NATIONAL CAVE & KARST RESEARCH INSTITUTE

2023 - 2024

ANNUAL REPORT

www.nckri.org

Table of Contents

NCKRI Annual Report Series

NCKRI produced this publication as part of its annual reporting of activities. The reporting period covers NCKRI's fiscal year, from July 1, 2023 to June 30, 2024. Digital copies of this and previous reports are available for free at www.nckri.org.

NCKRI NEWS

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Cover Photo

Christine Saw in a cave in Arkansas with a fault in the background. Photo courtesy of Kevin Liow.

Back Cover Photo

Graphic showcasing a bat echolocating, used in the Jr. Bat Biologist Activity Book. Graphic by Raquel Lugo.

All photos not credit are courtesy of NCKRI staff.

Vision

The National Cave and Karst Research Institute will catalyze the advancement of cave and karst knowledge.

Mission

The National Cave and Karst Research Institute promotes and facilitates cave and karst research, education, and sustainability.

Organizational Information

The National Cave and Karst Research Institute (NCKRI) is located in Carlsbad, NM; and is a research center of New Mexico Institute of Mining and Technology (New Mexico Tech or NMT). NCKRI was created by the US Congress in 1998 in partnership with the National Park Service, State of New Mexico, and the City of Carlsbad to be a nexus of research, stewardship, information and outreach for caves and karst while fostering interdisciplinary collaborations.

NCKRI's enabling legislation, the National Cave and Karst Research Institute Act of 1998, 16 U.S.C. §4310, identifies NCKRI's mission as to:

1) further the science of speleology;
2) centralize and standardize speleological information;
3) foster interdisciplinary cooperation in cave and karst research programs;
4) promote public education;
5) promote national and international cooperation in protecting the environment for the benefit of cave and karst landforms; and
6) promote and develop environmentally sound and sustainable resource management practices.

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EXECUTIVE DIRECTOR'S REPORT

Dear Friends,

NCKRI's fiscal year 2023-24 served as a transformational period for NCKRI - an important time for resetting, refocusing, and fully preparing for our future. It provided an opportunity to look back at the road we have traveled, and to embrace the upcoming journey toward NCKRI's renewed future. This year's report underscores the growth of the institute through the past year's challenges, and the achievements realized through our staff's dedicated effort toward accomplishing NCKRI's goals/mission.

Through the year, Dan Jones continued to grow his research lab while also managing our grants and awards program. During the year, we awarded three National Seed Grants. Dan and his students received five external grants, published four papers, and presented over 30 scientific conference presentations.

Devra Willingham continued to strengthen our outreach and education program, expanding NCKRI's reach to over 115,000 people. Her program worked with students, volunteers, and a Scientist in the Park (SIP) to expand online efforts such as spearheading Cave Week and in person events like running a decontamination station at the National Speleological Society annual convention.

In December 2023, our long-time research hydrologist, Lewis Land retired after 21+ years at NCKRI. Through his years at NCKRI, Lewis was a fixture in the karst community, helping grow the community and achieve NCKRI's goals through his research efforts, support of the Sinkhole Conference, and his involvement in the Karst Division of the Geological Society of America, among many other activities. We thank Lewis for his efforts, wish him well in his future endeavors, and look forward to working with him in his emeritus role at New Mexico Tech.

While some members have moved on, we have also welcomed new faces to our Carlsbad Headquarters. Raquel Lugo has joined as a New Mexico Tech employee after having been an National Park Service SIP. Her work initially focused on developing a Junior Bat Biologist book and has now grown into developing content for social media and other outreach events focused on science communication. Additionally, after a national search, we hired a new Director. Benjamin Tobin was hired at the end of the fiscal year after working as a research geologist at the Kentucky Geological Survey, University of Kentucky for the last six years: he began work at New Mexico Tech/ NCKRI at the start of the 2024 – 2025 fiscal year.

Through the year, Valerie Davis, wearing her hat as interim director and Operations Director, has worked to build a strong foundation for NCKRI's future growth. This has involved refocusing on ensuring the organization has clear processes in place for growth and working to take care of a maintenance backlog at the NCKRI headquarters so that incoming employees have the tools necessary to succeed in achieving NCKRI's goals.

As we move into the new fiscal year, we are excited about continuing to strengthen our relationships with our federal, state, and local partners in achieving our mission to push the science of speleology, improve management techniques, broadly communicate cave and karst science, and build capacity to sustainably nurture the next generations of cave and karst scientists.

We look forward to working with you all to achieve these exciting goals,

Valerie Davis
Interim Director

Benjamin Tobin
Director

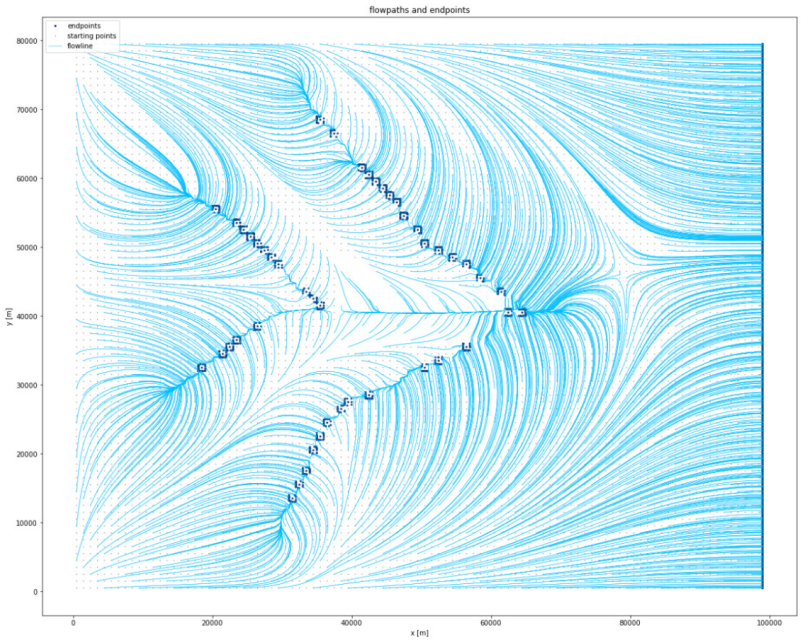
NCKRI RESEARCH GRANT PROGRAM

In 2019, NCKRI initiated three grant programs designed to facilitate and support cave and karst research at academic and research institutions across the United States:

- The NCKRI National Seed Grant Program is designed to enable investigators to initiate new cave and karst research as well as encouraging new principal investigators to enter the field.
- The NCKRI Scholar Fellowship Program supports cave and karst research by exceptional graduate and undergraduate students.
- The NCKRI-NMT Internal Seed Grant Program creates opportunities for investigators at NCKRI and New Mexico Tech (NMT) to initiate new cave and karst research. It also expands NCKRI's research footprint by enhancing collaborations with NMT faculty and students.

