future projections of impacts from urbanization/development is projected changes in impervious surfaces (Service 2023, p. 5–7). We also use projected changes in county (human) populations as an indicator of road usage and future development potential (Service 2023, p. 5–7). We looked at projections of these metrics for the years 2020, 2040, and 2070 to determine the change in these parameters from current out to two timesteps in our future conditions. Following the classifications provided in Theobald *et al*. (2009, p. 364), we classify the impact of impervious surface on conservation sites as follows: Unstressed (0-0.9 percent), Lightly stressed (1-4.9 percent), Stressed (5-9.9 percent), Impacted (10-24.9 percent), and Damaged (>25 percent) (Service 2023, p. 5–7). Currently all species' cave habitats are lightly stressed per this classification, with the exception of overlooked cave beetle, which is unstressed.

Commercial Cave Tour Operations

The effects of commercial cave tour operations within a cave can be numerous and depend on the frequency and size of cave tours, the extent of modifications like light and stairway/walkway installation, and the proportion of the cave that is accessed by tour groups (Service 2023, p. 4–2). In general, effects may include changes to air circulation, humidity, CO^2 concentration, temperature, organic matter input, chemical pollutants, and noise (causes and effects of these alterations are synthesized by Constantin *et al.* 2021, p. 3). The installation of lights can create a growing environment for fungi and algae that would not typically be able to survive inside caves, which may encourage nonnative inhabitants (Service 2023, p. 4–2). The construction of new or additional entrances for ease of access for large groups can affect humidity, temperature and other abiotic parameters within the cave (Service 2023, p. 4–2). Visitors introduce trash, and lint, dust, and spores from their clothing can deteriorate speleothems (mineral formations or deposits found in caves) and further promote the growth of fungi and algae (Service 2023, p. 4–2). To manage fungi and algae that develop, cave operators may deploy biocides that may impact native cave fauna, many of which are not well studied or understood. Hupp's Hill, Hubbard's, and Shenandoah cave beetles occur (Shenandoah Caverns, Shenandoah Wild Cave, Luray Caverns), or have occurred (e.g., Battlefield Crystal Caverns for Hupp's Hill cave beetle), in caves with either active or inactive commercial tour operations. It is unclear to what extent the many commercially related modifications that have been made may be impacting the species.

Timbering and Agriculture

Timbering and agriculture both have the potential to alter hydrology and introduce sediment and pollutants into cave systems (Service 2023, p. 4–2). Timbering or logging in areas with karst geology can result in the introduction of sediments into cave systems, and in extreme cases, the erosion and removal of the epikarst layer (the carbonate bedrock between the surface and the cave, which forms the cave ceiling) that serves to filter surface water before it enters the cave system (Service 2023, p. 4–2, 5–2). Overlooked and Little Kennedy cave beetles occur in the vicinity of National Forests where logging may occur; however, the U.S. Forest Service is required by the 2012 Planning Rule to develop and implement forest management plans to protect and restore National Forests and Grasslands for the benefit of communities, natural resources, and the environment (77 FR 21162–21260) (Service 2023, p. 4–3). In addition, the U.S. Forest Service manages caves and karst resources consistent with the 1988 Federal Cave Resources Protection Act (the purposes of which are to (1) secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people; and (2) to foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, education, or recreational purposes) and in accordance with the multiple use mission of the U.S. Forest Service (Service 2023, p. 4–3). Timbering activities do not appear to be a significant threat to the eight cave beetle species (Service 2023, p. 4–2).

Agriculture is a common land use throughout the collective ranges of the eight cave beetle species in rural parts of Virginia (Service 2023, p. 4–3). However, agricultural lands in the region are primarily hay or pasture versus row cropping; row cropping tends to involve more manipulation of surface hydrology and chemical applications (Service 2023, p. 4–3). VADCR biologists have noted that agriculture within the ranges of the eight cave beetles appears to be a compatible land use with species persistence (USFWS-VADCR 10/25/2021 pers. comm.).

Climate change

We have insufficient information to determine whether climate change is reasonably considered a potential stressor to cave environments. The impacts of climate change on cave environments are not well studied (Service 2023, p. 4–3). Caves and cave species have persisted through many large-scale landscape changes throughout geologic history, but current rates of climatic changes are unprecedented (Service 2023, p. 4–3). To the extent that climate change may result in increased temperatures within the ranges of the cave beetles, studies suggest that maintenance of physiological tolerance to high temperature up to some point (around 20ºC in most studies) might not pose an excessive energetic cost for subterranean beetle species (Colado *et al*. 2022, p. 7). The implications of these findings are that, at least in the cases of the studied lineages of subterranean beetle species, if exposed to climatic conditions and rates of change unprecedented in their evolutionary history, in most cases temperatures will still be within their tolerance limits and may not result in excessive energetic costs. However, there are a number of variables that make it difficult to apply these results to the eight species, given we do not have information on their specific thermal tolerances.

Another potential effect of future climatic changes is changes in precipitation leading to changes in drought and flooding frequency and intensity (Service 2023, p. 4–4). Droughts and floods both have the potential to affect cave environments and their associated fauna that are most often dependent on humidity, moisture, and organic inputs all associated with water in caves (Barr 1967, p. 476). Runoff was used as a proxy for streamflow in a climate analysis for three stonefly species with ranges that overlap with several of the eight cave beetle species (Service 2023, p. 4–3). Changes in runoff are less certain and have more spread in the data at higher elevations (Lyons *et al*. 2023, p. 20). This level of uncertainty in not only the magnitude, but also the direction of projected precipitation changes precludes any projections on how cave hydrology may be affected by climate related changes in the future (Service 2023, p. 4–4). Given the apparent adaptations to flooding within their habitats, and the uncertainty regarding future projections of precipitation in the region, the implications of potential changes in flooding frequency and intensity and/or drought for cave beetles are unclear (Service 2023, p. 4–4). We have no information that climate change has been a significant threat to existing populations of the eight cave beetles and because we can draw no reliable conclusions regarding potential future impact from the best available data, we did not carry forward climate change as a stand-alone factor in our assessment of future condition.

<u>Conservation Measures and Existing Regulatory Mechanisms</u>

Protection, management, and conservation measures that may improve the species' viability are summarized below.

Protective state legislation exists for caves and karst in Virginia that applies to all eight cave beetle species. The Cave Protection Act was enacted in 1966 to protect the cave and karst resources of the Commonwealth of Virginia (Service 2023, p. 4–6). In 1978, the Virginia legislature formed the Virginia Cave Commission, and in 1979 enacted a new comprehensive

Virginia Cave Protection Act (Service 2023, p. 4–4). The 1979 Virginia Cave Protection Act had two basic objectives: protecting Virginia cave resources from vandalism and degradation and protecting the cave owner's interest in his property (Lera 2016, p. 2). The 1979 Virginia Cave Protection Act prohibited disturbing or harming any cave organism, dumping of garbage, sewage, dead farm animals, and toxic wastes into caves and sinkholes without written permission from the landowner, and made it illegal to sell, or export for sale, speleothems. It also protected archeological resources by requiring a permit from the Virginia Historic Landmarks Commission and written permission from the cave owner, before excavating, removing, or disturbing any fossils, historic artifacts, or prehistoric animals. It also made it illegal to break, force open, tamper with or deface any gates, locks, signage, and other barriers installed by cave owners for cave access control. The cave owner was also exempted from liability for any injury sustained in the owner's cave if the owner had not charged an admission fee (Lera 2016, p. 3).

In 1980 the Virginia Cave Commission (now known as the Virginia Cave Board) became a permanent State agency as part of the Department of Conservation and Economic Development. However, since no funding was provided, interested cavers formed the Virginia Cave Conservancy to provide a means of funding to support cave acquisition, management, and research, as well as to assist organizations such as the Virginia Cave Commission (Lera 2016, p. 3). The Virginia Cave Board is tasked with protecting and maintaining cave life and protecting the natural groundwater flow in caves from water pollution, among other responsibilities (Service 2023, p. 4–7).

The Virginia Cave Board remains active throughout Virginia and engages in project reviews, development of cave and karst management plans, cave related outreach and awareness activities, enforcement cases, archaeological and natural resource protection efforts, property acquisition, and many other activities (Service 2023, p. 4–7). They maintain a list of caves designated as "significant" and 17 of the 20 caves collectively occupied by the eight species in this assessment have been designated as "significant" (Service 2023, p. 4–7). "Significant" caves as designated by the Virginia Cave Board under the Cave Protection Act are treated as element occurrences by the VADCR NHP, and each significant cave lies within a conservation site (Service 2023, p. 4–7). Any projects passing through the VADCR Office of Environmental Project Review are screened to see if they intersect conservation sites (Service 2023, p. 4–7). When conservation sites are intersected, VADCR NHP staff inform the project proponent and provide guidance on protection of the associated resources that may be affected by their project, including "significant" caves and species within (Service 2023, p. 4–7). Although no legal status accompanies this designation, VADCR NHP reports success in avoiding impacts to element occurrences via this review and communication process (Service 2023, p. 4–7). In addition, "significant" caves are given priority for implementation of conservation efforts such as easements, cost-share programs, and long-term protection initiatives (Service 2023, p. 4–7).

