Schedules

Daily Schedule

Monday October 6, 2025 schedule (workshops)

Tuesday October 7, 2025 schedule

Wednesday October 8, 2025 schedule

Thursday October 9, 2025 schedule

Friday October 10, 2025 schedule

ABSTRACTS -Oral presentations:

Biology

Cave and Karst Management

Education and Outreach

Hydrogeology

Monitoring and Modelling

ABSTRACTS – Posters

Monday October 6, 2025

Workshops

Grafitti Mitigation and Speleothem Repair Val Hildreth-Werker

Organizing a Cave Inventory – Dr. Ben Tobin

Developing a cave rescue plan

Introduction to Dye Tracing – Lee Anne Bledsoe

Simplifying Speleo Science – Nicole Ridlen

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Time	**Tuesday October 7, 2025**		
8:00-9:00	Coffee and Karst Roundtable		
Cave Management Session Chair: Val Hildreth-Werker			
Time	**Presentation Title**	**Speaker**	
9:00-9:25	Managing a Variety of Caves and Cave Issues at Great Basin National Park, Nevada, USA	Gretchen Baker	Great Basin National Park
9:25-9:50	50 Years of Preservation, Environmental Monitoring and Scientific Research at Kartchner Caverns	Chelsea Ballard	Kartchner Caverns State Park
9:50-10:15	History and Development of Defiance Cave reserve	Mike Frazier and Madonna Frazier	Southern Colorado Mountain Grotto
10:15-10:30	BREAK		
10:30-10:55	Buying Caves for Cavers (to Protect) - 34 Years of Cave Conservation Through Capitalism	Bill Putnam	SCC Co-Founder, Past Chairman, and Former Director
10:55-11:20	Thirty Years of Karst and Cave Conservation by the Virginia Natural Heritage Karst Program, Department of Conservation and Recreation	Wil Orndorff	Virginia Department of Conservation and Recreation, Division of Natural Heritage
11:20-11:45	An Introduction to the International Union of Speleology and the Proposed International Day of Caves and Karst	Val Hildreth-Werker	National Speleological Society (NSS) Conservation Lead
11:45-2:00pm	LUNCH		
Hydrogeology: Session Chair: Amy Hourigan			
2:00-2:25	Targeting the Right Terrain: Suitability Modeling for Areas of High Karst Conservation Value in Tennessee	Amy Hourigan	United States Geological Survey
2:25-2:50	Deep caves, big sinks, and anticlines, oh my: dye tracing efforts on Dorton Knob and Hinch Mountain near Grassy Cove, Tennessee	Ben Miller	Tennessee Cave Survey
2:50-3:15v	Comparative Performance of Mesh Bag and Milk Sock Charcoal Receptors in Field-Based Fluorescent Dye Tracing	Monica Galvez	Crawford Hydrology Laboratory, Depart of Earth, Environmental, and Atmospheric Sciences, Western Kentucky University
3:15-3:30	BREAK		
3:30-3:55	Preliminary Investigation on Stream Flow Variations in the Black River Complex, Roppel Section of the Mammoth Cave System	Ljubomir Risteski	Earth, Environmental and Atmospheric Sciences, Western Kentucky University
3:55-4:20	Groundwater Tracing and Hydrologic Monitoring of the River Styx: Management Applications for Oregon Caves National Monument and Preserve	Anastasiya Razumovska	Oregon Caves National Monument and Preserve
4:20-4:45	Illuminating Karst Hydrology: Dye Tracing for Informed Resource Management at Mammoth Cave National Park	Lee Anne Bledsoe	Crawford Hydrology Laboratory, Department of Earth, Environmental, and Atmospheric Sciences, WKU

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Wednesday October 8, 2025: Field Trips 8am - 5pm			
Field Trips 8:00-5:00 Kitchen hours for making your own lunch 6:30-8:30am			
Poster Session 7pm			
1	The Mapping of Lehman Caves	Shane Fryer & Cyndie Walck	
2	Preliminary Investigation on Stream Flow Variations in the Black River Complex, Roppel Section of the Mammoth Cave System	L.J. Risteski	Earth Environmental & Atmospheric Sciences, Western Kentucky University
3	Environmental personhood and karst management	Tamara González-Durán	Comunidad Espeleológica Puertorriqueña (CEP)
4	From Surface to Subsurface: Integrating Incrop Mapping in the Mammoth Cave System	Patricia Kambesis	Center for Human GeoEnvironmental Studies, Western Kentucky University
5	The Little Muddy Cave Carbon Dioxide (CO_2) Problem, Great Basin National Park	Kirsten Bahr	Physical Science Technician, Great Basin National Park
6	Protecting Wild Caves in White Pine County	Gretchen Baker	Great Basin National Park
7	Protecting Lehman Caves through improved structure and outreach	Gretchen Baker	Great Basin National Park

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Thursday October 9, 2025 Oral Presentations			
8:00-9:00am	Coffee and Karst Roundtable		
Biology - Session Chair: Dr. Jerry Lewis			
9:00-9:25	Mapping cave vulnerability and priority areas for biospeleological conservation	Lael Anderson	University of Alabama
9:25-9:50	Characterization and Composition of Skin and Exoskeleton Microbiomes of Aquatic Cave Fauna and the Influence of Environmental Variables on Microbiome Composition and Diversity in the Southern Cumberland Plateau, USA.	Bjorn V. Peterson	University of Alabama
9:50-10:15	New surveys of groundwater fauna in the Upper Floridan Aquifer of Florida and Georgia	Eric Maxwell	University of Alabama
10:15-10:30	BREAK		
10:30-10:55	Biodiversity on the brink: Sensitive communities on karst-associated cliffs	Jerry J. Lewis & Salisa L. Lewis	Lewis and Associates
10:55-11:20	Evaluating genetic diversity and potential cryptic diversity within the Georgia Blind Salamander (Eurycea wallacei) and the Dougherty Plain Cave Crayfish (Cambarus cryptodytes).	Jacob Schafer	University of Alabama
11:20-11:45	Phylogenomics of endangered *Batrisodes* and *Texamaurops* rove beetles from central Texas karst regions	Perry L. Wood, Jr	[1]*U. S. Geological Survey,*
11:445:12:10	Evaluating the Efficacy of the Translocation of the Biota from a Cave to a Mine	Dr Geo Graening	Dept of Biology, California State University
12:10-2:00	LUNCH		
Education & Outreach: Session Chair: Chelsea Ballard			
2:00-2:25	Cave Animal of the Year Programs and Resources for Managers	Shiloh McCollum	University of Alabama
2:25-2:50	An Education System Designed to Make Cave and Karst Management Easier"	Dave Jackson	CavSim
Monitoring and Modelling Session chair LJ Risteski			
2:50-3:15	Improving cave and climate awareness through research at Wounded Knee Cave, Southern Nevada	Sadie Carlin & Laura Rosales-Gegarde	Nevada State University
3:15-3:40	Park-wide Cave Climate Monitoring: Is it as simple as it seems	Claira Morrison & Gretchen Baker	Great Basin National Park
3:40-3:55	Break		
3:55-4:20	Coach Cave Microclimate: Piecing Together a Broken Past	Jim Kennedy	Cave Gators
4:20-4:45	Utilizing Structural Lineament Mapping with Digital Elevation Models for Understanding Speleogenetic Patterns in the Mammoth Cave Plateau	L.J. Risteski	Earth Environmental & Atmospheric Sciences, Western Kentucky University
4:45-5:05	Recharge-Driven Variability in Cave Temperature Regimes	Patricia Kambesis	Center for Human Geoenvironmental Studies, Western Kentucky University