NCKRI's research grant program is managed by Dr. Daniel Jones. Application and other information is posted at https://www.nmt.edu/research/organizations/nckri.php. In 2023, we were able to support three new National Seed Grants, but unfortunately were not able to fund NCKRI Scholar or Internal Seed Grants. We start below with progress reports on previously funded seed grant projects.

Fandel's summer research students at work
Photo courtesy of C. Fandel.



Visualization created by Fandel's students to map the flowpaths of individual particles in a groundwater system with both matrix and conduit flow
Graphic courtesy of C. Fandel.

NCKRI National Seed Grants – Reports from previously funded seed grants

Developing Open-source Tools to Simulate Reactive and Non-reactive Contaminant Transport in Karst Aquifers
Chloé Fandel
Carleton College, Northfield, Minnesota

The goal of this project is to improve our ability to simulate how groundwater and contaminantsmove through karst landscapes, using numerical modeling tools. Two undergraduate researchstudents were hired for the summer of 2023, and worked on developing open-source, well-documented, and reproducible example code linking existing but currently disconnected projects, with a particular emphasis on creating training materials that can be used by several generations of undergraduate student researchers.

Over the summer, the students produced a collection of Jupyter Notebooks demonstrating simple examples linking a pyKasso-generated conduit network, MODFLOW-CFP flow simulations, and MODPATH particle tracking. While the students were not able to develop a fully working model using MODFLOW-CLN, both of the summer research students funded by this grant continued working on the project over the course of the 2023-2024 academic year. Beck Arnow used the summer work as a starting point for a senior thesis project, testing the addition of MT3DMS to the models developed over the summer. Xiaoying Qu worked as a research assistant during winter and spring terms, doing field data collection and developing a different version of the same model using MODFLOW-CLN, so that the two approaches can be quantitatively compared.

Fandel and her students were also able to meet with potential collaborators and stakeholders in

the area, including farmers, state employees, and instrumentation manufacturing representatives. They also scouted new potential field sites and developed familiarity with the regional landscape that will enable her to establish a relevant, useful, and effective long-term research program in southeastern Minnesota. In total, they visited 20 sites on 11 different state land management units.

The students presented their work to date in poster form at the Carleton Summer Research Symposium in October, and were selected to present at a "Scholars at the Capitol" event in St. Paul, MN.

Fandel is developed several ongoing research proposals based on the modeling progress, meetings, and site surveys that were conducted over the course of the summer. A major subject of interest in the region is spring health, and in-depth studies have explored the importance of hydrogeologic settings on springs, and the impacts of changes in agricultural practices in the springsheds of individual sentinel springs. However, developing models to help understand the dynamics of spring behavior across the region and to project future impacts on spring health is limited by the lack of synchronous data apart from a small number of heavily-instrumented sentinel springs, the temporal resolution and the quality of data vary enormously at different springs. Based on the work funded by NCKRI, I submitted a successful proposal to the Keck Geology Consortium REU Program to hire six students for a follow-up project during the summer of 2024, undertaking a synchronous survey of 50 or so springs across the region. Building on the outcomes of the Keck project, I also submitted a successful NSF-EMBRACE proposal, to undertake a full-scale survey of 200+ springs across the region, in both winter and summer. That project's website can be seen here: https://arcg.is/1CLK5r These surveys will serve as the basis for numerous future research projects, including identifying sites of interest for numerical modeling experiments

Fandel's students visiting a potential field site.
Photo courtesy of C. Fandel

This Seed Grant has entirely accomplished its purpose of providing support for me to develop the foundations (code development, experience supervising undergraduate students, identification of future research directions, collaborators, and field sites, etc.) that larger future research projects will be built on.

Pure sulfur crystal soda-straw stalactites emerging out of stinky cave wall crust.
Photo courtesy of J. Spear

The Shoshone Canyon Conduit Cave: A Greater Yellowstone Ecosystem Sulfur Cave

John R. Spear
Department of Civil and Environmental Engineering, Colorado School of Mines