Dumping of garbage, sewage, dead farm animals, and toxic wastes is also illegal under other more general provisions of state law in Virginia (Service 2023, p. 4–7). Other forms of protective measures for individual species include occurrence on public lands like within a National Forest or a state-managed Natural Area Preserve (i.e., areas where direct threats from private landowners' activities [excluded from prohibitions under the Endangered Species Act] are likely reduced) or listing of the species as threatened or endangered under the Virginia Endangered

Plant and Insect Species Act (Service 2023, p. 4–7).

The Clean Water Act of 1972 (33 U.S.C. 1251 *et seq.*) aims to maintain, protect, and restore water quality. The eight cave beetle species' ecological and habitat needs are closely tied to the amount and quality of water entering the karst habitat where the species occurs. Contaminated surface and ground water may adversely impact these species.

Species-specific conservation measures and existing regulatory mechanisms are summarized below.

Hupp's Hill Cave Beetle

Hupp's Hill cave beetle is listed by the Virginia Department of Agriculture and Consumer Services as an endangered species under the Virginia Endangered Plant and Insect Species Act (Service 2023, p. 6–4). Prohibited acts for threatened and endangered species under the Virginia Endangered Plant and Insect Species Act include "to dig, take, cut, process, or otherwise collect, remove, transport, possess, sell, offer for sale, or give away any species native to or occurring in the wild in the Commonwealth that are listed in this chapter or the regulations adopted hereunder as threatened or endangered, other than from such person's own land, except in accordance with the provisions of this chapter or the regulations adopted hereunder" (Code of Virginia, Section 3.2–1003).

Because landowners are excluded from the prohibitions under the Act, caves in private ownership may be less protected. The species is assumed to be extirpated from the privately-owned Battlefield Crystal Caverns. However, as noted above (see "*Range/Distribution*"), Ogden's Cave is within a state-managed NAP (Service 2023, p. 6–4), and therefore direct threats from private activities despite the species listed status are likely reduced. The NAP was established in 2007 at 110 acres and expanded in 2012 to 131 acres (Service 2023, p. 6–4). Nearly 8,000 native trees have been planted in the Buffalo Run riparian zone, and 35 acres of upland fields have been restored to native warm-season grasslands within the NAP (Service 2023, p. 6–4). VADCR maintains riparian buffers along the stream banks to protect water quality (VADCR 2012, unpaginated).

Both sites for Hupp's Hill cave beetle are also designated as "significant" caves by the Virginia Cave Board, as described above (Service 2023, p. 6–4).

Hubbard's Cave Beetle

The Virginia Cave Board has designated Luray Caverns, the sole known location for Hubbard's cave beetle, as a "significant" cave; therefore, relevant projects would be flagged by VADCR Office of Environmental Project Review (Service 2023, p. 6–10).

Overlooked Cave Beetle

Kerns Cave No. 1, the sole known location for overlooked cave beetle, is included by the Virginia Cave Board as a "significant" cave, and relevant projects would be flagged by VADCR Office of Environmental Project Review (Service 2023, p. 6–15).

Shenandoah Cave Beetle

Three of the four caves occupied by the Shenandoah cave beetle are included on the Virginia Cave Board's list as "significant" caves: Shenandoah Caverns, Shenandoah Wild Cave, and Madden's Cave (Service 2023, p. 6–21). Thus, activities that require state agency review that may affect the cave environment would receive additional scrutiny by the VADCR karst program, which may result in additional cave-specific conservation recommendations (Service 2023, p. 6–15). Bakers Cave is not designated as "significant" (Service 2023, p. 6–21).

Small portions of the species' range are under conservation easements managed by the Virginia Outdoors Foundation (VOF) and the Valley Conservation Council (VCC) (figure 11) (Service 2023, p. 6–21). The VOF implements open-space easements on private lands; these voluntary legal agreements limit residential, commercial, and industrial development. Specific limitations are tailored to each property and depend on the conservation values being protected at a given location (i.e., water quality, wildlife habitat, historic significance, scenic viewsheds, or public access; VOF 2022, unpaginated) (Service 2023, p. 6–21). The mission of the VCC is to "protect the natural and cultural resources of the greater Shenandoah Valley region through land conservation, education, and experiences to preserve the life-enriching benefits our land and water provide" (VCC 2022, unpaginated) (Service 2023, p. 6–21). VCC works with private landowners to implement easements including open space easements, riparian easements, scenic easements, public recreation easements, and wildlife habitat easements (Service 2023, p. 6–21). We have no information on the specifics of the VOF or VCC easements within the range of Shenandoah cave beetle Service 2023, p. 6–21).

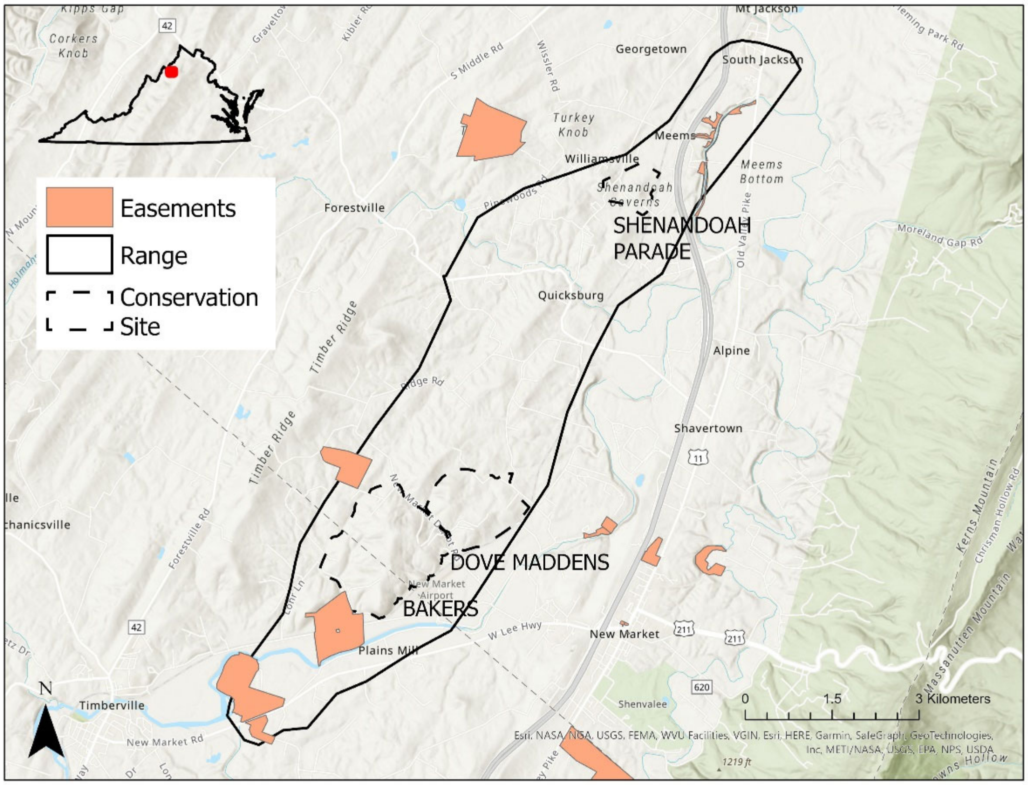

Figure 11: Shenandoah Cave Beetle Range, Conservation Sites, and Easements

Little Kennedy Cave Beetle

Seven of the eight known caves for this species have been designated as “significant” by the Virginia Cave Board: Little Kennedy Cave, Big Kennedy Cave, Kelly Cave, Parsons Cave, Wildcat Cavern, Omega Cave, and Wildcat Saltpetre Cave (Service 2023, p. 6–27). Thus, activities that require state agency review that may affect the cave environment would receive additional scrutiny by the VADCR karst program, which may result in additional cave-specific conservation recommendations (Service 2023, p. 6–15). Abe’s Abyss is not designated as “significant” (Service 2023, p. 6–27).

In addition, Kelly and Omega caves are U.S. Forest Service Special Biological Areas, with federal protection to preserve the natural areas in perpetuity (Service 2023, p. 6–27, USFS, unpaginated). Further, the lower section of Omega Cave is also part of the Powell Mountain Karst Preserve, which is owned by the Cave Conservancy of the Virginias (Service 2023, p. 6–27).

Holsinger’s Cave Beetle

Holsinger’s cave beetle is currently listed by the Virginia Department of Agriculture and Consumer Services as an endangered species under the Virginia Endangered Plant and Insect Species Act (Service 2023, p. 6–31). As discussed above, prohibited acts as a result of this designation include “to dig, take, cut, process, or otherwise collect, remove, transport, possess, sell, offer for sale, or give away any species native to or occurring in the wild in the Commonwealth that are listed in this chapter or the regulations adopted hereunder as threatened or endangered, other than from such person's own land, except in accordance with the provisions of this chapter or the regulations adopted hereunder" (Code of Virginia, Section 3.2-1003). The cave entrance is located on private land, but the landowners strictly prohibit entry into the cave (Service 2023, p. 6-30).