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Friday, October 10, 2025: Session chair: Pat Kambesis			
9:00-9:25	Speleological Inventory and Protection of Cultural Markings with Systematic Removal Processes for Selected Graffiti	Val Hildreth-Werker	National Speleological Society (NSS) Conservation Lead
9:25-9:50	Strip Coal Mine Reclamation at Sarah Furnace Cave, Pennsylvania	Bert Ashbrook	Mid-Atlantic Karst Conservancy
9:50-10:15	The Mapping of Lehman Caves	Shane Fryer & Cyndie Walck	National Speleological Society (NSS)
10:15-10:40	Graffiti Removal in Caves: Options and Experiences 12 Years of Cave Restoration	Neil Marchington	Western Region
10:40-11:05	Predicting Cave Distribution in the Greenbrier River Watershed WV Using Maximum Entropy Modeling	David Riggs	Mountain Hydrology Lab, West Virginia University Davis College of Natural Resources, Morgantown WV

BIOLOGY

Mapping cave vulnerability and priority areas for biospeleological conservation

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The University of Alabama in Huntsville

Caves represent some of the most biologically unique and fragile ecosystems on Earth yet remain among the least studied and most vulnerable to human disturbance. Systematic assessments that integrate biological, landscape, and anthropogenic data can help identify areas at greatest risk, especially in regions with high biodiversity but limited ecological information. This study applied a spatially explicit threat–vulnerability modeling approach to caves in Alabama, a state recognized for its exceptional subterranean diversity but lacking any prior statewide vulnerability analyses. Factors incorporated into the assessment included the size and proximity of human populations, surrounding land-use characteristics, and groundwater metrics related to risks in water quality and quantity. A modified DRASTIK method was developed to refine evaluations for aquatic cave species. Complementing these assessments, updated distribution maps were generated for terrestrial and aquatic cave-obligate species as well as cave-roosting bats. Major threats facing each group were examined, and both species and cave systems of highest conservation concern were identified. The resulting hybrid framework integrates measures of biological diversity with landscape-level pressures to produce a more comprehensive evaluation of cave vulnerability. By highlighting patterns and drivers of subterranean ecosystem risk, this work provides a foundation for conservation planning and policy in Alabama and offers a replicable model for other regions with rich but understudied cave faunas.

Evaluating the Translocation of the Biota from a Cave to a Mine: the McClean's Cave / Transplant Mine Case Study

Dr. Geo Graening[1] and Anastasiya Razumovska[2]
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[2]National Speleological Society, Mother Lode Grotto

Mines are known to provide surrogate habitat for cave fauna, especially bat species. Other animals use mines for hibernation, aestivation, or feeding opportunities. Troglobites have also been reported from mines. While cave fauna may voluntarily colonize mines, there has only been one documented effort to translocate the fauna from a cave to a mine. We evaluated the efficacy of this translocation effort fifty years later. The construction of the New Melones reservoir in 1978 inundated 30 caves in the Stanislaus River canyon in California's foothills of the Sierra Nevada. To rescue the cave fauna, which included globally-rare cave harvestmen in the genus Banksula, speleologists translocated the fauna from McClean's Cave to Transplant Mine from 1975 to 1978. Transplant Mine was chosen, and the environmental variables closely match that of McLean's Cave. To provide organic matter for the base of the foodweb, hundreds of kilograms of soil, humus, and woody debris were also translocated from McClean's Cave to the rather sterile mine. In 2024, Transplant Mine was surveyed to determine current environmental conditions and composition of its subterranean fauna. The mine still exhibited temperature and humidity conditions similar to caves in the region. After 50 years, the translocated fauna declined in species richness and in total individuals. However, the presence of both adult and juvenile Banksula in the habitat is remarkable, and it cannot be concluded that the translocation is a failure for this flagship species or the cave fauna in general. Management recommendations are suggested to protect the habitat and fauna in Transplant Mine.

Biodiversity on the brink: Sensitive communities on karst-associated cliffs

Julian J. Lewis and Salisa L. Lewis
Lewis and Associates: Cave, Karst and Groundwater Biological Consulting lewisbioconsult@gmail.com

Cliffs are common features of karst, and cave entrances are frequently continuations of rock faces in limestone as well as sandstone. Although as habitats cliffs may appear harsh and lifeless, a variety of organisms occur there and some of them specialize in inhabiting such places. The sites discussed here were not the focus of a study of the fauna or ecology of cliffs, but rather incidental to several projects concerning the fauna of caves. A good example occurs in Cave Hollow in the Bernheim Forest and Arboretum in north-central Kentucky, where the only known population of the Bluff vertigo snail *Vertigo meramecensis* occurs. As calciphiles, terrestrial snails are frequent inhabitants in limestone habitats. At Bernheim, *Vertigo meramecensis* occurs not in the caves of Cave Hollow, but on the vuggy limestone cliffs surrounding the cave entrances. Across its narrow range the rare snail occurs only on limestone cliffs, frequently in the presence of lush bryophytes.

Plants may be important parts of these communities. In Hemlock Cavern, the largest sandstone shelter cave in Indiana, the state-endangered Weft fern *Crepidomanes intricatum* was discovered last year. In Browns Hole, in southern Illinois, a rare population of Appalachian filmy fern *Vandenboschia boschiana* occurs among the verdant bryophytes in the entrance. The ferns are dependent on the high humidity associated with the cave. Entering the cave without disturbing the plant community is nearly impossible.

At Porter Cave in southern Indiana three species of spiders occur. The troglobiontic sheet-web spider *Phanetta subterranea* occurs in the dark zone, while the trogloxenic orb-weaver *Meta ovalis* is abundant in the twilight zone above the stream. The

cobweb spider *Cryptachaea porteri* occurs at the type-locality of the species only on the limestone cliff around the cave entrance. Not all cliff-dwellers are rare - *Cryptachaea porteri* is widespread across North America.

New surveys of groundwater fauna in the Upper Floridan Aquifer of Florida and Georgia

Eric Maxwell, Teddy Garlock, Jacob Schaefe,r
Dante B. Fenolio, Matthew L. Niemiller
University of Alabama, Huntsville, Alabama

The Upper Floridan Aquifer is one of the most productive aquifers in the United States, providing drinking water for millions of people across the southeastern United States. Despite its ecological and economic importance, the aquifer remains poorly studied with respect to its unique and often highly specialized groundwater fauna. Previous work has revealed that the region supports a remarkable diversity of stygobionts, including several iconic and imperiled taxa such as the Georgia Blind Salamander *(Eurycea wallacei*) and Dougherty Plain Cave Crayfish (*Cambarus cryptodytes*). Yet many areas of the aquifer, particularly in southwestern Georgia and the Florida panhandle, have received little recent biological study. To address this knowledge gap, we surveyed 47 cave springs in the Dougherty Plain across 58 surveys conducted from August 2024 through August 2025. We documented 52 taxa representing 5 phyla, 13 classes, 31 orders, and 37 families. A total of 9 stygobionts were observed across 20 sites, highlighted by new locality records for the Dougherty Plain Cave Crayfish and Georgia Blind Salamander. Notably, we also discovered two potential new sites for the Shaggy Ghostsnail (*Dasyscias franzi*), a species previously known only from a single cave spring in Washington County, Florida. These findings underscore both the exceptional biodiversity of the Upper Floridan Aquifer and the continued need for surveys in understudied regions. Expanding the known distributions of rare and endemic taxa provides critical baseline data for management and conservation of groundwater ecosystems in the southeastern United States.

Characterization and Composition of Skin and Exoskeleton Microbiomes of Aquatic Cave Fauna and the Influence of Environmental Variables on Microbiome Composition and Diversity in the Southern Cumberland Plateau, USA.