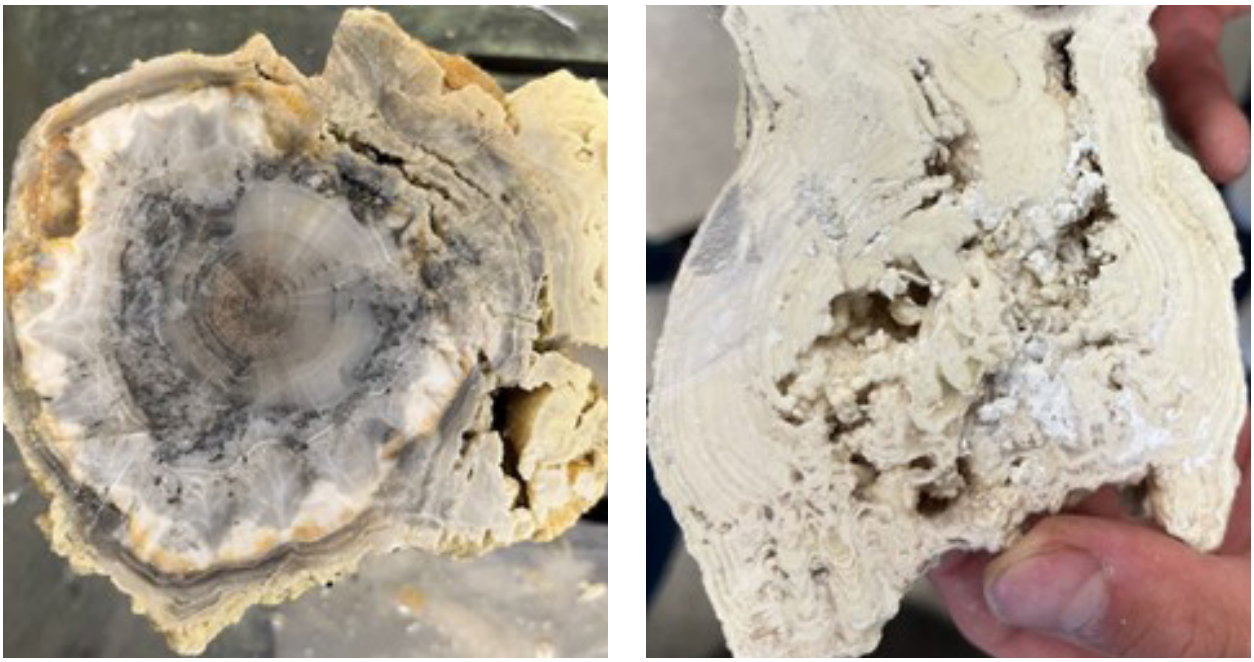
Five miles west of Cody, Wyoming and ~25 miles east of Yellowstone National Park lies the Shoshone Canyon Conduit Cave. Bisecting Cedar Mountain, an irrigation tunnel built by the Bureau of Reclamation (BoR), managed by the Heart Mountain Irrigation District, delivers water from the BoR Buffalo Bill Reservoir to more than 30,000 acres of irrigated lands in and around Cody. During the construction of that tunnel in the late 1940's, a cave was discovered and the tunnel was made to travel though the cave with only light disturbance to the cave. The cave can only be accessed with permission in the non-irrigation time of year. The cave is rich in sulfides and sulfur deposits with unique speleothems.

To date, we have conducted a preliminary geobiological survey of the geochemistry, microbiology and mineralogy of this sulfur cave on its speleothems, mineral deposits and waters. Sampled waters, of which there is little, were all highly acidic

(pH < 2). Microbiologically, an analysis of microbial communities present in approximately 25 sample locations (Figure 1) to answer the question of—who is there?—was conducted via small subunit ribosomal 16S rRNA gene (for Bacteria and Archaea) and 18S rRNA (for Eukarya) analyses. All samples were relatively low in biomass and resultant community analysis indicates a variety of Bacteria and Archaea phyla are represented with a dominance of known sulfur metabolizers. Mineralogically, petrography reveals a variety of crystal growth and habit in this sulfur-dominated, calcium carbonate-driven karstic ecosystem. X-ray diffraction analysis (XRD) was used to better determine the kinds and extant of mineral morphotypes and were surprisingly variable. The Shoshone Canyon Conduit Cave is a most intriguing sulfur cave to reveal what is known of the geobiology of sulfur caves in the Rocky Mountain Region. Findings from this work will likely apply to other cave systems such as Villa Luz (Mexico) and the Frasassi system (Italy). Finally, to learn about the Cedar Mountain Caves will inform on how either or both the National Park Service (NPS) and Bureau of Land Management (BLM) may better manage them as a meaningful component of the Greater Yellowstone Ecosystem.

Analysis is on-going of DNA sequence data by graduate student Carmen Villarruel at the Colorado School of Mines. We are also working with geologists to infer speleogenesis aspects of cave formations within the Conduit Cave via petrographic thin section and slab analyses. Figure 2 shows a cross section (Figure 2 Left) and slice (Figure 2 Right) of a piece of an 'Elephant's Feet' formation obtained from a piece of breakdown from the floor of the cave. The slice particularly, show stromatolytic like formation, whereby concentric, laminated layers of mineral growth are observed. Stromatolites in other environments such as those found in nearby Yellowstone National Park can be geologic, geochemical and/or microbiologically formed and have been found throughout the rock record of Earth's history. We do not yet know how these "Elephant's Feet' formations grew but are working on a model for their growth.

We were hoping to conduct more field work in the cave in 2024, but have instead moved this to the spring of 2025. We are currently working with the Bureau of Reclamation land manager for permitting and access to conduct follow-up work. Our cave work is being conducted mostly by undergraduate students at the Colorado School of Mines, members of the Caving Club and National Speleological Society Mines Grotto at the Colorado School of Mines.

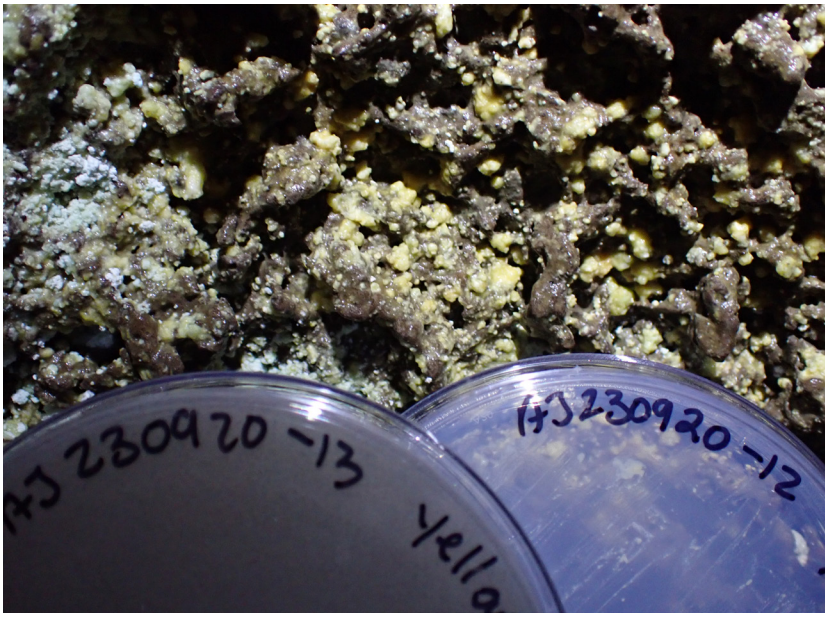


Left: A cross-section slab of a piece of 'Elephant's Feet' stalactite formation obtained from breakdown on the floor of the Shoshone Canyon Conduit Cave. Sample is approximately 10 x 10 cm in size.
Right: A vertical slice through a piece of 'Elephant's Feet' tip stalactite obtained from breakdown on the floor of the Shoshone Canyon Conduit Cave. Laminations of tree-ring-like growth are visible as are tortuous mineralogic growth leaving void spaces within the formation.
Photos courtesy of J. Spear