The Young-Fugate Cave, the sole known location of Holsinger's cave beetle, was designated "significant" by the Virginia Cave Board in 1980 (Hubbard and Balfour 1993, p.1); thus, activities that require state agency review that may affect the cave environment would receive additional scrutiny by the VADCR karst program, which may result in additional cave-specific conservation recommendations (Service 2023, p. 6–15).

Historically, there have been threats to the cave system that have been removed through policy action. In 1991, there was a proposal to realign part of U.S. Route 58, near the Young-Fugate Cave, which would have directed runoff into the entrance (Hubbard and Balfour 1993, p.1). Around the same time, there were reports of petroleum leakage, fumes in the cave, and sediments originating from underground storage tanks from the nearby gas station (Service 2023, p. 6–32). The storage tanks were replaced in 1992, remedying the problem, though previous contamination likely remains in the sediment within the cave (Service 2023, p. 6–32).

Despite the protection afforded by the Virginia Cave Protection Act, there have been reports of trash in and around the cave, along with other non-point source pollution (Malabad *et al*. 2021, p. 36).

Hubricht's Cave Beetle

Of the two known locations for the Hubricht's cave beetle, Daugherty's Cave is included on the Virginia Cave Board's list of "significant" caves; thus, activities that require state agency review that may affect the cave environment would receive additional scrutiny by the VADCR karst program, which may result in additional cave-specific conservation recommendations (Service 2023, p. 6–15). Bundy's Cave No. 2 has no designation (Service 2023, p. 6–34).

Silken Cave Beetle

Lane Cave, the sole known location for silken cave beetle, is included as a "significant" cave on the list maintained by the Virginia Cave Board (Service 2023, p. 6–40); thus, activities that require state agency review that may affect the cave environment would receive additional scrutiny by the VADCR karst program, which may result in additional cave-specific conservation recommendations (Service 2023, p. 6–15).

<u>Cumulative Effects</u>

We note that, by using the SSA framework to guide our analysis of the scientific information documented in the SSA report, we have analyzed the cumulative effects of identified threats and conservation actions on the species. To assess the current and future condition of the species, we evaluate the effects of all the relevant factors that may be influencing the species, including threats and conservation efforts. Because the SSA framework considers not just the presence of the factors, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone cumulative-effects analysis.

When potential stressors occur together, one factor may exacerbate the effects of another, causing effects not accounted for when factors are analyzed individually (Brook et al. 2008, entire). Quarrying, development/urbanization, commercial cave tour operations, timbering, and agriculture are factors that may cumulatively impact the eight cave beetle species.

ANALYSIS

Using the SSA framework established by the Service, we considered species needs to maintain viability over time by characterizing the biological status of the species in terms of its resiliency, redundancy, and representation (USFWS 2016, p. 6 and Smith *et al*. 2018, entire). For the purpose of our analysis, we generally defined viability as the ability of the species to sustain populations in natural ecosystems within a biologically meaningful timeframe: in this case, 20 years and 50 years into the future. We chose two time steps for analysis to balance the (assumed) relatively short generation time for these species with the longer-term information available on identified potential stressors and their expected trends over time.

CURRENT CONDITION

To evaluate current condition for each species we rely on ease of detection (in the absence of abundance or density information) to partially inform resiliency, and we put that into the context of confidence in the results based on the amount of effort (number of cave visits) for each species (Service 2023, p. v). For example, low resiliency is different from the limited ability to detect the species. Where effort is low (less than five cave visits), we have low confidence in conclusions regarding ease of detection (Service 2023, p. v). Although Holsinger's cave beetle, silken cave beetle, and Hubricht's cave beetle are found at only one or two caves, they were all "readily observed" over the course of cave visits between 2014 and 2021 (Service 2023, p. v). In cases of readily observed species, resiliency is unknown because we do not know how ease of detection relates to absolute abundance or density (Service 2023, p. 6–34).

We also consider redundancy as defined by the number of analysis units, as well as their geographic spread (Service 2023, p. vi). All but one of the assessed species has low or no redundancy. Little Kennedy cave beetle is the exception; this species occurs in eight caves, which are grouped into five analysis units, spread across an area of 89.3 km^2 (34.48 mi^2) (Service 2023, p. vi).

In the absence of species-specific information on life history traits for the eight species, we assume basic information on reproduction for surface-dwelling carabid beetles to apply to cave beetles and acknowledge that more detailed life history information is not available (Service 2023, p. 5–1). We cannot reliably assume more specific information based on proxy species given the demonstrated variability both between closely-related species and populations within the same species (Service 2023, p. 5–1).

Karst experts at VADCR delineated ranges for the eight cave beetle species individually using a consistent approach (Service 2023, p. 5–1). They included the extent of contiguous karst surrounding known cave locations for each species, with the assumption that caves within contiguous belts of karst may be interconnected via subterranean pathways (Service 2023, p. v). The borders of the ranges were determined by several factors including physical features likely to be barriers to further dispersal (e.g., nonkarst geology, large water bodies) and the nearest observations of a different species, assuming that for the most part the species are allopatric and do not co-occur (Service 2023, p. v). In some cases, species ranges include nonkarst areas between known species (Service 2023, p. v). The species ranges represent the best data available on potential suitable habitat, but in many cases, range maps would likely change with additional survey effort over time (Malabad *et al*. 2021, entire).

Cave beetles are cryptic species that can be hard to locate within their habitats (see "Population Estimates/Status"). As such, it is not possible to reliably assess abundance for any of these species. Similarly, it is not reasonable to assume lack of abundance or presence in suitable habitat simply because the species are not located with limited survey effort.

In the absence of information on how cave beetles may respond to specific influences like changes in water quality/quantity, we focus on influencing factors that are likely to present the biggest challenges to the physical habitat for cave beetles, specifically the physical structure of caves and the presence of water or moisture (Service 2023, p. 5–1). While we discuss the potential for impacts to environmental parameters like water quality, we are unable to draw any conclusions regarding how those changes may affect analysis units of cave beetles without reliable information on the species response to or reliance on those elements of their habitat (Service 2023, p. 5–1).

Quarrying, timbering, and agriculture have occurred in the region historically, and continue currently. Amidst these ongoing potential stressors, each of the eight cave beetle species has persisted. There is no evidence to suggest threats currently are negatively impacting cave beetle populations.

Hubbard's cave beetle, overlooked cave beetle, and Shenandoah cave beetle exhibit no or low redundancy and low ease of detection; however, the number of cave visits supports low confidence in the ease of detection inference for these three species, and as such their resiliency is unknown (Service 2023, p. vi). The remaining species, Hupp's Hill cave beetle, was rarely observed in one cave and is likely extirpated from another, consistent with elevated risk and moderate confidence that resiliency is low (Service 2023, p. vi).

Hupp's Hill Cave Beetle

Hupp's Hill cave beetle is believed extirpated from one of its two known locations (i.e., Battlefield Crystal Caverns), likely as a result of quarrying activities, commercial cave tour operations, industrial development, and roads (Service 2023, p. 6–5). At Ogden's Cave, low ease of detection suggests low density and low resilience, resulting in limited ability to withstand inherent stochasticity and threats (Service 2023, p. 6–5). Portions of the conservation site surrounding the Ogden's Cave occurrence are publicly owned and protected, and although quarrying activities have been ongoing in close proximity to the site, much of the remaining habitat appears unaffected by them (Service 2023, p. 6–5).

As a “significant” cave (see Conservation Measures and Existing Regulatory Mechanisms, above), relevant projects would be flagged by VADCR Office of Environmental Project Review, and are given priority for implementation of conservation efforts such as easements, cost-share programs, and fee simple acquisition for long-term protection (Service 2023, p. 6–4).

Ogden’s Cave is within a state-managed NAP. To enhance water quality in Buffalo Marsh Run, nearly 8,000 native trees have been planted in the riparian zone, and 35 acres of upland fields have been restored to native warm-season grasslands within the NAP (Service 2023, p. 6–5). The NAP was expanded in 2012 with the purchase of an additional 21 acres of wetlands bringing its current size to 131 acres (Service 2023, p. 6–5). As a result of the expansion, an additional 1,350 feet of Buffalo Marsh Run is protected (Service 2023, p. 6–5). VADCR maintains riparian buffers along the stream banks to protect water quality (VADCR 2012, unpaginated).

There is no evidence to suggest threats are negatively impacting the species at this location (Service 2023, p. 6–5). Hupp’s Hill cave beetle’s limited geographical extent and single extant occurrence render it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–5). We lack genetic information to inform genetic diversity and effective population size for this species; its ability to adapt to changing conditions is unknown (Service 2023, p. 6–5). However, under the assumption that different caves are likely to be genetically distinct, extirpation from one site represents a decrease in genetic diversity, and thus representation, for this species (Service 2023, p. 6–5). Overall, Hupp’s Hill cave beetle’s ability to withstand stochasticity and catastrophic events is limited based upon the assumption that there are no other occurrences of the species beyond the Ogden’s Cave site, and that the species is extirpated at Battlefield Crystal Caverns. Eight recent survey efforts at Battlefield Crystal Caverns found no individuals (the most recent observation of the species at this site is listed in the EO record as “pre-1981”), and there is ongoing degradation of habitat at the site leaving no suitable habitat at Battlefield Crystal Caverns (Service 2023, p. 6–5). We investigated potential stressors linked to water quantity, water quality, land use, and cave visitation. Despite the apparent low density and low resilience of the species, in all cases, the best available data and information does not indicate that these potential stressors are negatively affecting Hupp’s Hill cave beetle at the remaining Ogden’s Cave site.