Bjorn V. Peterson[*1], Joseph Benito[1], Annette Summers Engel[2,3], Audrey T. Paterson[2], Matthew L. Niemiller[1]*
[1]The University of Alabama in Huntsville
[2]The University of Tennessee, Knoxville
[3]National Speleological Society

Caves and other subterranean ecosystems are among the most understudied ecosystems globally and house unique and ecologically important biodiversity. While several studies have characterized the microbial communities of respective cave systems, research on microbiomes of cave fauna has been limited. This study investigated microbiomes for aquatic cave fauna in the southern Cumberland Plateau of Tennessee and Alabama, USA. Exoskeleton and skin swabs were taken from three species of cave-dwelling crayfishes, two species of salamanders, and one cavefish. Bacterial operational taxonomic units (OTUs) identified in host microbiomes were primarily members of the phylum Pseudomonadota, but also included Acidobacteriota, Actinomycetota, Bacteroidota, Chloroflexota, Cyanobacteriota, and Planctomycetota. Data for environmental and land cover/land use (LULC) variables were collected to assess their effects on microbiome composition and diversity for hosts and the surrounding aquatic environment. Environmental data, including pH and temperature, were collected from study sites. Water samples were taken from sites for geochemical analysis. LULC information was collected using data from the National Land Cover Database (USGS) and analyzed using ArcGIS Pro to calculate land cover in a 5km buffer surrounding cave entrances. Variation of pH and water temperature had at least some effect on microbiome community membership and abundance in at least one host. Water geochemical composition, including concentration of calcium, magnesium, potassium, and nitrate ions, and non-purgeable organic carbon (NPOC) explained variation in microbiome composition and diversity for at least one of the sampled hosts. Land cover types classified as 'agriculture,' 'developed,' and 'water' also affected microbiome composition and diversity. Microbiome diversity and composition varied between sites, primarily for Southern Cave Crayfish, and to a lesser degree for Southern Cavefish and Tennessee Cave Salamanders. Microbiomes have important roles for organism health, and, with further research, their composition and levels of diversity could serve as indicators of healthy cave ecosystems.

Examining genetic diversity and potential cryptic diversity within the Georgia Blind Salamander (*Eurycea wallacei*) and the Dougherty Plain Cave Crayfish (*Cambarus cryptodytes*) of the Upper Floridan Aquifer

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Understanding and preserving genetic diversity is vital for ensuring species persistence, particularly in the face of pervasive threats, such as global climate change and habitat loss. This is especially true for groundwater fauna, whose ranges are often restricted and populations highly vulnerable to extinction. Population genetic studies of subterranean species often reveal cryptic species complexes, which further elevate conservation concerns by revealing even smaller ranges and population sizes than previously recognized. Within the Upper Floridan Aquifer, the Georgia Blind Salamander (*Eurycea wallacei*) and Dougherty Plain Cave Crayfish (*Cambarus cryptodytes*) are iconic yet threatened taxa that often co-occur at many sites across the Marianna Lowlands and Dougherty Plain of Florida and Georgia. These species provide a unique opportunity to examine how groundwater connectivity shapes population structure and to test for cryptic diversity in co-occurring groundwater specialists. Here, we combine mitochondrial DNA, population genetic, and nuclear genomic (RADseq) approaches to assess levels of genetic diversity within and among populations of both species. Our analyses reveal patterns of genetic structure that reflect both local hydrogeologic conditions

and broader regional aquifer connectivity. By identifying population boundaries, levels of connectivity, and potential cryptic lineages, this study fills critical knowledge gaps in the biology of two imperiled subterranean species.These results provide a foundation for adaptive conservation and management strategies not only for *E. wallacei* and *C. cryptodytes*, but also for groundwater biodiversity in general.

Phylogenomics of endangered *Batrisodes* and *Texamaurops* rove beetles from central Texas karst regions

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The karst habitats of central Texas support a highly specialized assemblage of subterranean-obligate invertebrates, including several cave-adapted rove beetles in the genera *Batrisodes* and *Texamaurops*. We used targeted DNA sequencing to investigate species relationships, patterns of diversification, and regional distribution of these beetles, with particular emphasis on the relationships between *B. cryptotexanus* and *B. texanus*, which are currently treated as a single federally endangered species. Specimens representing five *Batrisodes* species and one *Texamaurops* species were collected from 34 caves in Travis, Williamson, and Bexar counties, yielding a dataset of 69 individuals. Genetic analyses confirmed that all troglobitic taxa form a single evolutionary lineage and revealed four well-supported clades, each generally restricted to a specific karst fauna region (KFR). This distribution pattern is consistent with hypothesized dispersal barriers and suggest a northward diversification over time, likely driven by the formation and isolation of karst habitats through faulting, structural geology, and drainage evolution.

The morphologically defined *B. cryptotexanus* and *B. texanus* were not recovered as distinct genetic lineages. Instead, analyses support five major subclades and up to seven genetic clusters, several of which may represent evolutionary significant units for conservation planning. Comparison with recent U.S. Fish and Wildlife Service cave habitat resiliency assessments indicated that four genetic clusters occur within at least partially resilient habitat, whereas three are confined to caves with low or impaired resiliency. These findings underscore that habitat quality varies considerably across the range of these beetles and that some genetic lineages are disproportionately vunerable. the North Williamson KFR. Such refinements can improve conservation strategies by ensuring protection of both the genetic diversity and the karst habitats essential to the persistence of these rare lineages. Integrating these genetic results with similar molecular studies of other co-occurring cave fauna supports recognition of additional geological and ecological subdivisions within

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HYDROGEOLOGY

Illuminating Karst Hydrology: Dye Tracing for Informed Resource Management at Mammoth Cave National Park

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Using fluorescent tracers to reveal subsurface flow paths is critical to managing water quality, protecting aquatic ecosystems, and making informed land-use decisions in complex karst systems. Building upon the hundreds of dye tracer tests that have been conducted in and around Mammoth Cave National Park as well as the decades of cave survey resulting in more than 600 kilometers of mapped cave passages, we continue to expand the understanding of the karst hydrology of the Mammoth Cave region. Since the mid-2000s, the Crawford Hydrology Lab in cooperation with the Division of Science and Resource Management, has conducted more than 30 dye traces that represent the next generation of fine-scale karst groundwater flow characterization.

This long-term effort includes qualitative and quantitative studies to address direct impacts such as sewage line breaks and parking lot runoff as well as informing the latest trail management plan and delineating habitat boundaries for the endangered Kentucky Cave Shrimp. More recently this research has focused on groundwater basins that primarily drain the Flint Ridge portion of the greater Mammoth Cave system. Through high-resolution tracing, we have refined basin boundaries, mapped complex flow path geometries, documented dynamic hydrologic responses, and informed both paleoclimate and modern climate change studies. Perhaps one the most exciting parts of our investigation is the rediscovery of several alluviated springs along the Green River and the potential implications that future traces hold for science and resource management in the park and beyond. By illuminating karst hydrology, we support protection, planning, and policy in a globally significant karst system.

Comparative Performance of Mesh Bag and Milk Sock Charcoal Receptors in Field-Based Fluorescent Dye Tracing

Monica Galvez[1], Lee Anne Bledsoe[1], Autumn Singer[1], Benjamin V. Miller[2], Amy Hourigan[2]

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[2] U.S. Geological Survey, Lower Mississippi-Gulf Water Science Center, Nashville TN.

Fluorescent dye tracing is a critical method for delineating groundwater flow paths in karst aquifers, where subsurface connectivity strongly influences water quality, resource protection, and contaminant transport. Charcoal receptors are a standard tool in dye tracing, yet the choice of construction material may influence dye recovery under field conditions. Despite this concern, little work has quantified how receptor material affects dye concentrations in real-world tracer tests. Preliminary controlled tests by Crawford Hydrology Lab (CHL) and the Kentucky Geological Survey (KGS) showed little difference between mesh and milk sock receptors. However, field conditions introduce uncontrolled variables that may influence receptor performance based on the material. This study presents the largest field-based comparison to date of fiberglass mesh bag and filter fiber ‘milk sock’ charcoal receptors.

To evaluate these differences under natural conditions, CHL, in partnership with U.S. Geological Survey (USGS), conducted a robust series of multi-dye tracer tests using in-field deployments of mesh and milk sock receptors. Results were obtained for Tinopal, Fluorescein, Eosine, Rhodamine WT, and Sulphorhodamine B. Out of 1,043 data pairs, 312 pairs yielded measurable dye concentrations, while the remainder were both matching non-detect pairs. Within the 312 positive pairs, 72% of mesh receptors recorded concentrations more than 10% higher than

their paired milk socks, and 35% recorded concentrations more than 50% higher. Additionally, several mesh receptors required dilution prior to analysis due to high dye concentrations, whereas their paired milk sock receptors did not. CHL also consistently observed milk sock receptors that contained fine charcoal dust, resulting in higher background noise that can interfere with the interpretation of fluorescence peaks and, therefore, concentrations.