NCKRI National Seed Grants – New seed grants funded in 2023

Investigation of Silica Solubilization and Uptake by Cultured Cave Bacteria
Diana E. Northup, Professor Emerita, and **Jennifer Hathaway,** Research Scientist I, University of New Mexico

Lava caves worldwide have silica deposits that were formed on their cave walls after the cave was formed. Some of these deposits are opal secondary mineral deposits, while others are what we call "ooze", a soft deposit that is often dominated by silica. Biosignatures, morphologies, chemical composition, etc. that provide evidence of past or present life in silica formations, may be an excellent life detection tool on extraterrestrial bodies. By using similar caves on Earth, we have accessible laboratories for such investigations. While the microbial role in these secondary deposits is hypothesized and supported by bacterial morphologies in silica deposits, the understanding of how specific microorganisms participate in silica secondary mineral formation needs extensive study. Are the microorganisms simply trapped in forming deposits, or are they active players in silica formations? We will investigate the ability of cave bacteria, cultured from lava caves in El Malpais National Monument, in New Mexico, to solubilize silica and/or uptake silica. Establishing if these basic mechanisms can be performed by cave bacteria, then investigating the types of Bacteria and Archaea performing these processes, will lay the foundation for investigating microbial mediated silica formation in caves.



Cave formations known to be rich in silica that were targeted for culturing. Photos courtesy of D. Northup

Fire and Carbon in an Arid Karst Landscape
Jessica Oster, Department of Earth and Environmental Sciences, Vanderbilt University, Nashville, TN USA, **Franziska Lechleitner**, University of Bern, Switzerland, **Cameron de Wet**, University of California, Davis, CA USA, **Michael Hren**, University of Connecticut, Storrs, CT, USA, **Ken Belanger**, Colgate University, Hamilton, NY, USA

Chemical records from stalagmites can illuminate the relationship between climate change and wildfire from past intervals of time when the human influence on the climate and land surface was greatly reduced compared to today. However, open questions remain as to how the chemical fingerprints of fire are transmitted from the surface into the cave and how fire influences soil carbon above the cave. To address these questions, we will initialize a long-term study

Jessica Oster, Ken Belanger, and Cameron de Wet assessing cave monitoring equipment in Titan Cave, WY
Photo courtesy of J. Oster

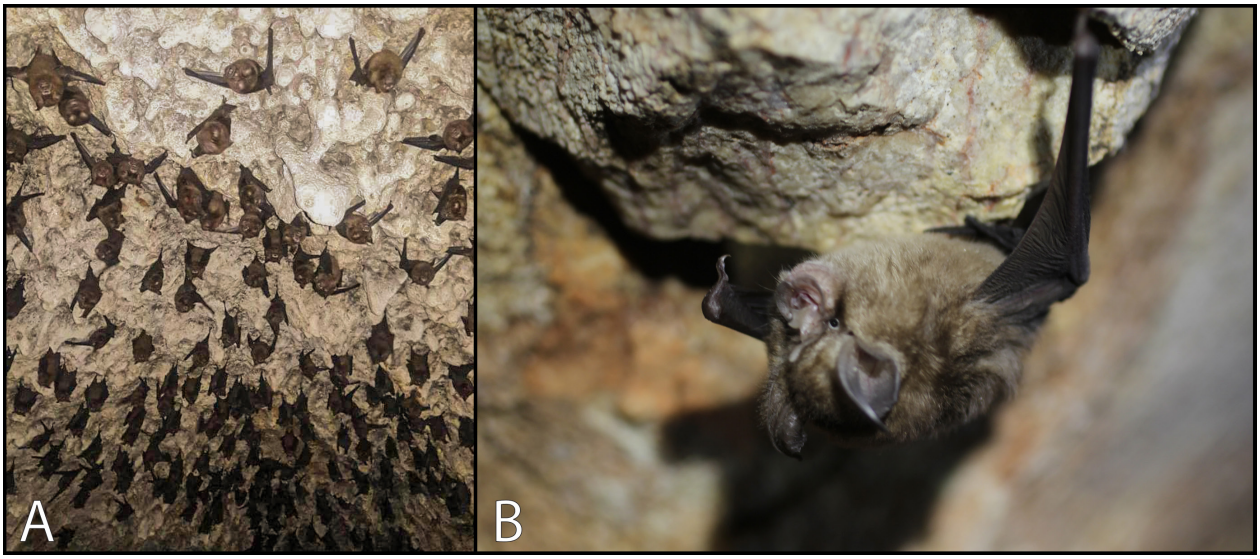
of the impacts of fire and the timing of recovery in a semi-arid karst landscape through implementing a controlled burn bracketed by monitoring of the soil microbiome, soil and cave gas and organic and inorganic dripwater chemistry. Our site is located in northern Wyoming in the highly threatened sagebrush steppe ecosystem. Understanding the interplay between soil microbial populations, carbon cycling, and fire and how these would be captured in a stalagmite record will improve our ability to reconstruct past fire activity. This knowledge is transferrable to other sagebrush steppe landscapes in the western US which occur across numerous National Parks and public lands.