Hubbard’s Cave Beetle

The only known location for Hubbard’s cave beetle, Luray Caverns, is a heavily used commercial cave; however, the species is thought to persist at the site despite over 100 years of commercial use mainly because Luray Caverns is one of the largest cave systems in the U.S. and much of the cave is not commercially used, as described further below (Service 2023, p. 6–10). Despite not collecting any live specimens of Hubbard’s cave beetle during survey efforts from 2016 to 2021 (the most recent live specimen was collected in 1996), VADCR biologists still consider the species likely to be extant and recommend additional surveys efforts to confirm the species at Luray Caverns and potentially other unsurveyed caves within the contiguous belt of limestone (Malabad *et al*. 2021, p. 40).

The magnitude and mechanisms for negative impacts from commercial tour operations are unclear (Service 2023, p. 6–10). The effects of operating a commercial cave tour company can be numerous and depend on the frequency and size of cave tours, the extent of modifications like light and stairway/walkway installation, the proportion of the cave that is made accessible to tour groups, and other factors (Service 2023, p. 6–9). There is no evidence to suggest threats are negatively impacting the species, and as described below, Luray Caverns is an expansive cave system with much of the cave commercially unused. Hubbard's cave beetle's limited geographical extent and single occurrence render it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–10), and we lack genetic information to inform the species' ability to adapt to changing conditions (Service 2023, p. 6–10). As a single site endemic, the species does not have the genetic advantage of multiple sites that are likely to be genetically distinct; however, one study found a correlation between cave length and genetic diversity in cave invertebrates, and Luray Caverns is one of the largest cave systems in the Eastern U.S. (Balogh *et al*. 2020, p. 6). Luray Caverns lies within a contiguous limestone exposure stretching 482.8 km (186.41 mi). As described above (see Biological Information), Hubbard's cave beetle's known range is 0.2 km^2 (0.08 mi^2), a small fraction of the limestone belt; however, this range is comparable to other species described herein (e.g., overlooked cave beetle's range is 0.12 km^2 [0.05 mi^2], silken cave beetle's range is 0.24 km^2 [0.09 mi^2]). The commercial tour route is 2.4 km (1.49 mi) and there are substantial additional portions of the cave system that are not used commercially; the nature of caves is such that there is presumed to be a large portion of area that has suitable habitat and is accessible to beetles, but not to humans (Service 2023, p. 6–10). This synthesis is predicated on the assumptions that the species is extant in Luray Caverns and there are no other occurrences of the species (Service 2023, p. 6–11). We investigated potential stressors linked to water quantity, water quality, land use, and cave visitation; in all cases, the best available data and information do not indicate that these potential stressors are negatively affecting Hubbard's cave beetle.

Overlooked Cave Beetle

Although specimens have not been collected in visits between 2015 and 2020, given low survey effort, we have reduced confidence in the low ease of detection for overlooked cave beetle (Service 2023, p. 6–15). Best available data indicates suitable habitat remains available and the species is believed to persist at the site. Overlooked cave beetle's limited geographical extent and single occurrence render it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–15), and we lack genetic information to inform the species' ability to adapt to changing conditions (Service 2023, p. 6–15). However, there is no evidence to suggest threats are negatively impacting the species. As a single site endemic, the species does not have the genetic advantage of multiple sites that are likely to be genetically distinct (Service 2023, p. 6–15). Overall, overlooked cave beetle's ability to withstand stochasticity and catastrophic events is presumed to be limited due to its single occurrence location, and its ability to adapt to changing conditions is unknown (Service 2023, p. 6–15). This synthesis is predicated on the assumptions that the species is extant in Kern's Cave No. 1 and that there are no other occurrences of the species (Service 2023, p. 6–15). We investigated potential stressors linked to water quantity, water quality, land use (including mining), and cave visitation; in all cases, the best available data and information do not indicate that these potential stressors are negatively affecting overlooked cave beetle. There is no information or evidence supporting recreational caving or mountaintop mining within the cave, conservation site, or range of the species.

Shenandoah Cave Beetle

Among the four known locations for Shenandoah cave beetle, two were visited between 2015 and 2021, and they had different ease of detection results (rare with moderate confidence, and readily observed) (Service 2023, p. 6–21). VADCR was unable to confirm that the species is still present at Shenandoah Caverns or Shenandoah Wild Cave. According to VADCR, site occupancy, as measured by sampling success for cave beetles in the Shenandoah Valley is generally lower than in other regions of Virginia's karst, and VADCR's failure to verify the Shenandoah cave beetle at these sites may reflect this (Malabad *et al*. 2021, p. 41).
Despite some redundancy with three analysis units, Shenandoah cave beetle's limited geographical extent renders it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–21). We lack genetic information for the species to inform an assessment of its ability to adapt to changing conditions (Service 2023, p. 6–21). However, under the assumption that different caves are genetically distinct from one another, we assume the species has some genetic diversity with three distinct analysis units (Service 2023, p. 6–21). There is no direct evidence to suggest threats are negatively impacting the species. Overall, Shenandoah cave beetle's ability to withstand stochasticity and catastrophic events is constrained given its restricted geographical range, and its ability to adapt to changing conditions is currently unknown (Service 2023, p. 6–21). This synthesis is predicated on the assumptions that there are no other occurrences of the species, and the species is extant in Madden's cave, Shenandoah Wild Cave, and Shenandoah Caverns (Service 2023, p. 6–21).

The petition to list Shenandoah cave beetle cited recreational/commercial spelunking, and "general threats to cave beetles" including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or creation of new entrances as threats to the species (Service 2023, p. 6–19). We found no information to indicate that recreational spelunking, toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or creation of new entrances are likely to be influencing viability for the species currently or in the future at any of the known sites (Service 2023, p. 6–19).

Shenandoah Caverns, one of the sites for the Shenandoah cave beetle, is currently operating as a commercial cave open for public tours (Service 2023, p. 6–19). The effects of operating a commercial cave tour company within a cave can be numerous and depend on the frequency and size of cave tours, the extent of modifications like light and stairway/walkway installation, the proportion of the cave that is accessed by tour groups, and other factors (Service 2023, p. 6–19). In general, they may include changes to air circulation, humidity, carbon dioxide concentration, and temperature, organic matter input, chemical pollutants, and noise (causes and effects of these alterations are synthesized by Constantin *et al*. 2021, p. 3). The installation of lights can create a growing environment for fungi and algae that would not typically be able to survive inside caves, which can lead to other non-native species inhabiting those microenvironments (Service 2023, p. 6–19). The construction of new or additional entrances for ease of access for large groups can affect humidity, temperature, and other abiotic conditions within the cave. Visitors introduce pollutants (Service 2023, p. 6–19). To manage fungi and algae that develop, cave operators often deploy biocides which have their own implications for native cave fauna, many of which are not well studied or understood (Service 2023, p. 6–19).

We investigated potential stressors linked to water quantity, water quality, land use, recreational spelunking and commercial cave operations, agriculture (specifically animal feeding operations), and proximity to the Interstate 81 corridor. In all cases, the best available data and information do not indicate that these potential stressors are negatively affecting Shenandoah cave beetle. There is insufficient information to draw reliable conclusions about potential stressors linked to water quantity, water quality, land use, recreational spelunking and commercial cave operations, agriculture, and proximity to the highway.

Little Kennedy Cave Beetle

Little Kennedy cave beetle is known from eight locations grouped into five analysis units that span two differently aged limestone deposits (Service 2023, p. 6–27). This level of redundancy confers some ability to withstand stochasticity and catastrophic events; all five analysis units cover a total area of 89.3 km^2 (34.48 mi^2) (Service 2023, p. 6–27). In two analysis units, we have moderate confidence that the species is infrequently observed, which may indicate low density and therefore low resilience in those locations (Service 2023, p. 6–27). We lack genetic information to inform an assessment of the species' ability to adapt to changing conditions (Service 2023, p. 6–27). Under the assumption that different analysis units are genetically distinct, however, the isolation of five different analysis units confers some genetic diversity at the species level (Service 2023, p. 6–27). The Omega cave system is one of the longest cave systems in the eastern U.S. at over 47 km (29.2 mi) in length, which may indicate the potential for significant genetic diversity at this analysis unit (Balogh *et al*. 2020, p. 6). There is no evidence to suggest threats are negatively impacting the species. Overall, Little Kennedy cave beetle's ability to cope with stochasticity and catastrophic events is higher than that of a single site endemic, but still limited given its restricted geographic range (Service 2023, p. 6–27). The species' ability to adapt to shifting and novel conditions is unknown (Service 2023, p. 6–27). This synthesis is predicated on the assumption that there are no other occurrences of the species (Service 2023, p. 6–27).