These findings indicate that mesh bags more consistently yield higher dye recoveries than milk socks. While milk socks may offer logistical and cost benefits, their use increases the risk of underestimating dye presence. For cave and karst management, such underestimation may obscure contaminant transport routes, underestimate aquifer vulnerability, and compromise resource protection decisions.

Targeting the Right Terrain: Suitability Modeling for Areas of High Karst Conservation Value in Tennessee

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Karst underlies over 2/3 of Tennessee, and the state has the highest number of documented caves in the United States. Tennessee is the most biodiverse inland state with a high rate of endemism. Within these karst systems are many hydrological, geological, biological, and cultural resources, as well as sites of educational and recreational value. Understanding karst systems in areas that intersection with valuable resources is important for successful conservation and management of those resources and the karst systems.

Agencies often need additional information regarding groundwater flow and spring sources to guide decision management and prioritize land acquisitions. Fluorescent dye tracing can provide flow path and recharge area data to stakeholders in these areas where key resources exist. To identify areas of high karst conservation value in Tennessee, a suitability model was created. The U.S. Geological Survey (USGS), in cooperation with Tennessee Department of Environment and Conservation (TDEC), is conducting fluorescent dye tracing to better understand groundwater in karst systems in areas of high conservation value that were identified with this suitability model.

Using the Suitability Modeler Spatial Analyst tool in ArcGIS Pro, rasterized geology, cave density, cave biodata, rare and endangered species, public lands, and other geospatial criteria were transformed and weighted by conservation value. A suitability map ranked each 1 square kilometer cell with an individual conservation value. From that map, the locate tool created polygons that represent karst areas of highest calculated conservation values based on statistical analysis of the weighted criteria. The raster map and location polygons provided information for more data driven site selection for future dye tracing studies. The first study site was Scott's Gulf Wilderness State Park, where 40 dye injections have been completed since March 2024. The Wolf, Calfkiller, and Duck Rivers also ranked highly on the model and may receive additional study.

Deep caves, big sinks, and anticlines, oh my: dye tracing efforts on Dorton Knob and Hinch Mountain near Grassy Cove, Tennessee

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Dorton Knob and Hinch Mountain are located in Cumberland County, Tennessee along the southeastern edge of Grassy Cove, the largest karst depression in North America. Hinch Mountain, the highest point on the Cumberland Plateau, is home to Jewett 3, the deepest cave in Tennessee at 946 ft. Adjacent Dorton Knob also contains many caves, including 2 caves over 600 ft-deep and Tennessee's deepest pit. In the 1970's Dr. Nicholas Crawford conducted hydrologic studies and dye tracing in the Grassy Cove-Head of Sequatchie system, constructing the initial framework for the complex hydrologic network. Over the past 15 years a renewed interest in mapping and documenting the many caves across the landscape has sought additional ways to understand the karst systems of Dorton Knob, Hinch Mountain, and Swagerty Cove. Many major cave systems in the study area were unknown or only partially explored during Dr.

Crawford's initial work and the data accumulated since has documented many other subterranean streams and posed new questions. Starting in 2019, a dye tracing effort was started to map the karst groundwater pathways on Dorton Knob and in Swagerty Cove to hydrologically connect caves and ultimately help to delineate boundaries for 2 major springs, Head of Sequatchie and Roaring Branch Spring. From 2019-2024, 15 dye injections over 6 rounds which have hydrologically connected many caves (5 in Swagerty, 6 on Dorton Knob), delineated boundaries for 2 major recharge areas, and helped better understand one of the more complex karst hydrologic systems in Tennessee. Three injections in Grassy Cove determined some of the internal drainage divides for the 12.8 mi^2 depression. The final trace conducted was a 9.7 mi-long trace from McClough Hollow to Head of Sequatchie, which is now the 2nd longest trace in Tennessee and established the northern-most extent of the 21.75 mi2 recharge area.

Groundwater Tracing and Hydrologic Monitoring of the River Styx: Management Applications for Oregon Caves National Monument and Preserve

Anastasiya Razumovska[1], Sierra M. Heimel[1], and Benjamin V. Miller[2]

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Karst aquifers are uniquely vulnerable to surface-derived impacts due to their direct hydrologic connectivity between recharge areas and subterranean streams. Understanding and monitoring these linkages is essential for protecting water resources in cave systems. At Oregon Caves National Monument and Preserve in southwest Oregon, recent groundwater tracing and new hydrologic monitoring efforts are providing valuable insights into watershed processes that directly inform cave management.

From 2021 to 2024, the U.S. Geological Survey, in partnership with park personnel, conducted a dye tracing study to delineate recharge areas for Oregon Caves and the adjacent Cave Next Door system. Eight dye injections confirmed distinct recharge zones, revealed new hydrologic connections within Oregon Caves, and identified previously undocumented resurgences. These results highlight the rapid and direct vulnerability of the River Styx—the only designated subterranean Wild and Scenic River in the United States—to surface activities within the recharge area.

Building on this foundation, a River Styx monitoring plan has been implemented to track both water quality and quantity. Key parameters include discharge, pH, specific conductivity, dissolved oxygen, water temperature, alkalinity, calcium carbonate concentrations, and *E. coli*.

Data collection utilizes multiparameter sondes, pressure transducers, and Hach titrations, with results compiled into annual reports for resource managers.

Together, the tracing and monitoring programs provide an integrated approach: tracing defines where threats may originate, while monitoring establishes a baseline for detecting and responding to changes. This work strengthens the scientific basis for watershed protection, visitor management, and long-term stewardship of karst water resources at Oregon Caves. By pairing dye tracing with sustained monitoring, managers gain both the spatial and temporal tools needed to protect the River Styx and its surrounding subterranean ecosystems.

Preliminary Investigation on Stream Flow Variations in the Black River Complex, Roppel Section of the Mammoth Cave SystemL

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Scallops are asymmetrical, scoop-like indentations with a steep slope on the upstream side and a gentler slope on the downstream side, bound by crests that are also angled in the downstream direction. These features can vary greatly from the millimeter to the decameter in scale. Scallops were measured throughout the Black Canyon passage and surrounding area named the Black Canyon Complex in the Roppel section of Mammoth Cave System. Here, scallops vary in size but show multiple flow

regime velocities. Furthermore, the localized stratigraphy of the passage also seems to be a controlling factor. Measurements were taken of both base and high flow stage scallops and input into the program ScallopEx (Woodward and Sasowsky, 2009) with the following parameters: scallop length, temperature, and average passage width. Our analysis yielded four different velocity calculations representing high flow and base flow from measurements taken in an upper and lower bed. Preliminary observations reveal multiple regimes that formed the Black Canyon passage that appear to be partially stratigraphically controlled with some perching layers. Scallop velocity data coupled with discharge estimates of the passages in relation to one another suggest that a preliminary conclusion of this study is that this area is evidence of drainage via to the north, towards Pike Spring, and is indicative of a shift from southward drainage towards Turnhole Bend Spring. These data refine understanding of conduit initiation, entrenchment, and abandonment, thereby enhancing understanding of temporal and spatial variability in aquifer recharge and discharge pathways. In the Roppel Section, this integration paleo-hydrological mapping into management strategies strengthens efforts to protect water quality, mitigate human impacts, and sustain the long-term integrity of a globally significant karst landscape.

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Strip Coal Mine Reclamation at Sarah Furnace Cave, Pennsylvania

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Sarah Furnace Cave is the longest surveyed cave in the northeastern US (16.2 km; 10.1 mi.) and is believed to be the densest two-dimensional maze cave in the world. She is formed in flat-lying Vanport Limestone just 1.7 m (5.5 ft.) thick. In the 1860s, the ceilings of one quarter of her passages were mined for a 0.5 m (1.6 ft.) vein of overlying siderite iron ore which was used in the nearby Sarah pig iron furnace. The Lower Kittanning Coal vein is 15 m (50 ft.) stratigraphically above the cave and was underground mined from 1902 to 1950. Although the coal mine did not intersect the cave, acid mine drainage pollutes the cave. In the 1950s, strip coal mining left a spoils pile atop the cave on some of which vegetation would not grow for another 70 years.