First Study to Examine Cave-dwelling Animal Communities in Bhutan

Jut Wynne, Northern Arizona University, and **Kuenzang Dorji**, Ugyen Wangchuck Institute for Conservation and Environmental Research, Bhutan

Dr. Jut Wynne, Department of Biological Sciences and Center for Adaptable Western Landscapes, Northern Arizona University and Mr. Kuenzang Dorji, Ugyen Wangchuck Institute for Conservation and Environmental Research, Bhutan are co-leading the first study to document and characterize Bhutan's cave biodiversity. While some work on bats has been undertaken, the wholesale examination of cave ecosystems remains largely uncharted territory within the country.

Overall, the significance of their research lies in filling the knowledge gap concerning cave ecosystems in Bhutan. Specifically, the research team will systematically: (1) identify cave-roosting bats via mist-netting and recording ultrasonic calls; (2)



(A) Great roundleaf bats (Hipposideros armiger) roosting in cave in Bhutan. Courtesy Sangay Tshering. (B) Intermediate horseshoe bat (Rhinolophus affinis) observed in cave near Yujiacun village, Guangxi Province, China. The distributional range of this species extends through southern Bhutan.
Photos courtesy J. Wynne.

collect (and likely subsequently describe) subterranean-adapted taxa; and (3) document the frequency of cave use by tigers, leopards, Asiatic black bears, sloth bears, grey wolves, and primates using trail cameras. Through their efforts, Wynne, Dorji, and their team will gather data on cave-dwelling communities and their diversity, heighten awareness about the importance of cave biodiversity, characterize cave use by bats, other wildlife, and arthropods, and establish monitoring procedures. Educational outreach will involve seminars, workshops, and popular science articles designed to engage Bhutanese and global audiences.

In essence, their project endeavors to address the prevailing dearth of cave biological information in Bhutan. With multifaceted objectives spanning an array of activities and ranging from primitive arthropods to charismatic megafauna, the researchers will begin to unearth the intricacies of cave ecosystems and elucidate their ecological significance beneath Bhutan. With the generous backing of the NCKRI National Seed Grant program—a monumental initial stride—Wynne, Dorji, and colleagues are confident this endeavor will make a substantial contribution to further our understanding of cave ecology in southeast Asia. Moreover, it holds the potential to help safeguard vulnerable Bhutanese cavernicoles and the sensitive habitats essential to their survival.

Additional team members crucial to the ultimate success of this project include: Mr. Chris Corben, BatSense, Columbia, Missouri; Dr. Patricia Kambesis, Center for Human GeoEnvironmental Studies, Department of Earth, Environmental, and Atmospheric Sciences, Western Kentucky University, Bowling Green; and Dr. Bruce W. Miller, Wildlife Conservation Society, Bronx, New York.

Trail camera footage from a similar on-going country-wide effort to characterize cave-dwelling communities in Belize; these images illustrate the potential for this sampling method in Bhutan. (A) An adult female jaguar (Panthera onca) with her juvenile male cub at a cave entrance (06/2023), (B) an adult cougar (Puma concolor) exiting a cave (10/2020), and (C) a ~2m adult crocodile (Crocodylus sp.) exiting a flooded cave (11/2022), Runaway Creek Nature Reserve, Belize. Images courtesy J. Wynne and the Foundation for Wildlife Conservation.

NCKRI ACADEMIC PROGRAM

Cave and Karst Studies

Cave and Karst Studies at New Mexico Tech (NMT) is NCKRI's Academic Program, directed by Dr. Daniel Jones. It is designed to provide specialized undergraduate and graduate instruction for students interested in or pursuing a career in the cave and karst sciences.

This was a big year for Cave and Karst Studies. Over the last year, we piloted a new research-based course, supported undergraduate student researchers, and saw the revival of the NCKRI Seminar Series. In addition, Dr. Jones was awarded tenure, and received new grants including some that will support new research in and around Great Basin National Park. We also hosted the Rocky Mountain Geobiology Symposium at NMT in May.

In September 2023, we hosted several scientists from NASA's Goddard Space Flight Center and Johnson Space Center on an expedition for the Goddard Instrument Field Team (GIFT). The GIFT program scientists spent a week evaluating evaporite and carbonate deposits in the Quebradas area, just East of Socorro, as a possible Mars analog. They worked with several NMT faculty and students. Dr. Jones was Deputy Field Lead for the program.

This spring, Jones and NMT students hosted the 6th annual Rocky Mountain Geobiology Symposium at NMT. The Symposium was attended by more than 50 students and researchers from Colorado, Arizona, and New Mexico. The symposium featured three keynote speakers, presentations by students and postdocs, and a poster session, as well as many opportunities for students to network with researchers from other universities and national labs. See more at https://rmgeobio2024.wixsite.com/rmgs-home.

Zoë Havlena (NMT) collecting X-ray fluorescence data from gypsum in the Upper Yeso Formation with Amy McAdam (left) and Christine Knudson (middle), NASA Goddard Space Flight Center during the GIFT program.

Courses

Over the 2023-2024 academic year, Dr. Jones taught classes in Cave Geology, Earth History, and a new course-based undergraduate research experience (CURE) course in Environmental Microbiology.

Students in "Introduction to Cave Geology" (GEOL 0289) visited limestone caves in New Mexico's Black Range, and at El Malpais National Monument. In addition, students in the course wrote accessible summaries for the website Sciworthy on new primary scientific literature that was published in the two years. Three students had their pieces selected for publication on the Sciworthy website:

- https://sciworthy.com/how-do-mountains-affect-earths-climate/
- https://sciworthy.com/archeologists-uncover-ancient-fishhooks-in-indonesia/
- https://sciworthy.com/scientists-described-a-couch-potato-cave-salamander-called-the-olm/

Dr. Jones presented on this Sciworthy activity at the Geological Society of America fall meeting in October and at the Astrobiology Science Conference in May.