The petition to list the species cited recreational spelunking, federal oil and gas development, and mountaintop removal coal mining as potential threats to the species (Service 2023, p. 6–25). We have no information indicating recreational spelunking occurs within caves occupied by Little Kennedy cave beetle at a magnitude that would influence viability for the species (Service 2023, p. 6–25). There are no active coal mining permits within the range or conservation sites for the species (Service 2023, p. 6–25). The petition cited the U.S. Forest Service's 2004 Revised Land and Resources Management Plan regarding the potential for federal oil and gas development within the watersheds near Little Kennedy cave beetle locations (Service 2023, p. 6–25). However, Little Kennedy cave beetle caves formed in the Greenbrier limestone have forested land use in their watersheds and Kelly and Omega caves have the additional protection of inclusion in U.S. Forest Service Special Biological Areas which would preclude oil and gas development (Service 2023, p. 6–26).

Wildcat Saltpetre Cave has a history of fuel oil contamination from a nearby tank yard (Service 2023, p. 6–26). When the Wildcat Cavern beetle specimens were collected, VADCR staff were able to proceed only about 152 m (499 ft) into the main cave before encountering a plug of trash that filled the passage (Service 2023, p. 6–26). Of additional concern are the proximity to both U.S. Route 23 and the railroad and the associated potential for the introduction of contaminants directly into Wildcat Cavern via runoff or a catastrophic spill (Malabad *et al*. 2021, p. 24). Despite these conditions, Wildcat Cavern had the highest rate of detection among the Little Kennedy cave beetle sites that were visited, underscoring the uncertainty associated with the species response to various types of habitat degradation (Service 2023, p. 6–26).

Thus, having investigated potential stressors linked to water quantity, water quality, land use, and cave visitation, we found that the best available data and information do not indicate that these potential stressors are negatively affecting Little Kennedy cave beetle.

Holsinger's Cave Beetle

Holsinger's cave beetle was readily detected at its single known location based on surveys from 2015-2019 (Service 2023, p. 6–32). Despite contamination and seasonal flooding events over the last five decades, the survey results from 2015-2019 are comparable to those from 2000-2001 and from the 1960s (Service 2023, p. 6–32). Survey results over time suggest the population of Holsinger's cave beetle in Young Fugate Cave may fluctuate seasonally but has potentially been relatively stable over the long term (Service 2023, p. 6–32). The species' limited geographical extent and single occurrence render it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–32). We lack genetic information to inform an assessment of the species' ability to adapt to changing conditions (Service 2023, p. 6–32). There is no evidence to suggest threats are negatively impacting the species. As a single site endemic, the species does not have the genetic advantage of multiple sites that are likely to be genetically distinct (Service 2023, pp. 6–32 to 6–33). Overall, Holsinger's cave beetle's ability to withstand stochasticity and catastrophic events is currently constrained due to its single occurrence location, and its ability to adapt to changing conditions is unknown (Service 2023, p. 6–33). This synthesis is predicated upon the assumption that there are no other occurrences of the species (Service 2023, p. 6–33).

Young-Fugate Cave runs beneath U.S. Highway 58, a four-lane road that is the main thoroughfare connecting Tennessee to Virginia, through the Cumberland Gap mountain pass (Service 2023, p. 6–31). In 1991, the cave was contaminated by petroleum product leaking from an underground storage tank at a gas station above the cave (Malabad *et al*. 2021, p. 36). The gas station is no longer present and the storage tanks were replaced (Service 2023, p. 6–31). The cave's proximity to the highway introduces the potential for road-related contaminants to enter the cave as well as the potential catastrophic effects of a major spill nearby; however, we do not have a clear understanding of the species' response to contaminants, or the likelihood of minor or major contamination events at this site (Service 2023, p. 6–31). This uncertainty is highlighted by the relatively high density of cave beetles still present in the cave despite prior contamination from leaking petroleum storage tanks (Service 2023, p. 6–31).

We investigated potential stressors linked to water quantity, water quality, land use, and cave visitation; as noted above, despite evidence of various threats operating over time, in all cases, the best available data and information do not indicate that these potential stressors are negatively affecting Holsinger's cave beetle.

Hubricht's Cave Beetle

Hubricht's cave beetle was readily detected at both analysis units based on surveys from 2017-2020 (Service 2023, p. 6–37). The species' limited geographical extent renders it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–37). There are no apparent immediate threats to the species beyond the speculative potential for contaminants from nearby roadways (Service 2023, p. 6–37). Agricultural land use is the dominant use within this species' range and the low-intensity pastures and hay production that predominates is, as noted earlier, largely considered compatible with cave beetle persistence (Service 2023, p. 6–36). We lack genetic information to inform an assessment of the species' ability to adapt to changing conditions (Service 2023, p. 6–37). Under the assumption that different caves are genetically distinct, having two occurrence locations confers limited genetic diversity to the species (Service 2023, p. 6–37). There is no evidence to suggest threats are negatively impacting the species. Overall, Hubricht's cave beetle's ability to withstand stochasticity and catastrophic events is constrained due to its limited geographic range, and its ability to adapt to changing conditions is unknown (Service 2023, p. 6–37). This synthesis is predicated on the assumption that there are no other occurrences of the species (Service 2023, p. 6–37).

The petition cited recreational spelunking, mountaintop removal coal mining, and "general threats to cave beetles" including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances as potential threats to the species (Service 2023, p. 6–36). We found no information to indicate that recreational spelunking, toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or creation of new entrances are likely to be influencing viability for the species currently or in the future (Service 2023, p. 6–36). There are no active coal mining permits within the range or conservation site for this species (Service 2023, p. 6–36).

Having investigated potential stressors linked to water quantity, water quality, land use, and cave visitation, we found no evidence of potential threats beyond those noted above. In all cases, and with respect even to the identified potential stressors, the best available data and information do not indicate that these potential stressors are negatively affecting Hubricht's cave beetle.

Silken Cave Beetle

Silken cave beetle was readily detected at its only known location in surveys from 2016-2019 (Service 2023, p. 6–40). The species' limited geographical extent and single known location renders it vulnerable to stochastic and catastrophic events (Service 2023, p. 6–40). However, there are no apparent immediate threats to the species (Service 2023, p. 6–40). The entrance to the cave is adjacent to a road but there is no information that this circumstance negatively impacts the species. The surface land within the species' range and conservation site are privately owned residential parcels that are predominantly forested, with no evidence of negative impact from that land use. We lack genetic information to inform an assessment of the species' ability to adapt to changing conditions (Service 2023, p. 6–40). As a single site endemic, the species does not have the genetic advantage of multiple sites that are likely to be genetically distinct (Service 2023, p. 6–40). Overall, silken cave beetle's ability to withstand stochasticity and catastrophic events is limited due to its single occurrence location, and its ability to adapt to changing conditions is unknown. This synthesis is predicated on the assumption that there are no other occurrences of the species (Service 2023, p. 6–40).

The petition to list the species cited recreational spelunking and mountaintop removal coal mining as potential threats to the species (Service 2023, p. 6–40). We have no information indicating recreational spelunking is affecting the viability of the species, and there are zero active coal mining permits within the range or conservation site for the species (Service 2023, p. 6–40).

We investigated additional potential stressors linked to water quantity, water quality, land use, and cave visitation; in all cases, the best available data and information do not indicate that any potential stressor is negatively affecting silken cave beetle.

FUTURE CONDITION

To develop future scenarios for the evaluation of species viability, we carried forward those threats in which we have enough confidence that their magnitude of impact would be likely to cause harm at the analysis unit level (Service 2023, p. vi). Due to the lack of information on species response to changes in habitat condition at smaller magnitudes, there is significant uncertainty as to the type and magnitude of changes in habitat conditions that would elicit a response from the species at the individual level (Service 2023, p. vi). We are confident that changes to the physical structure of an occupied cave, and changes to the water table and the functioning of the rest of the hydrological system within a cave would likely be detrimental at the analysis unit level for each species (Service 2023, p. vi). We identified sources of those impacts to include commercial cave tour operations, quarries/mining, and large-scale urbanization/development (residential and/or commercial) (Service 2023, p. vi). These sources also have the potential to impact water quality within cave systems (Service 2023, p. vi). Despite the uncertainty associated with the species' response to changes in water quality, we make a conservative assumption that these riparian-associated species may experience negative effects as a result of compromised water quality (Service 2023, p. vi).

We discuss quarrying and commercial cave operations qualitatively for individual species where each is relevant, but we have no meaningful, standardized way of predicting or quantifying their future impacts as the future intentions of private landowners are unpredictable (Service 2023, p. vi). The metric we use for future projections of impacts from urbanization/development is projected changes in impervious surfaces (Service 2023, p. vi). It is challenging to predict future changes in land use on private lands; however, the impervious surface projections are intended to capture expected changes in development regardless of ownership within our spatial analysis units (Service 2023, p. 6–16). We also use projected changes in county (human) populations as an indicator of road usage and future development potential (Service 2023, p. vi). We looked at projections of these metrics for the years 2020, 2040, and 2070 to determine the change in these parameters from current out to two timesteps in our future conditions (Service 2023, p. vi). We evaluated two future time steps to balance the (assumed) short generation time of the species with the availability of future threat projections (Service 2023, p. vi).