Twenty acres surrounding the cave were purchased by the Mid-Atlantic Karst Conservancy in 2019, and in 2021, the Commonwealth of Pennsylvania began plans to reclaim the surface above the cave. Funding sources changed based on adjacent landowner non-cooperation and funds availability, but eventually Bipartisan Infrastructure Law funding was secured. The formal design phase began in early 2023 and lasted 18 months, with significant input from MAKC. Construction was delayed until spring 2025 to avoid disturbing tree-roosting bats. Construction took three months. The reclaimed property now features erosion-mitigated slopes with sapling trees, a grassy meadow, brush barriers and a gate to inhibit all-terrain vehicle use, a parking area, and access to the cave entrance via a foot trail. The cave suffered one minor instance of ceiling collapse from the heavy earth moving equipment involved in the property reclamation.

Managing a Variety of Caves and Cave Issues at Great Basin National Park, Nevada, USA

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Great Basin National Park, located in east-central Nevada, USA, contains 40 known caves. These include the highly decorated show cave Lehman Caves, which 30,000 visitors a year traverse on approximately a 1 km (0.6 mi) paved path with lights, as well as wild caves that span an elevational gradient of over 1370 m (4,500 ft). Conditions include dry and dusty; streams, pools, waterfalls, and caves that completely sump during high water; caves with rattlesnake dens at their entrances; caves with seasonal bad air; caves with perennial ice that is rapidly sublimating and melting; and caves with rare endemic species. Management issues include recreational access, wildfire, working with tribes, illegal access, vandalism, long-term protection of cultural and natural resources, and more. Over the past ten years, two cave management plans have been written and enacted, one for Lehman Caves and one for the wild caves and karst. For each of the plans, data gaps and recommendations were documented. This set the stage for applying for funding to address these issues which was granted. Two grants for Lehman Caves focused on improving infrastructure, education and outreach, and monitoring cave conditions and populations. One grant for wild caves provided for a wild caves inventory, education via a CaveSim, a new wild cave tour, protection of cultural resources in caves, and an ethnographic report. These activities have generated additional recommendations to address cave management issues. Keys to continue making progress in cave management are recruiting talented cave scientists and interns, working with all the park divisions, communicating regularly with other parks and partners, and finding creative ways to overcome challenges.

50 Years of Preservation, Environmental Monitoring and Scientific Research at Kartchner Caverns

Chelsea Ballard, Cave Resource Manager at Kartchner Caverns State Park
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Kartchner Caverns, a limestone cave system discovered in 1974 in southeastern Arizona, has become an international model for cave conservation and scientific research. Preserved in pristine condition for over a decade following its discovery, the cave was protected through a collaborative effort involving cavers, scientists, the Kartchner Family, The Nature Conservancy and Arizona State Parks. This unique partnership ensured minimal disturbance during development into a show cave, culminating in its public opening in 1999 as Kartchner Caverns State Park.

Ongoing scientific monitoring has provided insights into cave microclimate dynamics, carbonate deposition, hydrology, and microbial communities. One key innovation has been to use airlock doors, misting systems and foggers to maintain humidity and temperature levels, preserving fragile formations, and stabilizing the ecosystem. Long-term environmental data collection—coupled with dye tracing and water chemistry analysis—has enhanced understanding of recharge pathways, supporting

watershed management practices that safeguard the cave's continued activity.

Kartchner Caverns also serves as a living laboratory for subterranean biology. Researchers have documented extremophile microbial populations with potential biotechnological applications including antibiotic production. Paleoclimatic studies based on speleothem isotopes further illustrate the region's environmental history over tens of thousands of years.

This symposium presentation will highlight key scientific findings from over two decades of research, what we have learned and where we are going, emphasizing the vital interplay between preservation, public education, and scientific discoveries. Kartchner Caverns exemplifies how intentional design, stewardship, and interdisciplinary collaboration can balance resource protection with public access—offering a replicable model for conservation in other sensitive cave environments. Kartchner recently celebrated its 50th anniversary, and continues to provide new scientific frontiers, while inspiring generations to appreciate and protect the cave.

History and Development of Defiance Cave Preserve

Mike Frazier and Donna Fazier, Southern Colorado Mountain Grotto

Cave of the Clouds was discovered in 1886 by railroad surveyors. It quickly became a popular tourist destination and many newspapers of that day described it as one of the most beautiful caves in the country. After a series of owners and managers, it fell into decline when the entrance door was broken, allowing amateur explorers and ne'er do wells to contribute to cave deterioration and damage. It was mostly forgotten when nearby Fairy Caves, (now known as Glenwood Caverns) was discovered and developed. In 2018, Mike and Donna Frazier purchased the cave property from the descendants of the original homesteaders, calling it "Defiance Cave Preserve" after an early moniker for Glenwood Springs. They organized volunteers to carry up nearly 3000 pounds of cement, steel and equipment to install a gate and prevent further damage. The maternal Townsend bat population has benefitted from greatly decreased human visitations and campfires. Another cave just off the Defiance Cave Preserve property line, Drapery Den, was the site of an enormous homeless camp and decades of garbage and abandoned belongings. Volunteers worked over a period of seven months backpacking all the trash down the mountain. Bats are now returning to a clean hibernaculum. Other projects include trail development, historical signature identification, discovery of new bug species, and multiple digs. The 45 acre property is home to Big Horn Sheep, Mountain Goats and a wide variety of mammals, small reptiles and birds. The property contains the internationally known rock climbing area, "The Puoux" which receives daily visitation by locals and tourists alike. Mike and Donna have permitted the area to be used by the Fire Department, for rock climbing instruction, school trips and caver training. Their hope for the future is to develop a road through the rocky terrain permitting easier access for all to enjoy Defiance Cave Preserve well into the future.

Graffiti Removal in Caves: Options and Experiences 12 Years of Cave Restoration

Neil Marchington, Director of Special Projects, Western Cave Conservancy

Please join Neil to learn about options to remove graffiti from caves. Since 2013 Neil has been restoring vandalized caves around the Western US. Neil will discuss different methods and a variety of other factors for graffiti removal. We will explore real world examples of past projects in a variety of cave and geological settings. We will also discuss biological and hydrological factors.

An Introduction to the International Union of Speleology and the Proposed International Day of Caves and Karst

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George Veni, UIS President 2017-2022
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The International Union of Speleology (UIS) promotes the development of speleology and advances` the protection and management of the world's speleological and karst heritage. UIS does not have individual members but 57 member countries, each represented by the country's national speleological organization. The USA is represented by the National Speleological Society (NSS). UIS has 20 commissions advancing specific aspects of speleology. Every four years, one member country hosts an International Congress of Speleology, the world's most important speleological conference. At the Congress, member country delegates meet as the General Assembly to elect a new Bureau and make decisions to guide the UIS for the next four years.

In 2021-2022, the UIS organized the International Year of Caves and Karst to educate the world about the importance of speleological concerns. UIS was joined by 263 partner organizations from 51 countries to organize at least 1,491 events worldwide. These events reached a minimum of nearly 321 million people. The International Year was supported by UNESCO, the United Nations (UN) Educational,

Scientific and Cultural Organization, but was not an official UNESCO or UN program. To build on that success, UIS is proposing an International Day of Caves and Karst to UNESCO.

The International Day, proposed as September 13th, will promote the importance of caves and karst annually and more effectively with UNESCO's official support. In late August 2025, this initiative was supported by 138 international organizations and member countries, including the USA through the NSS. But more help is needed. The International Day of Caves and Karst is proposed to UNESCO by Slovenia, which needs co-sponsoring countries. The USA is no longer part of UNESCO and cannot co-sponsor. If you have connections with any national government or organization that may co-sponsor or support this crucial global program, please let us know ASAP.