In the new Environmental Microbiology CURE, students participated in a weekend field trip to the Carlsbad area, where they collected samples from Cottonwood Cave in the Guadalupe Mountains outside of Carlsbad, NM. Students also visited Carlsbad Cavern and NCKRI Headquarters. Over the course of the semester, they performed culture-dependent and independent microbiological analyses on the samples that they collected. They isolated multiple new strains of bacteria from the cave

NMT Caving Club members in Sand Cave. Photo by Sharon Minnix

wall samples, designed their own experiments with defined media to enrich specific microorganisms that are important for cave formation, and extracted DNA and analyzed rRNA gene libraries from their samples. Students from the class presented results at NMT's Student Research Symposium, the New Mexico Geological Society Spring Meeting, and the Rocky Mountain Geobiology Symposium.

Jones' classes take advantage of New Mexico's amazing geology for field trips to Paleozoic carbonate formations near Socorro, to the caves and karst landscapes of the Guadalupe Mountains.

NMT also supports the NMT Caving Club, which thrived under Club President Sharon Minnix (NMT Earth Science). Sharon graduated in May, and the club is transitioning to new leadership under Aurelia Vargas (NMT Mineral Engineering) and Cameron Sanchez (NMT Mechanical Engineering). See more at https://techconnect.nmt.edu/cave/home/. Dr. Jones is the academic advisor for the club, which is supported by NMT's Recreation and Wellness program. Devra Heyer has been instrumental in supporting the club by leading trips and trainings.

NMT-NCKRI Geobiology Lab

This was an exciting year for Dr. Jones and the students in his lab group. We saw several lab members finish their undergraduate and graduate degrees, and welcomed new students members into the group.

Students

Zoë Havlena is a Ph.D. candidate in Geobiology, in her final year. Zoë published her research on gypsum and other secondary mineral deposits in Lehman Caves, Great Basin National Park, in the journal Geobiology, and is wrapping up her dissertation (defending in Fall, 2024). She also presented at the Geological Society of America fall conference in Pittsburg, PA, and the Astrobiology Graduate Conference in Atlanta, GA. You can read a summary of her Lehman Caves work here from Great Basin National Park's newsletter The Midden: https://www.nps.gov/articles/000/mineralsmicrobeslehmancaves.htm

Mackenzie Best is a Ph.D. candidate in Geobiology, in her fourth year. Mackenzie presented at the Geological Society of America

Students in Environmental Microbiology on a fieldtrip to Cottonwood Cave listen to Dr. Daniel Jones for instructions on how to collect biological samples.

Environmental Microbiology students presenting their results from their collected samples at NMT's Student Research Symposium.

The NMT Geobiology Lab in Spring, 2024.
Left to right: Katelyn Green, Calyssa Huff, Mackenzie Best, Zoë Havlena, Joseph Hoberg, Jimmy Swift, Nathaniel Jobe (Kieft lab MSc student), Cassandra Skaar, Anika Baloun, Abigail Brown, Laura Rodríguez.

fall conference in Pittsburg, PA, the Astrobiology Graduate Conference in Atlanta, GA, and the Society for Mining, Metallurgy & Exploration (SME) in Phoenix, AZ. Mackenzie received NMT's prestigious "Rising Star" award in Fall 2023.

Katelyn Green graduated with a MSc in Biology Spring, 2024. For her thesis, which was titled "High-Throughput nifH Sequencing Reveals Limited Diversity Of Nitrogen-Fixing Microorganisms In A Subterranean Chemosynthetic Ecosystem, she tested hypotheses about nitrogen fixing bacteria in sulfuric acid caves, and participated in fieldwork in the Frasassi Caves. In addition to defending her MSc, she presented at the Geological Society of America fall conference in Pittsburg, PA, the Rocky Mountain Geobiology Symposium, and the New Mexico Geological Society Spring Meeting in Socorro. She is now working in the Biochemistry & Biotechnology (B-TEK) group at Los Alamos National Laboratories.

Abigail Brown graduated with a MSc in Biology in Spring, 2024. Her thesis was titled Extremophilic Microorganisms from Volcanically-Influenced Environments in Valles Caldera National Preserve, New Mexico. Abbey has been working with Dr. Jones as an undergraduate since 2020, studying sulfur-cycling microorganisms in acidic streams and lakes in Valles Caldera National Preserve and in nearby travertine hot springs. Abbey participated in the SIP program in 2023, and presented her research at the Geological Society of America fall conference in Pittsburg, PA, and the Rocky Mountain Geobiology Symposium in Socorro. She is now teaching high school chemistry in Belin, NM.

Calyssa Huff graduated with a Bachelor's of Science degree in Biology in Spring, 2024. Calyssa worked on a NASA-funded project on microbial bioburden in clean rooms, and had a chance to visit NASA's Goddard Space Flight Center and work on planetary protection projects in Spring, 2024. She presented her research at the Rocky Mountain Geobiology

Dr. Magdalena Osburn gives a keynote presentation at the Rocky Mountain Geobiology Symposium organized by the Geomicrobiology Lab graduate students.

Symposium in Socorro in Spring, 2024. She is now pursuing a medical virology career, and is currently an ICARE post-baccalaureate researcher at the University of Iowa
.

Joseph Hoberg started as a MS student in Hydrology in Fall 2023, after joining the lab as a SIP intern in summer 2023. Over the last year, he established new experiments to detect human derived contamination in Carlsbad Cavern and Valles Caldera National Preserve as part of a new project supported by NASA Planetary Protection Research. He presented his SIP research at the Geological Society of America fall conference in Pittsburg, PA, and on his planetary protection research at the Astrobiology Graduate Conference in Atlanta, GA.

Laura Rodríguez started as a Ph.D. student in Geobiology in January 2024. She is studying microbial and fungal communities in the Frasassi Caves as part of a new NSF-supported project on sulfuric acid cave formation. Prior to NMT, she defended her MSc in Plant Pathology at Auburn University, and is working on her first manuscript from her MSc research. She will be participating in her first fieldwork expedition to Frasassi in the summer 2024.