Impervious surface projections

The extent of impervious surface in a watershed affects the integrity of the freshwater ecosystems within it (Theobald *et al.* 2009, p. 364). Because the assessed species are associated with moisture (e.g., drip pools, riparian areas), they may be impacted by the same issues that affect surface waters (Service 2023, p. 5–7). We used ICLUS projections to quantify impervious surface within the conservation sites (i.e., the surface area draining into a cave with a known occurrence of an assessed species) under two different scenarios — the A1 and B1 scenarios — for the years 2020, 2040, and 2070 (Service 2023, p. 5–7). We chose the A1 and B1 scenarios for their contrasting economic conditions, and the three time horizons to represent current and future conditions (EPA 2009, pp. 2–1 to 2–7). Finally, we classified the impact of impervious surface on conservation sites as follows: Unstressed (0–0.9 percent), Lightly stressed (1–4.9 percent), Stressed (5–9.9 percent), Impacted (10–24.9 percent), and Damaged (>25 percent) (Service 2023, p. 5–7).

County population projections

The proximity to roads can be a threat for cave beetle species from possible runoff of sediment, hydrocarbons, and deicing agents; trash from the roadway entering the mouth of a cave; and the possibility of spills of hydrocarbons and other hazardous materials (Malabad *et al*. 2021, entire). The severity of these threats depends on usage of roads in areas draining into the habitat of the assessed species (Service 2023, p. 6–6). We used projected changes in human populations at the county level as a proxy for future road usage and development potential (Service 2023, p. 5–8). The ICLUS dataset contains county population projections for the same scenarios and years as projected impervious surface (Service 2023, p. 5–8).

We do not expect any changes in redundancy or representation for any of the eight species as a result of future threats (by 2040 or 2070) (Service 2023, p. vii). Additional surveys may result in new occurrence locations, which would confer additional redundancy (Service 2023, p. vii). Despite our expectation that viability is unlikely to change significantly for any of the eight species in the assessment, most will remain vulnerable to stochastic and catastrophic events given their low redundancy and restricted geographic ranges (Service 2023, p. vii).

Hupp's Hill Cave Beetle

We do not expect Hupp's Hill cave beetle's abundance or spatial extent to change relative to current status through 2070; thus, the species' viability is unlikely to change (Service 2023, p. 6–6). The rationale for our conclusion is twofold. First, despite the projected increase in county road density, the percentage of impervious surface within the conservation sites remains unchanged (i.e., lightly stressed) through 2070 (Service 2023, p. 6–6). Second, although quarrying activities are likely to continue just outside the southern edge of the Ogden's conservation site, we have no information to indicate they are likely to expand, and the state's NAP designation will likely prevent any future degradation to the cave and the surrounding sensitive habitats (Service 2023, p. 6–6). Thus, we conclude under projected future conditions, the species' abundance and spatial extent will not change from its current condition (Service

2023, p. 6–6). Under projected future conditions, Hupp's Hill cave beetle will remain vulnerable to stochastic and catastrophic events and will have limited ability to adapt to shifting and novel conditions; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–6).

Hubbard's Cave Beetle

We do not expect Hubbard's cave beetle's abundance or spatial extent to change relative to current status through 2070; thus, the species' viability is unlikely to change (Service 2023, p. 6–12). The rationale for our conclusion is twofold. Under the A1 scenario, the conservation site may go from "lightly stressed" to "stressed" in terms of impervious surface cover by 2070, though the classification would remain unchanged under both projected scenarios in 2040 and under the B1 scenario through 2070 (Service 2023, 6–11). However, despite this potential for an increase in impervious surface cover in the future, we anticipate potential impacts from this change would be offset by a projected decline in the county's human population over the same time, indicating less road usage (Service 2023, p. 6–12). In addition, although we expect the commercial tour operations to continue in Luray Caverns, the species is thought to persist despite such commercial activities for more than 100 years. We understand this to indicate it can persist at current commercial tour operation levels, and we have no information to indicate they are likely to expand (Service 2023, p. 6–12). Therefore, under projected future conditions the species' viability and spatial extent will not change (Service 2023, p. 6–12). Under projected future conditions, Hubbard's cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size, and its ability to adapt to changing conditions remains unknown; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–12).

Overlooked Cave Beetle

We do not expect overlooked cave beetle's abundance or spatial extent to change relative to their current status through 2070; thus, the species' viability is unlikely to change (Service 2023, p. 6–16). The rationale for our conclusion is twofold. First, the conservation site for Kern's Cave No. 1 is projected to remain "unstressed" through 2070 (Service 2023, p. 6–16). Second, there is a projected decline in the county's human population through 2070, which will result in lower road usage (Service 2023, p. 6–16). Thus, projected future conditions indicate the species' viability and spatial extent will not change (Service 2023, p. 6–16). Under projected future conditions, overlooked cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size and its ability to adapt to changing conditions remains unknown; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–16).

Shenandoah Cave Beetle

We do not expect Shenandoah cave beetle's abundance or spatial extent to change relative to their current status through 2070; thus, the species' viability is unlikely to change (Service 2023, p. 6–23). The rationale for our conclusion is twofold. First, all three conservation sites for the species are currently classified as and are projected to remain “lightly stressed” through 2070 (Service 2023, p. 6–23). Second, there is a projected decline in the counties’ human populations through 2070, which will result in lower road usage (Service 2023, p. 6–23). Accordingly, projected future conditions indicate the species’ viability and spatial extent will not change (Service 2023, p. 6–23). Under projected future conditions, Shenandoah cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size, and its ability to adapt to shifting and novel conditions remains unknown; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–23).

Little Kennedy Cave Beetle

We do not expect Little Kennedy cave beetle’s abundance or spatial extent to change relative to current status through 2070; thus, the species’ viability is unlikely to change (Service 2023, p. 6–28). The rationale for our conclusion is threefold. First, all five conservation sites for the species are classified as “lightly stressed” in their current condition and are projected to remain “lightly stressed” through 2070 (Service 2023, p. 6–28). Second, there is a projected decline in the counties’ human populations through 2070, which will result in lower road usage (Service 2023, p. 6–28). Accordingly, projected future conditions indicate the species’ viability and spatial extent will not change (Service 2023, p. 6–28). Third, occurrence in eight locations grouped into five analysis units confers some ability to withstand stochastic and catastrophic events that may affect one or more of the analysis units (Service 2023, p. 6–29). Despite our expectation that viability is unlikely to change significantly, the species will remain vulnerable to stochastic and catastrophic events in at least two analysis units given its possibly low resilience in those units; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–29).

Holsinger’s Cave Beetle

We do not expect Holsinger’s cave beetle’s abundance or spatial extent to change relative to current status through 2070; thus, the species’ viability is unlikely to change (Service 2023, p. 6–34). The rationale for our conclusion is twofold. First, the conservation site is classified in its current condition and is projected to remain “lightly stressed” through 2070 (Service 2023, p. 6–34). Second, there is a projected decline in the county human population, indicating decreasing road usage (Service 2023, p. 6–34). Under projected future conditions, Holsinger’s cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size, and its ability to adapt to shifting and novel conditions remains unknown; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–34).

Hubricht’s Cave Beetle

We do not expect Hubricht’s cave beetle’s abundance or spatial extent to change relative to current status through 2070; thus, the species’ viability is unlikely to change (Service 2023, p. 6–38). The rationale for our conclusion is twofold. First, the conservation site is classified in its current condition as and is projected to remain “lightly stressed” through 2070 (Service 2023, p. 6–38). Second, there is a projected decline in the county’s human population, indicating less road usage (Service 2023, p. 6–38). Under projected future conditions, Hubricht’s cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size and will have limited ability to adapt to shifting and novel conditions; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–38).

Silken Cave Beetle

We do not expect silken cave beetle’s abundance or spatial extent to change relative to current status through 2070; thus, the species’ viability is unlikely to change (Service 2023, p. 6–42). The rationale for our conclusion is twofold. First, the conservation site is classified in its current condition as and is projected to remain “lightly stressed” through 2070 (Service 2023, p. 6–42). Second, there is a projected decline in the county’s human population, indicating less road usage (Service 2023, p. 6–42). Under projected future conditions, silken cave beetle will remain inherently vulnerable to stochastic and catastrophic events due to its naturally occurring small range size, and its ability to adapt to shifting and novel conditions remains unknown; however, the best available data and information do not indicate an increase in threats into the future (Service 2023, p. 6–42).

FINDING

<u>Regulatory Framework</u>

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species is an “endangered species” or a “threatened species.” The Act defines an endangered species as a species that is “in danger of extinction throughout all or a significant portion of its range,” and a threatened species as a species that is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The Act requires that we determine whether any species is an “endangered species” or a “threatened species” because of any one or a combination of the following 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.

These factors represent broad categories of natural or human-caused actions or conditions that could have an effect on a species’ continued existence. In evaluating these actions and conditions, we look for those that may have a negative effect on individuals of the species, as well as other actions or conditions that may ameliorate any negative effects or may have positive effects.