Thirty Years of Karst and Cave Conservation by the Virginia Natural Heritage Karst Program, Department of Conservation and Recreation

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In 1994 the Virginia Department of Conservation and Recreation established the Karst Program in the Division of Natural Heritage (VDCR-DNH), hiring caver and geologist Terri Brown as Karst Protection Coordinator using grant funds (US-EPA Section 319 Clean Water Act) requested by VDCR-DNH in cooperation with the Virginia Cave Board. Efforts focused on educating citizen, agency, and government stakeholders about karst issues and performing technical investigations of impacts to karst. Additional funding came from source water protection efforts by the Department of Health around the year 2000, and two additional full-time positions were added including a Karst Educator. Karst Program focus slowly shifted toward karst biodiversity conservation in line with the primary mission of VDCR-DNH. Following the housing crisis of 2008, the administration diverted EPA funds to support positions formerly funded by the state and cut all but one full-time staff. The program persisted on small grants and contracts, many associated with the arrival of White Nose Syndrome, until 2014 when state funds were finally allocated to karst staff. In 2016 a second full-time position was added in addition to wage positions. In 2022, a third full-time position was added. Karst program and collaborator achievements include protection of significant caves, discovery of new cave- and spring-limited invertebrate species, dye tracing studies delineating cave and spring recharge areas, ecological monitoring, improvements of stormwater management practices and regulations in karst, collaborations with scientists including university students and faculty, and implementation of avoidance, mitigation, and compensation measures in response to development projects in karst areas through the VDCR-DNH environmental review office. Advocacy by the Virginia Cave Board, prioritization of karst conservation by agency leadership, and support from stakeholder agencies, including a new collaboration with the U.S. Forest Service, have been and continue to be critical to the success of the Virginia Karst Program.

Buying Caves for Cavers (to Protect) - 34 Years of Cave Conservation Through Capitalism

Bill Putnam
SCC Co-Founder, Past Chairman, and Former Director

The Southeastern Cave Conservancy (SCC) has worked for 35 years to acquire, protect, and manage caves in the southeastern United States. Its interest area has more than 15,000 documented caves, and is one of the most active caving areas in North America. In 1991, the SCC's founders were concerned about several issues they felt were impacting caves and caving in the region, including development of cave lands, activities of hunting clubs, policies and practices of wildlife management agencies and public land managers, and cave management practices of government agencies. The organizers of the SCC created a private non-profit corporation operated by and for cavers. Its purpose is to acquire and manage significant caves and cave resources in the southeastern US. The organizers believed that cavers would be the best stewards of caves and their resources, and that the best cave protection strategy is cave ownership by cavers.

The SCC also uses several other methods, including leases, donation, management agreements, and MOUs. Such projects are often hampered by complications not encountered in direct purchase. Conservation easements can also be used to protect caves. However, the issues inherent in that method can be substantial.

The success of the SCC's acquisitions program created challenges. Development and implementation of management plans, establishment and maintenance of preserve boundaries, anagement

and tracking of visitation, and interactions with neighboring landowners are just a few of the daily responsibilities of the SCC's staff and volunteers. Also, partnerships with government agencies, other land trusts, private non-profit foundations, and large land and wildlife conservation organizations have become increasingly important in the operations of the SCC. Nevertheless, the backbone of its strategy remains cave ownership and management by cavers.

We will describe several key strategies and methods for cave acquisition and management that have consistently yielded good results for more than three decades. We will discuss elements that contributed most to successful outcomes in key projects, such as Neversink, Fern Cave, and Wolf River Cave. We will also discuss key elements of unsuccessful efforts, and provide examples of some things we have learned not to do.

Graffiti Removal in Caves: Options and Experiences 12 Years of Cave Restoration

Neil Marchington, Director of Special Projects, Western Cave Conservancy

Please join Neil to learn about options to remove graffiti from caves. Since 2013 Neil has been restoring vandalized caves around the Western US. Neil will discuss different methods and a variety of other factors for graffiti removal. We will explore real world examples of past projects in a variety of cave and geological settings. We will also discuss biological and hydrological factors.

Speleological Inventory and Protection of Cultural Markings with Systematic Removal Processes for Selected Graffiti

Val Hildreth-Werker, NSS Conservation Lead
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Graffiti in caves is a nemesis and conundrum for the speleological community. We love the pictographs and petroglyphs of prehistoric cultures. We honor historic cave markings. We hold disdain for ugly swaths of contemporary graffiti. Because graffiti begets graffiti, it is important to define minimum-impact methods to respect and address it while avoiding disruption of spelean biota, hydrology, and geologic processes. Imperative to the protection of cultural and natural heritage, projects should start with systematic inventory, documentation, and assessment before starting removal of contemporary graffiti. Various cave marking categories are frequently found near each other. Sometimes, cultural art is obscured by thick layers of contemporary paints and scratchings. Formulations of modern pigments and products can be toxic to cave life. It is best to avoid using commercial removal products or biodegradable products. We want to protect the cave life and cavers as well as the caves. Our team is developing systematic methods to better address cave graffiti through inventory, identification, and protection of heritage as we implement specific processes to analyze and gently remove contemporary markings.

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Monitoring and Modelling

Improving cave and climate awareness through research at Wounded Knee Cave, Southern Nevada

Sadie Carlin & Laura Rosales-Lagarde

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Wounded Knee is a small, gated limestone cave in Southern Nevada. Its location, near Las Vegas, makes it accessible for day trips with the support from Southern Nevada Grotto cavers. Nevada State University's students measured cave air temperatures along horizontal and vertical transects for one week during the spring starting in 2017 until 2025 using Thermochron thermometers. Additionally, temperatures from February 2021 to 2022 were measured with a 2019-built Cave Pearl data logger. This research allows students to become stewards of the cave as they gain quantitative skills. The increase trend in Las Vegas temperatures and the sensitivity of bats to disturbances during their maternity makes these measurements relevant. The week-long temperature measurements at the "Big Room", an approximately 50 ft-wide collapse room in the center of the cave, had low variability [18.0±0.3°C or 64.4°F], similar to the February 2021 to 2022 average temperatures 17.8±0.3°C. In comparison, temperatures at the nearby Red Rock National Weather Service station averaged 18.3 ±10.7°C during the 2021–2022-time range. The variability in the cave temperature decreases as the distance from the cave entrance increases, being noticeable already in the first 24 feet of passage with respect to the entrance. Measured temperature differences inside the cave Big Room are below the resolution of the thermometers used. They do not seem to be affected yet by climate change related temperature increases or by the number of visitors during this period [70 visitors from February 2022 to March 2025, based on the cave registry]. Students presented the annual temperature research results four times furthering their knowledge about caves. Even short-period temperature measurements could provide insight into cave temperature changes as temperatures continue to increase. Increasing the resolution of the thermometers used will make it easier to detect these changes.

Coach Cave Microclimate: Piecing Together a Broken Past

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Coach Cave (aka Gatewood Saltpeter Cave, Hundred Domes Cave, Dome House Cave), is located just outside Mammoth Cave National Park on Bald Knob in Edmondson County, Kentucky. It was mined for saltpeter during the War of 1812 by Williamson and Fleming Gatewood. Sporadic, rugged tours commenced soon after the war. Further development occurred in 1859 by Kellion Peddicord, who installed paths, bridges, ladders, and a wooden dance floor. Business dropped off during the Civil War, but the cave was visited by Union soldiers, who left their signatures there. In the 1960s the cave and land above it were purchased and developed into Park Mammoth Resort. During that period extensive modifications were made to the entrances and passageways. The consequence of all of these changes was the steady decline of the resident bat population, including the almost complete abandonment by more than 100,000 Federally Endangered Indiana bats (*Myotis sodalis*).