Cassandra Skaar started working with Dr. Jones as an undergraduate in Spring 2023, studying bacteriophages and other viruses that infect microorganism in the extremely acidic environments of Valles Caldera National Preserve in New Mexico. She will continue this research as an accelerated Master's student in Biology. Prior to starting in the Geobiology Laboratory, she worked with Dr. Thomas Kieft, first studying different methods of inhibition of photosynthetic growth from Carlsbad Caverns National Park, and then studying viruses in deep groundwater brines in South Africa. Cassandra recently received the prestigious Barry Goldwater National Scholarship, a national award for sophomore and junior students who want to pursue a career in research.

Jimmy Swift was a SIP intern in summer 2023, and then continued as an undergraduate researcher in the Geobiology Lab. He has been studying microbial communities in Soda Dam, a spectacular travertine structure near Valles Caldera National Preserve, and presented his research at the Geological Society of America fall conference in Pittsburg, PA, and the Rocky Mountain Geobiology Symposium in Socorro.

Anika Baloun was a SIP intern in summer 2023 after graduating with her Bachelor of Science degree in 2023. She presented her research at the Geological Society of America fall conference in Pittsburg, PA, and the Rocky Mountain Geobiology Symposium in Socorro. She started working as a laboratory technician in the Geobiology Lab in Spring, 2024, and will start as a MSc student in the fall.

Left to right: Graduate students Katelyn Green, Abigail Brown, Joseph Hoberg, Mackenzie Best, Zoë Havlena, and Joseph Hoberg, at the Geological Society of America fall meeting in October, 2023.

NCKRI Seminar Series at NMT

We had five excellent speakers in the NCKRI Seminar Series this year. All the NCKRI seminars are well attended by students and faculty from throughout the NMT campus, and are sometimes followed by receptions hosted by Dr. Daniel Jones to connect students with the guest speakers and promote fellowship and research collaborations.

Dr. Jennifer Stern, NASA Goddard Space Flight Center, gave a talk entitled "Life on Mars – why haven't we found it yet?" on September 14th, 2024. Dr. Stern was visiting NMT as part of the GIFT program, and her talk included an update on their work looking at Martian analog sulfate minerals in New Mexico.

Carol Hill gave a talk entitled "Hypogene Speleogenesis of Guadalupe Mountains and Grand Canyon: A Comparison" on


NCKRI Seminar Series

Life on Mars – why haven't we found it yet?

Dr. Jennifer Stern
Solar System Exploration Division
NASA Goddard Space Flight Center

Department of Earth and Environmental Science
Thursday, September 14th, 2023
4:00 PM, MSEC 101

Dr. Jennifer Stern is a Space Scientist at NASA Goddard Space Flight Center in Greenbelt, MD, specializing in the study of the atmosphere and surface of Mars, and instrument development for measurements on planetary surfaces. She is a member of the science team for the Mars Science Laboratory (MSL) Rover Curiosity, which landed in Gale Crater on Mars in August 2012. In addition, she leads the development of part of an instrument on the Dragonfly mission to Saturn's moon Titan.

Dr. Stern has a BA in Geology-Biology from Brown University and a PhD in Geochemistry from Florida State University, where she studied environmental geochemistry. She decided to apply her interest in geochemistry to astrobiology as a postdoctoral fellow at NASA. Today, in parallel with conducting experiments on Mars and developing flight hardware for Titan, she participates in field expeditions to places where geochemical processes similar to those that may have occurred Mars are recorded in Earth's rock record.

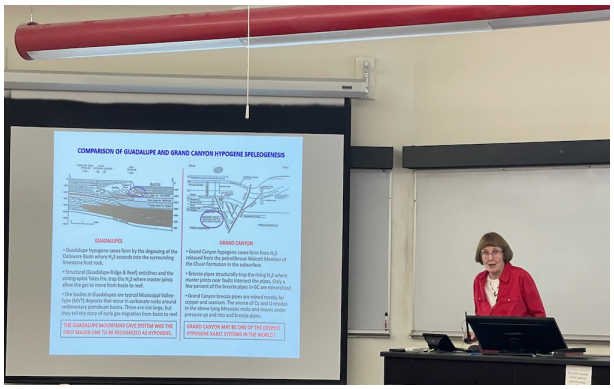
The flyer for Dr. Stern's seminar on September 14th, 2023

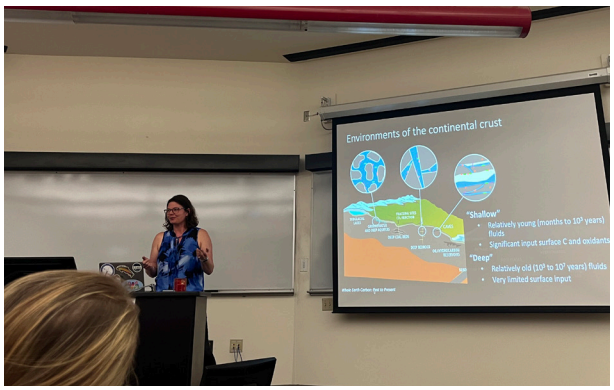
November 16th, 2024. Carol Hill was recently awarded the prestigious Meritorious Contribution Award by the Karst Division of the Geological Society of America.

Zoë Havlena gave a seminar entitled "Microbial colonization of sulfidic cave gypsum: Are acidic sulfates potential repositories for molecular biosignatures?" on February 15th, 2024. Zoë Havlena is a Ph.D. candidate in the Geobiology group, and defended her Ph.D. at the end of the summer.

Dr. Lewis Land, recently retired from NCKRI, gave a seminar entitled "An overview of brackish water resources and desalination in New Mexico: Recurring themes in the semi-arid southwest" on April 4th, 2024. Dr. Land was a hydrologist with NCKRI since the early 2000s before he retired in 2023.

Dr. Magdalena Osburn, Northwestern University, gave a seminar "Subsurface geomicrobiology of the heterogeneous terrestrial crust" on April 18th, 2024. Dr. Osburn was also one of the invited speakers for the Rocky Mountain Geobiology Symposium on April 20th.





Clockwise Doctor's Carol Hill, Zoë Havlena, Lewis Land and Magdalena Osburn present at the NCKRI Seminar Series.

