U.S. Fish & Wildlife Service

Key Cave National Wildlife Refuge
Lauderdale County, Alabama

Map Sheet 2: Key Cave NWR Cave Habitat

Cave Objectives for the Priority Resources of Concern:
Alabama cavefish (*Speoplatyrhinus poulsoni*), Alabama cave crayfish (*Cambarus jonesi*), and Gray bat (*Myotis grisescens*)

Cave Habitat Objective	Primary Habitat and Wildlife Response Variables
Cave - Alabama Cavefish and Alabama cave crayfish and other aquatic cave fauna Objectives: Continue to contribute to the protection and maintenance of the integrity of Key Cave for appropriate abiotic and biotic conditions that are suitable to support a sustainable population of the Alabama cavefish (which is currently estimated to be between 100 and 130 individuals) and Alabama cave crayfish (which is currently estimated to be between 1,000-10,000 individuals in the 12 caves it has been found) : 1.A.1. Minimize groundwater contamination on 1,060 acres by utilizing selected BMPs. 1.A.2. Annually monitor water quality in Key Cave, including parameters such as ground water elevation, water temperature, dissolved oxygen, turbidity, nutrients, and pesticides to detect changes in water-quality over time. 1.A.3. Provide maximum protection of the Gray bat maternity colony within Key Cave to foster continued nutrient inputs that provides for micro-invertebrate communities of copepods, isopods, amphipods, and crayfish. 1.A.4. Within 5 years of this plan identify known and suspected sinkholes on the refuge and characterize each's hydrologic function/connectivity to Key Cave (**Figure 1**). 1A.5. Upon the development of an Inventory and Monitoring Plan, develop standardized protocol and methodology for cave and cavefish monitoring, including pool location, pool depth, species occurrence, species abundance, estimated age/size class, total number of individual surveyors, visual-timed area searches, and method of survey. 1.A.6. As technology advances in molecular science, utilize institutions for genetic sampling (e.g. eDNA) to determine cavefish population size, reproduction, genetic diversity and other aquatic species diversity.	• Water quality and quantity gauge(s) • Monitor water quantity (partners) • Monitor water quality (FWS and partners) • Monitor cavefish population
Cave - Gray Bat Objectives: • Protect and maintain the integrity of Key Cave for the listed desired conditions and actions to continue to support a Priority 1 Gray bat maternal colony of approximately 36,000 adult females and to continue to support tricolored bat use. • 1.A.7. Coordinate with TVA, USGS, and other partners to avoid disturbance in Key Cave from mid-April through September for Gray bats. • 1.A.8. Coordinate with TVA, USGS, and other partners to avoid disturbance in the cave from mid-October through April for the tricolored bat. • 1.A.9. Maintain a 0.25-mile protective forested cover buffer around the Key Cave entrance for Gray bat foraging and to minimize alterations in cave air flow and ambient temperature. • 1.A.10. Biennially, conduct abundance counts during the summer months for Gray bats and during winter months for tricolored bats within Key Cave utilizing most current standardized protocols and methodology for cave and bat monitoring.	• Monitor bat abundance

Key Cave NWR: Cave and Cave Recharge Area

Cave Habitat Objective	Primary Habitat and Wildlife Response Variables
Recharge Area Objective Contribute to the protection and maintenance of the integrity of Key Cave within the larger recharge area landscape (**Figure 2, 3, and 4)** and the endemic threatened and endangered species by working with the partners to: 1.B.1. Within 5 years of the plan delineate and refine the recharge area. 1.B.2. Maintain at minimum, 300 acres of grassland habitat in native vegetation encompassing nearly 30% of the refuge land base to aid in ground water filtration, erosion reduction, and nutrient cycling. 1.B.3. Maintain 50 ft-wide vegetative buffer strips around cropland edges to aid in ground water filtration and soil erosion stabilization. 1.B.4. Maintain grassland or forested habitat within and adjacent to wetlands, sink holes, and drainages. 1.B.5. In cooperation with Tennessee River Valley Authority (TVA), maintain 300 acres of hardwood forests along the Tennessee River and Key Cave entrance, to aid in cave habitat protection, ground water filtration, and soil erosion stabilization. 1.B.6. Annually monitor groundwater quality and quantity, including parameters such as ground water elevation, water temperature, dissolved oxygen, turbidity, nutrients, and pesticides to detect changes over time. 1.B.7. In cooperation with USFWS private lands biologist, support implementing water quality and recharge area protection projects with landowners within the Key Cave recharge area.	• Water quality and quantity gauge(s) • Monitor water quantity (partners) • Monitor water quality (FWS and partners) • Monitor cavefish population