In the late 1990s to early 2000s, the author began studying the microclimate of Coach Cave and initiating stepwise restoration efforts during his employ with Bat Conservation International. These early efforts proved somewhat effective, but resulted in the attraction of a vary large population of Endangered gray bats instead of the desired Indiana bats. The project was restarted in 2022 at the instigation of the US Fish and Wildlife Service. Repeat data collecting at the old locations, data collecting at new locations, testing of various new dataloggers now on the market, collection of additional data, and acquisition of historical information not previously known is leading towards new restoration efforts. All work is hoped to be completed before the cave's eventual transfer to the National Park Service.

Recharge-Driven Variability in Cave Temperature Regimes

Pat Kambesis
Center for GeoEnvironmental Studies
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Allogenic recharge can cause significant variations in cave air and water temperature. A long-term study conducted in an active, epigene cave system in northeast Iowa illustrated that despite not having a natural entrance, allogenic recharge alone caused significant changes in cave stream and air temperatures. Data loggers, recording at 10-minute intervals, were installed at six in-cave sites to measure air and stream temperatures, and at the two springs to measure water temperature. Weather stations located above the cave and from a local climate station documented surface air temperature. This eight-year study demonstrated that both resurgences, and in-cave sites proximal to surface recharge points displayed significant variation in water and air temperature hourly, daily and seasonally as well as during storm events. In-cave sites that were located farthest from surface recharge showed very little fluctuation in water and air temperature and corresponded to the mean annual temperature of the area. These results offer important implications in terms of the study of aquifer vulnerability to surface contaminants, cave ecosystems, speleothem development, and thermodynamic controls on subterranean karst processes.

Park-wide Cave Climate Monitoring: Is it as simple as it seems?

Clara Morrison: Scientist-in-Parks at Great Basin National Park, Presenter, Author, claramorrison@nps.gov/cmorrison9528@gmail.com

Gretchen Baker: Great Basin National Park Cave Specialist and Ecologist, Author, gbaker@nps.gov

Cave climate has often had the assumption of being simple, constant, and replicable from cave to cave. Being deep underground with only small amounts of air circulation from the surface, the temperature and humidity of caves stay fairly constant year round, with only small seasonal changes of 1-2°C. However, from our long-term analysis of the temperature and relative humidity of more than half of the caves at Great Basin National Park, it is clear that this is not always the case. Differences in locations, elevation, size and aspect of entrances, and cave geometry all come together to give each cave in the park a unique climate, so much so that caves within a mile of each other can have such large differences in temperatures that some can host ice and not others! Our initial analysis of these caves' climates has uncovered unique climate cycles that do not correspond with outside changes in temperatures and given us a better understanding of how the physical characteristics of each cave affect its climate, already informing where to focus our efforts in the future.

Once fully understood, cave climate can then help us discover new species, forecast White-Nose Syndrome risk, and monitor for climate change impacts in our cave and karst environments. For all of these benefits, monitoring cave climate is also surprisingly simple; from a management standpoint, adding cave climate monitoring into the workload only requires a yearly trip to download dataloggers, tracking of those dataloggers' locations and functionality, and basic graphing and statistical analysis to paint a clear picture of what is happening in the cave. This is a great addition to any management of a cave and karst landscape.

Predicting Cave Distribution in the Greenbrier River Watershed WV Using Maximum Entropy Modeling

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This research applies Maximum Entropy (MaxEnt), a presence-only species distribution model, to predict cave entrance locations in the Greenbrier River watershed of West Virginia's Allegheny Mountains region. This represents an unconventional application of MaxEnt methodology to geological features rather than biological species. The study area contains globally significant karst terrain, including two of the ten longest caves in the United States. Predictive modeling can improve cave inventory efficiency and support proactive karst resource management by identifying high-probability areas for undiscovered entrances.

The model utilizes 878 cave entrance records from the West Virginia Speleological Survey database with documented passage lengths of at least 30 meters. Predictor variables included geologic, hydrologic, and terrain-derivative raster layers at 10m spatial resolution. The model was trained using the R language MaxNet package with an 80/20 training/testing split. Evaluation demonstrated strong predictive performance with a median AUC of ~0.90 across multiple iterations, with refinements ongoing. This research demonstrates that presence-only modeling approaches can be effectively adapted to geological feature prediction. The approach provides cave and karst managers with a quantitative modeling tool for prioritizing survey efforts and informing land management and conservation decisions.

Utilizing Structural Lineament Mapping with Digital Elevation Models for Understanding Speleogenetic Patterns in the Mammoth Cave Plateau

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Lineament analyses provide a valuable framework for understanding the structural controls on karst development, groundwater flow, and surface–subsurface interactions in karst terrains. In the Mammoth Cave region of south-central Kentucky, the intersection of mapped faults, joints, and fracture zones with topographic lineaments strongly influences the orientation of cave passages, sinkhole alignments, and conduit-dominated aquifers. By integrating remote sensing of 10-inch resolution Digital Elevation Models (DEM), ArcGIS-based lineament mapping, and ongoing field verification, this study highlights the role of regional structural trends in the Mammoth Cave Plateau in guiding speleogenesis and level development within the Mammoth Cave Plateau. It can be utilized to identify zones of preferential flow pathways and can therefore improve vulnerability mapping, help predict contaminant transport, and influence land-use decisions within sensitive recharge areas. The results indicate that lineaments of NE–SW and NW–SE trending orientation exert some directional influence on conduit orientation, thereby influencing both the hydrologic regime and the geomorphic expression of the Mammoth Cave Plateau. These findings show the importance of structural mapping in karst terrains, providing an interpretive framework for predicting anisotropic groundwater flow, delineating zones of enhanced vulnerability, and refining conceptual models of karst aquifer dynamics. In addition, this research demonstrates that lineament analyses offer an essential tool for advancing both theoretical understanding of karst evolution and applied strategies for the conservation and management of large cave systems.

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Education and Outreach

Cave Animal of the Year Programs and Resources for Managers

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The Cave Animal of the Year Program provides an accessible and fun approach to educating scientists, cave and karst managers, and the general public about biological diversity and conservation in subterranean habitats. Each year, a cave animal is selected and promoted. Germany started the program in 2009, and it has spread to several other countries. The U.S.A. has participated in this annual event since 2019 in cooperation with the National Speleological Society (NSS), with dedicated webpages on the NSS website, an annual article in the *NSS News* Conservation issue, and a logo sticker available at the NSS Convention and various other cave locales. For 2025, the U.S.A. discussed cave shrimp in general and in greater depth for five listed endangered and threatened species. In addition to national campaigns, an International Cave Animal of the Year began in 2021 to help bring broader appeal across many nations to subterranean dwellers. Learn more about how these programs work, this year's cave shrimp, and how to leverage this event and resources for your caves or karst areas.

An Education System Designed to Make Cave and Karst Management Easier

Dave Jackson, CaveSim, Dave@cavesim.com

Cave and karst management is a challenging job that is easier when the general public becomes part of the solution rather than part of the problem. One

effective way that managers can enlist public support is to educate the public about the importance of caves and karst in the everyday lives of the public. CaveSim is an easy-to-use educational system that is designed specifically to teach lay people of all ages about cave and karst conservation, and to increase public enthusiasm for caves, for cave-dwelling species, for culturally-relevant artifacts found in caves, and for karst areas. CaveSim makes learning about caves and karst a low-friction activity; the experience of exploring CaveSim is so much fun that it naturally draws in visitors without significant effort from interpretive staff, and visitors become eager to learn about cave and karst conservation principles. Although the CaveSim system has existed for 15 [illegible] latest mobile CaveSim system include wheelchair accessibility, improved comfort for non-caver adults who explore, far more realistic passage, highly professional conservation education displays on the exterior of the mobile caves, and a greatly improved visitor interface. Although the newest mobile cave has only existed for a little over a year, it has already been used to educate over 30,000 visitors in 10 states, including at educational events on both coasts. The CaveSim curriculum has also been significantly improved, specifically to help young people understand the importance of not defacing caves and rock art. This presentation will illustrate how cave managers are partnering with CaveSim to better inform the public about conservation, and will explain the numerous ways that your organization can collaborate with CaveSim to do the same.