The Act does not define the term "foreseeable future, which appears in the statutory definition of "threatened species." Our implementing regulations at 50 CFR 424.11(d), as revised in 2019, set forth a framework for evaluating the foreseeable future on a case-by-case basis. The term "foreseeable future" extends only so far into the future as we can reasonably determine that both the future threats and the species' responses to those threats are likely. In other words, the foreseeable future is the period of time in which we can make reliable predictions. "Reliable" does not mean "certain"; it means sufficient to provide a reasonable degree of confidence in the prediction. Thus, a prediction is reliable if it is reasonable to depend on it when making decisions.

It is not always possible or necessary to define the foreseeable future as a particular number of years. Analysis of the foreseeable future uses the best scientific and commercial data available and should consider the timeframes applicable to the relevant threats and to the species' likely responses to those threats in view of its life-history characteristics. Data that are typically relevant to assessing the species' biological response include species-specific factors such as lifespan, reproductive rates or productivity, certain behaviors, and other demographic factors.

Status Assessment

Status Throughout All of Its Range

After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we find that the eight cave beetles (Hupp's Hill cave beetle, Hubbard's cave beetle, overlooked cave beetle, Shenandoah cave beetle, Little Kennedy cave beetle, Holsinger's cave beetle, Hubricht's cave beetle, and silken cave beetle) do not meet the definition of an endangered species throughout all of their ranges. In our assessments of current conditions, we evaluated the impacts of habitat destruction or modification and changes to the water table and the functioning of the hydrological system within caves from quarrying/mining, cave visitation, timbering, urbanization, agriculture, and climate change (Factor A). The best available information indicates that changes to the physical structure of an occupied cave, and changes to the water table and the functioning of the rest of the hydrological system within a cave, are impacts that are likely to be detrimental at the level of the analysis unit for each cave beetle species. The primary threats with potential to affect the eight cave beetle species' biological status, which were assessed, include quarrying, commercial cave operations, and urbanization/development (residential and/or commercial). These sources also have the potential to impact water quality within cave systems. Despite the uncertainty associated with the eight cave beetle species' response to changes in water quality, we make a reasonable assumption that as riparian-associated species they may experience negative effects as a result of compromised water quality. We assessed the population status for each species based on the condition of the habitat and made the assumption that healthy habitat will support a healthy population.

Despite potential impacts from the primary threats, the best scientific and commercial data available indicate that the Little Kennedy, Shenandoah, and Hubricht's cave beetles species have maintained resilient populations throughout their respective ranges based upon the best available data and information on potential threats. This projection also applies to the single site endemic species (Hubbard's, Holsinger's, overlooked, and silken cave beetles). Holsinger's and silken cave beetles have been readily observed demonstrating clear presence and while Hubbard's and overlooked cave beetles had low detection, there was insufficient survey effort to have confidence in drawing a negative resilience inference. Importantly, for each of the cave beetle species, as described above (see CURRENT CONDITION), the best available information does not indicate that the threats are acting on the species, that there are negative effects from general threats, or provide species-specific information on the exposure, timing, and scale of threats at the individual, population, or species levels. We assume that Hupp's Hill cave beetle is extirpated from one location (Battlefield Crystal Caverns) and acknowledge it may have low resilience (moderate confidence) at the Ogden's Cave; however, the best available information indicates the species persists in suitable habitat and no threats are acting on the species at the Ogden's location.

As explained above, the mere identification of "threats" is not sufficient to compel a finding that listing is warranted. The eight cave beetle species' redundancy and representation are naturally limited due to their narrow ranges; however, this may be similar to historical conditions for most of the eight species.

As described above ("Population Status/ Estimate"), it is not possible to reliably assess abundance for any of these species. Cave beetles are cryptic species that can be hard to locate within their habitats. Most caves likely undergo seasonal fluctuations in moisture that may influence the distribution of cave fauna within the system. The nature of caves and karst systems is such that there is presumed to be a large portion of area that is accessible to cave beetles (but not to humans), including cracks and crevices that may extend long distances and connect to unknown caves. Accordingly, we find that the best available data and information for the eight cave beetle species indicates that potential threats are not having population or species level impacts. Thus, after assessing the best available information, we conclude that the eight cave beetle species (i.e., Hupp's Hill, Hubbard's, overlooked, Shenandoah, Little Kennedy, Holsinger's, Hubricht's, and silken cave beetles) are not in danger of extinction throughout all of their ranges.

Therefore, we proceed with determining whether the eight cave beetle species are likely to become endangered within the foreseeable future throughout all of their ranges. Our evaluation is based upon analysis of threats and regional land use projections for a foreseeable future extending out to 2070. We chose to project to 2070 consistent with best available information on identified potential stressors, their expected trends over time, and the species' response to threats (Service 2023, p. 1–2). The best available information does not indicate the threats will impact the species such that any of them meet the definition of a threatened species. As explained above (see FUTURE CONDITION), we do not expect any changes in redundancy or representation for any of the eight species as a result of future threats (by 2040 or 2070).

Under the classification described above for impervious surfaces (see FUTURE CONDITIONS), the Luray-Ruff conservation site, which drains into the cave inhabited by Hubbard's cave beetle, is currently lightly stressed, and is projected to become stressed by 2070 in the A1 scenario (Service 2023, p. vi). This is the only species that is projected to experience any level of increase in stress from impervious surfaces in the future (Service 2023, p. vi). Despite this increase, human population in the county is projected to decline in the foreseeable future likely offsetting potential impacts, and we have no evidence to suggest the future resilience of the species would change significantly from its current status by 2040 or 2070.

The Hupp's Hill cave beetle is the only species that is projected to experience an increase in human population within its county of occurrence (Frederick County) (Service 2023, p. vi). Despite this increase, the percentage of impervious surface within the conservation sites for the species is not projected to increase by 2040 or 2070 (Service 2023, p. vi). In addition, Ogden's Cave's inclusion in a Natural Area Preserve indicates the state has a vested interest in the management and mitigation of impacts to not only the cave itself, but the surrounding sensitive habitats that include springs, wetlands, and Buffalo Marsh Run (Service 2023, p. vii). We do not expect resilience to change significantly relative to its current status by 2040 or 2070 (Service 2023, p. vii).

For all eight species, we do not expect any changes in redundancy or representation as a result of future threats by 2040 or 2070 (Service 2023, p. vii). Additional surveys may result in new occurrence locations which would confer additional redundancy (Service 2023, p. vii). Despite our expectation that viability is unlikely to change significantly for any of the eight species in the assessment, most will remain vulnerable to stochastic and catastrophic events given their low redundancy and restricted geographic ranges (Service 2023, p. vii).

After assessing the best available information, we conclude that the eight cave beetle species (i.e., Hupp's Hill, Hubbard's, overlooked, Shenandoah, Little Kennedy, Holsinger's, Hubricht's, and silken cave beetles) are not likely to become endangered within the foreseeable future throughout all of their ranges.

Status Throughout a Significant Portion of Its Range

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the eight cave beetle species are not in danger of extinction or likely to become so in the foreseeable future throughout all of their ranges, we now consider whether the species may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of their ranges—that is, whether there is any portion of the species' ranges for which it is true that both (1) the portion is significant; and (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the "significance" question or the "status" question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

Hupp's Hill Cave Beetle, Hubbard's Cave Beetle, Overlooked Cave Beetle, Holsinger's Cave Beetle, and Silken Cave Beetle

In undertaking this analysis for Hupp's Hill cave beetle, Hubbard's cave beetle, overlooked cave beetle, Holsinger's cave beetle, and silken cave beetle, we chose to address the status question first. We began by identifying portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency condition of populations.

We evaluated the range of the Hupp's Hill cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The Hupp's Hill cave beetle is a narrow endemic that functions as a single, contiguous population and occurs within a very small area (Ogden's conservation site, where the species is extant, is 8.55 km^2 or 3.30 mi^2); thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status.

We evaluated the range of the Hubbard's cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The Hubbard's cave beetle is a narrow endemic that functions as a single, contiguous population and occurs within a very small area (0.2 km^2 [0.08 mi^2]); thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status.

We evaluated the range of the overlooked cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The overlooked cave beetle is a narrow endemic that functions as a single, contiguous population and occurs within a very small area (0.12 km^2 [0.05 mi^2]); thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status.

We evaluated the range of the Holsinger's cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The Holsinger's cave beetle is a narrow endemic that functions as a single, contiguous population and occurs within a very small area (0.26 km^2 [0.1 mi^2]); thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status.

We evaluated the range of the silken cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The silken cave beetle is a narrow endemic that functions as a single, contiguous population and occurs within a very small area (0.26 km^2 [0.1 mi^2]); thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status.

Therefore, we conclude that there are no portions of the species' range that warrant further consideration, and the species is not in danger of extinction or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors* v. *U.S. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d. 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Shenandoah Cave Beetle

In undertaking this analysis for Shenandoah cave beetle, we chose to address the status question first. We began by identifying portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency condition of populations.

We evaluated the range of the Shenandoah cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The range of a species can theoretically be divided into portions in an infinite number of ways. We focused our analysis on portions of the species' range that may meet the definition of an endangered species or a threatened species. For Shenandoah cave beetle, we considered whether the threats or their effects on the species are greater in any biologically meaningful portion of the species' range than in other portions such that the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. We examined the following threats: (1) quarrying, (2) development/urbanization, and (3) commercial cave tour operations, and (4) agriculture.