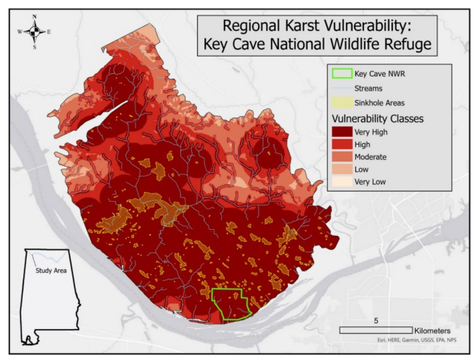


Figure 2. Regional karst and aquifer vulnerability model (USFWS unpublished 2024)

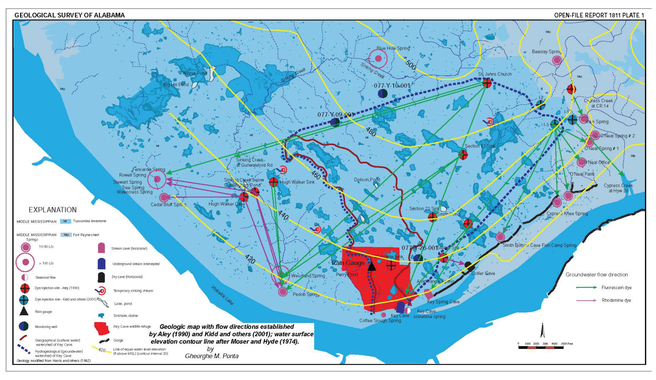


Figure 3. Subsurface flow directions from dye studies used to delineate the Key Cave recharge aquifer (Ponta, et. al 2018).

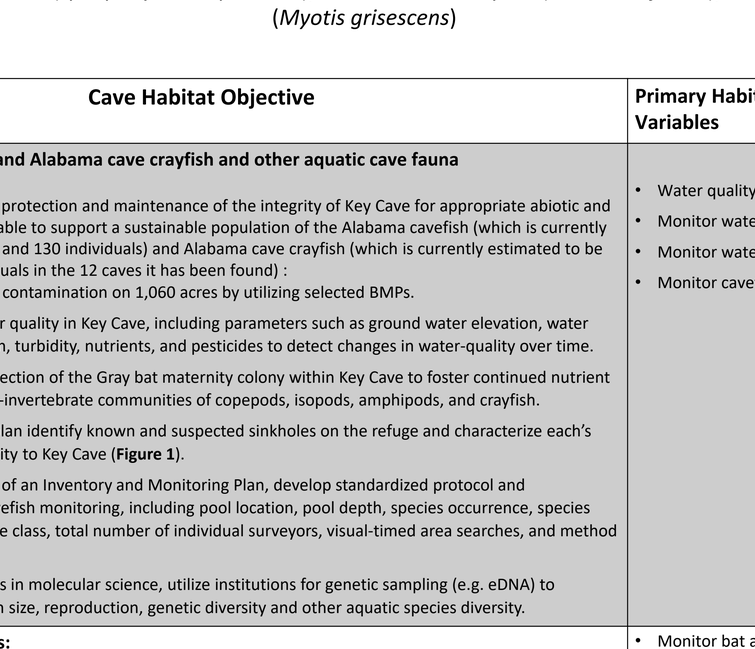


Figure 1. Approximate Key Cave topographic underlay as well as delineated recharge area for Key Cave aquifer, Key Cave NWR boundary, and related sinkholes (GSA 2016).