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Poster Session

The Little Muddy Cave Carbon Dioxide (CO_2) Problem, Great Basin National Park

Kirsten Bahr, Physical Science Technician, Great Basin National Park

Little Muddy Cave, a small joint-controlled maze cave in Great Basin National Park, presents a long-standing management challenge due to elevated carbon dioxide (CO_2) concentrations. Discovered in 1979 during construction of park wastewater ponds, the cave was first recognized as hazardous in 1992 when CO_2 exceeded 9,000 ppm—well above OSHA and NIOSH limits. Subsequent monitoring revealed strong seasonal variation, with CO_2 concentrations exceeding 20,000 ppm in summer but dropping below exposure limits in winter. This pattern prompted managers to restrict recreational access to October–April, when ventilation effectively lowers CO_2 levels. In 2022, Great Basin National Park deployed new prototype CO_2 sensors developed by the U.S. Geological Survey to continuously track cave atmosphere dynamics. Despite logistical challenges, including battery maintenance and wildlife interference, these sensors recorded seasonal fluctuations that highlight the interplay of barometric pumping, thermal stratification, soil and epikarst respiration, and cave morphology in driving cave-air CO_2 dynamics. Data show gradual accumulation of CO_2 through summer, exceedances in August, transitional conditions in October, and effective winter flushing below 1,000 ppm. These findings refine understanding of cave-atmosphere processes in Little Muddy Cave and raise new management considerations, such as whether the seasonal opening date should shift later in the fall. Ongoing monitoring will inform adaptive strategies that balance visitor access, staff safety, and conservation.

Protecting Lehman Caves Through Improved Infrastructure and Outreach (R17) & Install New Lehman Caves Electrical System (R19)

Gretchen Baker, Great Basin National Park Cave Specialist and Ecologist

Originally the removal of the old cave lighting system and installation of a new one were to be done under this project. However, during the design phase, it was found that the budget greatly exceeded what was available, so that part of the project was removed and resubmitted as the R19 project on the other side of this poster.

Live feed cameras at the natural entrance were also removed from this project due to cultural sensitivity.

Protecting Wild Caves in White Pine County, Nevada

Gretchen Baker, Great Basin National Park Cave Specialist and Ecologist

Wild Cave Crew (archaeologist, two biologists, geologist, and paleontologist) inventoried 28 Park caves from June 2022-October 2023. Findings included:

- Potential new spider species
- Enhanced species list for each cave
- Additional cave passage found
- Reclassification of speleogenesis for some caves (how they formed)
- New and updated cave maps for several caves
- Canid teeth and bones from marmots, pika, packrats, extinct horses, and more found and photographed
- Detailed notes for each cave
- Multiple presentations at scientific conferences

The Mapping of Lehman Caves

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The Mapping of Lehman Cave Project is a collaborative initiative between the National Park Service and volunteers from the National Speleological Society, aimed at advancing the understanding and stewardship of Lehman Cave. From 2018 to 2025, 38 participants conducted 43 survey trips, systematically documenting the cave's intricate passages and geological features. This effort has significantly expanded both the scientific and spatial knowledge of the cave system while providing essential tools for its long-term conservation and management. Looking ahead, the project will incorporate Geographic Information Systems (GIS) to develop a suite of base layers that spatially represent the cave's environment and attributes. These maps will be integrated into a handheld, tablet-based geodatabase designed to inventory and analyze key cave resources. Lehman Cave hosts a remarkable diversity of rare speleothems, including high densities of shield formations, folia, welts, and bulbus stalactites. It is also rich in speleogen

structures such as bubble trails and thick precipitated gypsum crusts, offering critical insight into the cave's hypogenic speleogenesis.

The overarching goal is to create geospatial tools that facilitate scientific discovery and support informed decision-making and targeted conservation strategies. Ultimately, the resulting data underscores the value of community-driven exploration in preserving our natural heritage and enhancing resource protection, visitor education, and cave management.

Environmental personhood and karst management

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Conceding legal personhood to Nature or the Rights of Nature movement is rooted (from a contemporary Western standpoint) in the question proposed by Prof. Christopher Stone in 1972: *Should Trees Have Standing? Towards Legal Rights of Natural Objects*. The idea sustained that trees can have legal standing in courts by themselves and should be subject to legal personhood like human beings and corporations. Nowadays in 2025, over 35 countries through State laws, local jurisdiction enactments, or court rulings, have granted legal personhood to freshwaters, forests, and animals, among other organisms. Illustrious models include New Zealand (Whanganui River), Ecuador (Los Cedros Forest) and Colombia (Atrato River), where respectively legal personhood was granted to natural entities based on historical indigenous conceptions of the land, express constitutional recognition of Nature's Rights or derived judicial analysis of the Ecological Constitution. This shift suggests an eco-centric viewpoint towards our relation with Nature rather than the prevailing ego-centric perspective.
In Puerto Rico, a proposed legislative bill to grant legal personhood to the karst was introduce in 2023 with no success in becoming a law. Could this bill have been an ally to manage already protected landscapes by giving environmental personhood to karst regions in the Archipelago? A comparative analysis of this first intent named *Bill of Rights for the Forests and Karst* will argue that a detailed conception of the law is needed to have a better opportunity to successfully enact and implement a concession of legal personhood to the karst. An express mandate to ordain regulations and directives by precise government agencies with a minimal guidance in the law itself is necessary in any effort to give additional protection to the karst landscape by conceding legal personhood and potentially provide caves and karst with another tool in their preservation and management.

From Surface to Subsurface: Integrating Incrop Mapping in the Mammoth Cave System

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Geologists typically rely on surface outcrops or remote sensing methods—such as aerial photography and well-log analysis—to document and interpret geologic units. In karst terrains, however, subsurface exposures within cave passages—"incrops"—provide a unique and underutilized opportunity to extend geologic mapping beneath the landscape. Unlike well-log analysis, which is costly and equipment-intensive, incrop mapping offers a direct, efficient, and highly accurate means of observing stratigraphy and structure from within the cave itself.This study integrates detailed incrop mapping with cave survey data and high-resolution digital elevation models derived from LiDAR to create georeferenced 3D visualizations of the Roppel Section of the Mammoth Cave System. The laterally continuous passages of Roppel provide exceptional incrop exposures that clarify stratigraphic and structural relationships between the subsurface and surface geology. These new geologic datasets allow for the construction of 3D profiles that link the cave's internal architecture to the broader landscape, extending geologic understanding beyond the limits of traditional surface mapping within and outside Mammoth Cave National Park

Preliminary Investigation on Stream Flow Variations in the Black River Complex, Roppel Section of the Mammoth Cave System

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Scallops are asymmetrical, scoop-like indentations with a steep slope on the upstream side and a gentler slope on the downstream side, bound by crests that are also angled in the downstream direction. These features can vary greatly from the millimeter to the decameter in scale. Scallops were measured throughout the Black Canyon passage and surrounding area named the Black Canyon Complex in the Roppel section of Mammoth Cave System. Here, scallops vary in size but show multiple flow regime velocities. Furthermore, the localized stratigraphy of the passage also seems to be a controlling factor. Measurements were taken of both base and high flow stage scallops and input into the program ScallopEx (Woodward and Sasowsky, 2009) with the following parameters: scallop length, temperature, and average passage width. Our analysis yielded four different velocity calculations representing high flow and base flow from measurements taken in an upper and lower bed. Preliminary observations reveal multiple regimes that formed the Black Canyon passage that appear to be partially stratigraphically controlled with some perching layers. Scallop velocity data coupled with discharge estimates of the passages in relation to one another suggest that a preliminary conclusion of this

study is that this area is evidence of drainage via to the north, towards Pike Spring, and is indicative of a shift from southward drainage towards Turnhole Bend Spring. These data refine understanding of conduit initiation, entrenchment, and abandonment, thereby enhancing understanding of temporal and spatial variability in aquifer recharge and discharge pathways. In the Roppel Section, this integration paleo-hydrological mapping into management strategies strengthens efforts to protect water quality, mitigate human impacts, and sustain the long-term integrity of a globally significant karst landscape.

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