Quarrying is a type of open-pit mining where stone, minerals, or other materials are extracted from the ground (see THREATS). Limestone deposits are typically quarried to supply materials for the building and construction industry. The three primary ways that quarrying may affect cave environments are physical alterations to the cave's structure, changes to the cave's established hydrological system, and impacts to water quality. There is no evidence to suggest quarrying is impacting the Shenandoah cave beetle.

Data and information are not available on whether or how development and urbanization is acting on the Shenandoah cave beetle; however, projections show that all three conservation sites for the species remain "lightly stressed" through 2070 (see FUTURE CONDITION). There is no evidence to suggest development and urbanization is impacting the Shenandoah cave beetle in any portion of its range.

Shenandoah cave beetle has historically been collected from four caves (3 analysis units): Shenandoah Caverns and Shenandoah Wild Cave (first analysis unit), and Madden's Cave (second analysis unit) (three caves in Shenandoah County, VA), and Bakers Cave in Rockingham County, VA (third analysis unit). For the purpose of this analysis, we consider these three analysis units to be portions in which to evaluate status. Shenandoah Wild Cave and

Shenandoah Caverns house commercial cave tour operations; however, data and information are not available on whether or how this potential threat is acting on Shenandoah cave beetle. Therefore, there is no evidence to suggest commercial cave tour operations are negatively impacting the Shenandoah cave beetle.

Agriculture is a common land use throughout the collective ranges of the eight cave beetle species in rural parts of Virginia; however, agricultural lands in the region are primarily hay or pasture versus row cropping; row cropping tends to involve more manipulation of surface hydrology and chemical applications (Service 2023, p. 4–3). VADCR biologists noted that agriculture within the ranges of the eight cave beetles appears to be a compatible land use with species persistence (USFWS-VADCR 10/25/2021 pers. comm.). Concentrated animal feeding operations (poultry farms) are located within the southern half of the species range (Madden's Cave and Bakers Cave analysis units); however, none are within the conservation sites (i.e., areas within which activities have the potential to influence the known cave locations) (see figure 11) (Service 2023, p. 6–20). Moreover, although such operations may result in the introduction of contaminants and other pollutants into the cave system, there is high uncertainty regarding the species response to this type of habitat alteration. There is no evidence that agriculture is negatively impacting the Shenandoah cave beetle in any portion of its range (Service 2023, p. 6–20).

After evaluating the best available scientific and commercial information on potential stressors acting individually or in combination, we found no biologically meaningful portion of the Shenandoah cave beetle's range where threats are impacting individuals differently from how they are affecting the species elsewhere in its range, or where the biological condition of the species differs from its condition elsewhere in its range such that the status of the species in that portion differs from its status in any other portion of the species' range.

Therefore, we find that the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors v. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Little Kennedy Cave Beetle

In undertaking this analysis for the Little Kennedy cave beetle, we chose to address the status question first. We began by identifying portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency condition of populations.

We evaluated the range of the Little Kennedy cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The range of a species can theoretically be divided into portions in an infinite number of ways. We focused our analysis on portions of the species' range that may meet the definition of an endangered species or a threatened species. For Little Kennedy cave beetle, we considered whether the threats or their effects on the species are greater in any biologically meaningful portion of the species' range than in other portions such that the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. We examined the following threats: (1) quarrying, (2) development/urbanization, and (3) timbering. Little Kennedy cave beetle has historically been collected from eight caves grouped into five analysis units (figure 6): Wildcat, Kennedy, Cracker Neck, East Stone Gap, and Kelly conservation sites. For the purpose of this analysis, we consider these five analysis units to be portions in which to evaluate status.

Quarrying is a type of open-pit mining where stone, minerals, or other materials are extracted from the ground (see THREATS). Limestone deposits are typically quarried to supply materials for the building and construction industry. The three primary ways that quarrying may affect cave environments are physical alterations to the cave's structure, changes to the cave's established hydrological system, and impacts to water quality. There is no evidence to suggest quarrying is impacting the Little Kennedy cave beetle.

Data and information are not available on whether or how development and urbanization, including proximity to roads and highways, is acting on the Little Kennedy cave beetle. Wildcat Saltpetre Cave has a history of fuel oil contamination from a nearby tank yard (Service 2023, p. 6–26). Although this issue was resolved, its long-term impact on the cave is unknown (Service 2023, p. 6–26). When the Wildcat Cavern beetle specimens were collected, VADCR staff encountered a trash plug within the passage (Service 2023, p. 6–26). Despite these conditions, Wildcat Cavern had the highest rate of detection among the Little Kennedy cave beetle sites that were visited, underscoring the uncertainty associated with the species response to various types of habitat degradation (Service 2023, p. 6–26). Projections show that all five conservation sites for the species remain "lightly stressed" through 2070 (see FUTURE CONDITION). There is no evidence to suggest development and urbanization is negatively impacting the Little Kennedy cave beetle in any portion of its range.

As discussed above (see "THREATS"), timbering has the potential to alter hydrology and introduce sediment and pollutants into cave systems (Service 2023, p. 4–2). Timbering or logging in areas with karst geology can result in the introduction of sediments into cave systems, and in extreme cases, the erosion and removal of the epikarst layer that serves to filter surface water before it enters the cave system (Service 2023, p. 4–2). The Kennedy caves on Stone Mountain underlie a forested area that is privately owned and was left untouched during a clear-cut harvest by the landowner (Malabad *et al*. 2021, p. 24). There is no evidence to suggest timbering is impacting the Little Kennedy cave beetle in any portion of its range.

After evaluating the best available scientific and commercial information on potential stressors acting individually or in combination, we found no biologically meaningful portion of the Little Kennedy cave beetle's range where threats are impacting individuals differently from how they are affecting the species elsewhere in its range, or where the biological condition of the species differs from its condition elsewhere in its range such that the status of the species in that portion differs from its status in any other portion of the species' range.

Therefore, we find that the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors v. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Hubricht's Cave Beetle

In undertaking this analysis for Hubricht's cave beetle, we chose to address the status question first. We began by identifying portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency condition of populations.

We evaluated the range of the Hubricht's cave beetle to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The range of a species can theoretically be divided into portions in an infinite number of ways; however, as described above (see *Range/Distribution*), VADCR has established a single conservation site associated with these two EOs that delineates the area of influence surrounding the caves. We focused our analysis on portions of the species' range that may meet the definition of an endangered species or a threatened species. For Hubricht's cave beetle, we considered whether the threats or their effects on the species are greater in any biologically meaningful portion of the species' range than in other portions such that the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. We examined the following threats: (1) quarrying, (2) development/urbanization, and (3) agriculture.

Quarrying is a type of open-pit mining where stone, minerals, or other materials are extracted from the ground (see THREATS). Limestone deposits are typically quarried to supply materials for the building and construction industry. The three primary ways that quarrying may affect cave environments are physical alterations to the cave's structure, changes to the cave's established hydrological system, and impacts to water quality. There is no evidence to suggest quarrying is impacting the Hubricht's cave beetle.

Data and information are not available on whether or how development and urbanization is acting on Hubricht's cave beetle; however, projections show that the conservation site for the species remains "lightly stressed" through 2070 (see FUTURE CONDITION). There is no evidence to suggest development and urbanization is impacting the Hubricht's cave beetle.

Agricultural land use is the dominant land use within the range of Hubricht's cave beetle. A large portion of the species range consists of open pastures used for livestock and hay production. Low intensity agriculture is considered largely compatible with cave beetle persistence (USFWS-

VADCR 10/25/2021 pers. comm.). There is no evidence to suggest agriculture is negatively impacting the Hubricht's cave beetle in any portion of its range.

We found no biologically meaningful portion of the Hubricht's cave beetle range where threats are impacting individuals differently from how they are affecting the species elsewhere in its range, or where the biological condition of the species differs from its condition elsewhere in its range such that the status of the species in that portion differs from its status in any other portion of the species' range.

Therefore, we find that the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors v. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Determination of Status

Our review of the best available scientific and commercial information indicates that the Hupp's Hill, Hubbard's, overlooked, Shenandoah, Little Kennedy, Holsinger's, Hubricht's, and silken cave beetles do not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the Hupp's Hill, Hubbard's, overlooked, Shenandoah, Little Kennedy, Holsinger's, Hubricht's, and silken cave beetles is not warranted at this time. Our analysis for this decision applied our current regulations, portions of which were last revised in 2019. Given that we proposed further revisions to these regulations on June 22, 2023 (88 FR 40764), we have also undertaken an analysis of whether the decision would be different if we were to apply those proposed revisions. We concluded that the decision would have been the same if we had applied the proposed 2023 regulations. The analyses under both the regulations currently in effect and the regulations after incorporating the June 22, 2023, proposed revisions are included in our decision file.

COORDINATION WITH STATES

While conducting the SSA for the eight cave beetle species, we closely coordinated with State Department of Conservation and Recreation in Virginia. Virginia, the sole State within the range of the species, was given the opportunity to provide data, participate in the SSA process, and review the draft SSA report. We received information from Virginia.

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