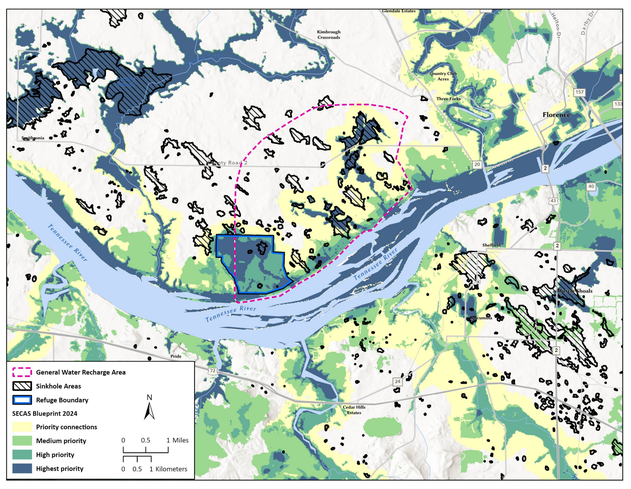


Figure 4. Southeast Conservation Blueprint Priorities (SECAS) on the refuge and within the currently defined recharge area of Key Cave. Identified also are known sink holes (GSA 2016).

Key Cave is a multi-level, complex cave with just over two miles of linear solution passageways, many of which are inundated throughout the year, and a groundwater recharge area of 12,800 acres. Water throughout the cave system is slow moving and levels rise and fall with the underlying groundwater table, which corresponds to above-ground conditions and water elevations in Pickwick Reservoir (Ponta et al. 2018, USFWS 2017).

Groundwater is recharged mostly from surface water that enters the Cave through sinkholes or seeps, as there are no above-ground perennial streams on the Refuge, and just one stream, Sinking Creek, in the recharge area. Waters from the cave discharge into Pickwick Reservoir through Coffee Slough (Milewski et al. 2019, USFWS 2007, 2017). Aley (1990) estimated that Key Cave has about 3,774 m (12,381 ft) of linear solution passageways, much of which are inundated throughout the year.

Priority Resources of Concern: Alabama cavefish, Alabama cave crayfish, and Gray bat
Other benefitting species: Phantom cave crayfish (*Cambarus pecki*), copepods, isopods, amphipods, shrimp and tricolored bats

Alabama Cavefish

- <100 individuals (Kuhajda 2004, as cited in USFWS 2017)
- <100 individuals (Cooper and Kuehne 1974 and Cooper 1975, as cited in Kuhajda and Mayden 2001).
- "In 36 recorded excursions into Key Cave by biologists from 1967 to 1998, a total of only 130 Alabama cavefish were observed" (Boschung and Mayden 2004).

Alabama Cavefish Recovery Criteria (USFWS 2019)

- Criterion 1. Existing population in Key Cave demonstrates a stable or increasing trend, evidenced by natural recruitment and multiple age classes.
- Criterion 2. Two (2) additional populations are discovered or established that demonstrate a stable or increasing trend, evidenced by natural recruitment and multiple age classes (**Figure 5 and Table 1**).
- Criterion 3. The aquifer recharge areas for these populations are thoroughly delineated, mapped, and protected from any foreseeable threats.
- Criterion 4. At least two (2) additional populations demonstrate a stable or increasing trend, evidenced by natural recruitment and multiple age classes; and, for at least one of these, the aquifer recharge area is protected by a conservation mechanism.
- Criterion 5. All other threats have been addressed or managed to the extent that the species(**Figure 6**) will remain viable for the foreseeable future.

Alabama Cave Crayfish

- Global abundance: 1,000–10,000 in 12 cave systems in Alabama (NatureServe Explorer n.d.)
- All populations are composed of very few individuals; fecundity is low and (Buhay et al., 2007). Bouchard (1974) noted it uncommon in Tennessee River tributaries in Alabama.
- The species (**Figure 7**) are in a limited number of cave localities and have a small, fragmented range (Buhay et al., 2007)

Gray Bat

- Number of major hibernacula in Alabama = 1 (USFWS 1982)
- Total Alabama population = 700,000 (estimates may differ from actual numbers by 25–50% according to text) (USFWS 1982); Martin 2007 cites 1.2 million within Fern Cave during winter.
- Four National Wildlife Refuges (NWR) have been established in Alabama that, in part, provide protection for some of the largest populations of Gray bats (**Figure 8**) in the country: Fern Cave NWR, Sauta Cave NWR, Key Cave NWR, and the Wheeler NWR which includes Cave Springs Cave.
- Range-wide population increased from approximately 1,575,000 to roughly 2,678,000 in 2002 and to ca. 3,400,000 in 2004 (Ellison et al. 2003; Martin 2007)
- Population trend: increasing (USFWS 2009) (**Table 2**)
- Key Cave maternity roost population estimate: 33,402–48,800 (Martin 2007); Latest estimates include 38,000 in 2020 (Gates pers. comm.)

Tricolored Bat

- During the winter, tricolored bats (**Figure 9**) roost in caves and mines, although in the Southern United States, where caves are sparse, tricolored bats are often found roosting in road-associated culverts.
- During the spring, summer and fall, tricolored bats are found in forested habitats where they roost in trees, primarily among leaves.
- White-nose syndrome, a disease that impacts bats, is caused by a fungal pathogen. It has led to 90 to 100% declines in tricolored bat winter colony abundance at sites impacted by the disease.
- Tricolored bats were proposed for listing as endangered as of September 14, 2022.

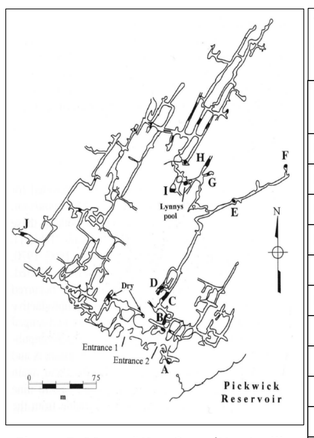


Figure 5. Map of Key Cave (Huntsville Grotto-National Speleological Society)

Table 1. Pools with historic positive detections of *S. poulsoni* to date (Kuhajda and Mayden, 2001

Pool Name	Alabama Cavefish Detected?*
Pool A	**Yes**
Pool B	**Yes**
Pool C	**Yes**
Pool D	**Yes**
Pool E	No
Pool F	**Yes**
Pool G	No
Pool H	No
Pool I	No
Pool J	No
Lynny's Pool	No

The pools inhabited by the Alabama cavefish lie in a zone of seasonal oscillation of the water table where pools that form during high water become isolated during drier conditions (Trajano 2001).

Most pools and all cavefish observations to date have occurred within the eastern half of the cave, although more habitat potentially exists in areas that are difficult to access and survey.

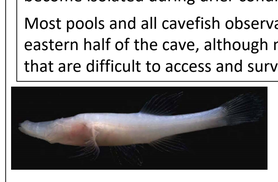


Figure 6. Alabama cavefish, listed as endangered, the Alabama cavefish is only known to occur in Key Cave.

Figure 7. Alabama cave crayfish have low fecundity, and a long immature period.

Figure 8. Gray bats provide guano that is the food resource for the copepods, isopods, and amphipods living in Key Cave; those animals are what the cavefish feed on.

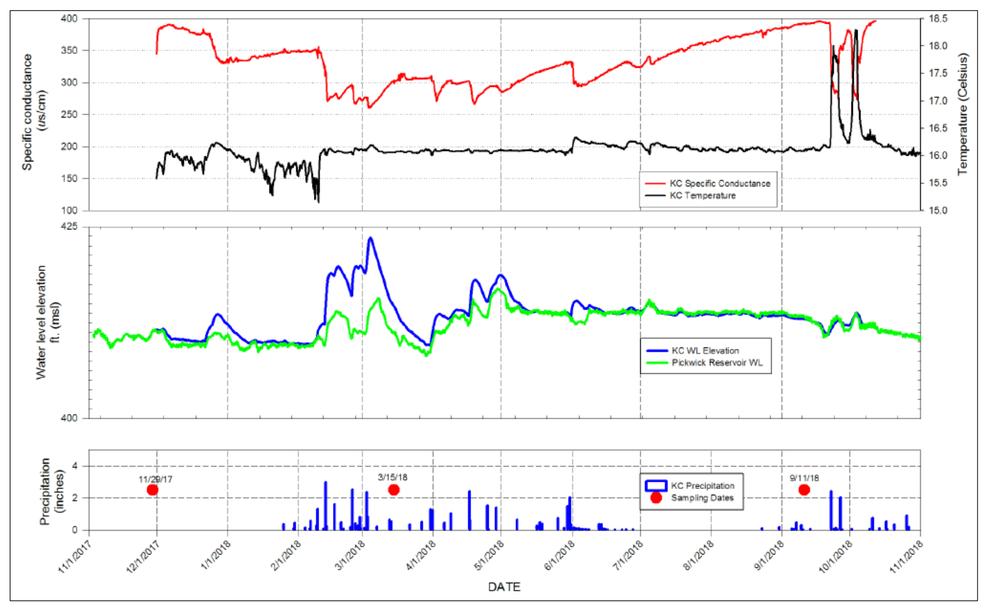
Table 2. Gray Bat population estimates from 2002 through 2005 in Key Cave (Martin 2007) noting an increasing population trend.

Year	Population
2002	33,402
2003	31,514
2004	34,916
2005	48,800

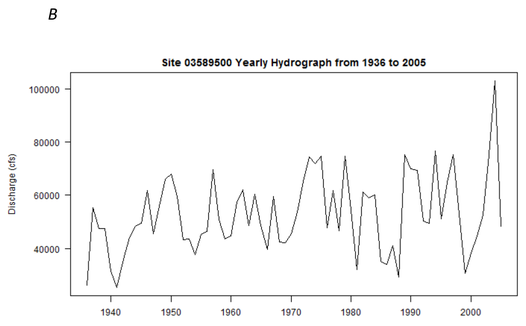
Figure 9. The tricolored bat uses the cave as a winter hibernaculum.

Baseline Cave Characteristics and Potential and Selected Management Strategies and Tools

A



B



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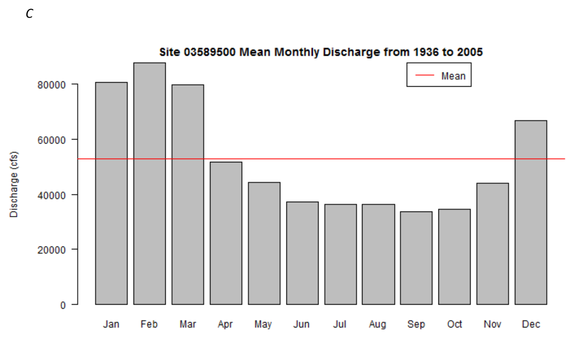

Figure 10. A. Plot of values of conductance and water levels in Key Cave and Pickwick Reservoir, with precipitation from November 2017 to December 1, 2018; B. Average yearly discharge from 1936-2005; C. Mean monthly discharge from 1936-2005 (GSA, 2018 and Milewski et. al 2019).

Cave Environment Management Strategies

- Coordinate with universities, NGOs, and state partners to facilitate hydrological and biological monitoring (**Figure 10**).
- Utilize special use permits to manage access into Key Cave.
- Continue to use and maintain cave entrance barriers, gates, or fencing to restrict access.
- Maintain vegetation buffers along drainages, wetlands, and sinkholes.
- Retain a large buffer of mature hardwood forests with no active management (thinning, burning, mulching) around the cave entrance.
- Reduce pesticide use, fertilizer use, and soil erosion through BMPs.