Cave and Karst Research Fellowships for NMT Undergraduates

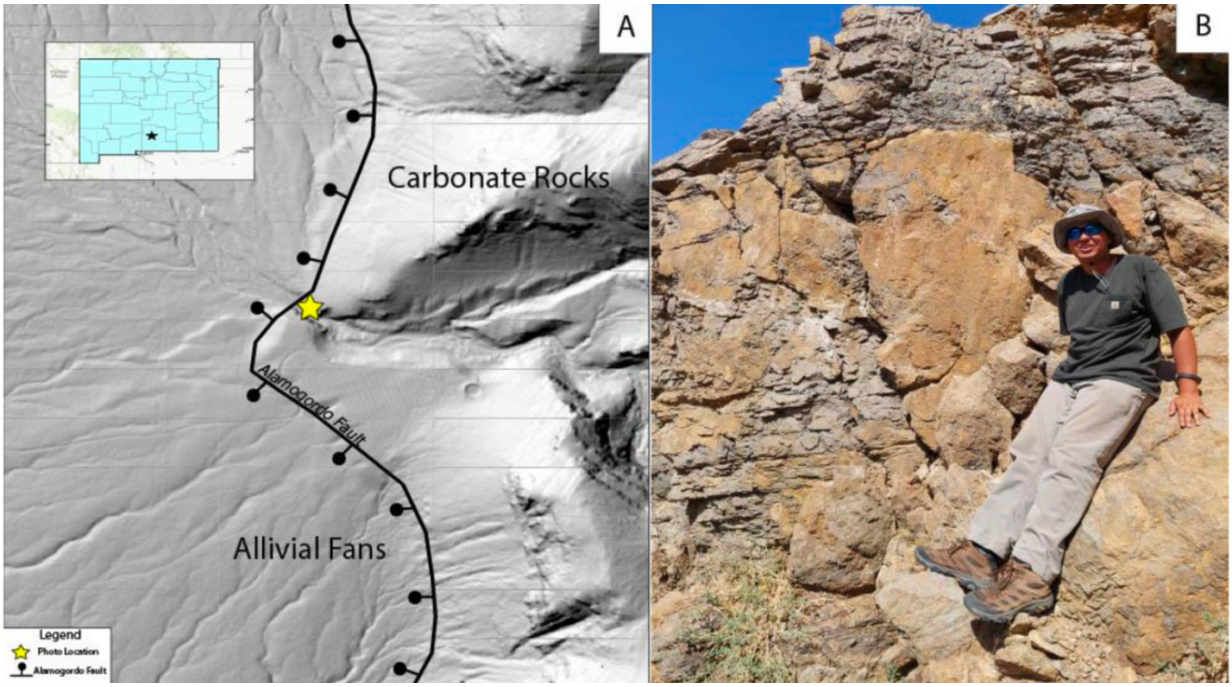
Antonio Chavez received a UROCK award for his proposal entitled "The deformation of carbonate rocks in Mule Canyon, Alamogordo, New Mexico". This award funded the completion of his senior thesis objectives. He was advised by Dr. Veronica Prush of the NMT Earth and Environmental Science Department during fall 2023 and spring 2024.

Localized deformation along fault zones affects the structural integrity of surrounding rocks by adding weak points and fractures throughout the rock volume. These weak points can cause preferential pathways for fluid flow. Preferential fluid pathways in carbonate rocks enhance dissolution and can eventually create large voids, such as caves, through differential acid precipitation.

One of the best locations to study the deformation of carbonate lithologies due to faulting is in the foothills of the Sacramento Mountains in the Tularosa Basin of south-central New Mexico. The type of carbonates found range from crystalline dolomite to argillaceous limestone and are 485 to 250 million years old. They have been subjected to different tectonic events, including Ancestral Rocky Mountain building, Laramide orogenesis, and Rio Grande rift (RGR) faulting. The multiple deformation events that have impacted this region have created structural fabrics that are ideal for preferential fluid migration.

Chavez worked with Dr. Prush and MS student George Pharris to produce a neotectonic map of the Alamogordo fault, a RGR-related structure that has caused significant damage to regional bedrock carbonates bounding the eastern margin of the Tularosa Basin. Chavez also carried out a fracture analysis study that measured the orientation, length, width, and mineral precipitation along fractures within bedrock carbonates to test the hypothesis that more deformation would be localized near the Alamogordo fault. Chavez found that the density of fractures decreased with increasing distance along a ~2 km-long transect perpendicular to the Alamogordo fault, suggesting that his hypothesis is correct. He also documented a change in prevailing fracture orientation from northwest-southeast to northeast-southwest with increasing distance from the fault. Chavez presented his results at the New Mexico Geological Society spring meeting in April, 2024.

Chavez (left) and Pharris (right) posing with the world's largest pistachio in the Tularosa Basin.
Photo courtesy of A. Chavez



Map view of Mule Canyon and the location of the Alamogordo Fault where Chavez worked. Panel B shows Chavez at a carbonate bedrock outcrop in Mule Canyon, immediately east of the Alamogordo fault.
Photos courtesy of A. Chavez

Other Student Opportunities

Daniel Runyan did an independent study with Dr. Jones where he worked with and Devra Heyer Willingham, NCKRI's education program manager, to create learning modules on volcanic and solution caves. Daniel recently graduated with a bachelor's degree in Earth Science with a minor in Technical Communications, and he used his independent study to apply both of those skills to translate cave science into accessible educational materials and diagrams. Daniel Runyan presented his research at the New Mexico Geological Society annual spring meeting

Daniel Runyan with his poster at the New Mexico Geological Society Spring Meeting. In the photo, he is showing one of the interactive features in his learning module to Dr. Jones' children.

In addition to her leadership of the caving club, Sharon Minnix did an independent study with Dr. Jones in the spring, where she collected data on chemical weathering in a watershed in New Mexico's Black Range. She found that sulfate increases in North Percha Creek where it flows over a section with both carbonates and black shales, and considered the implications for sulfuric acid versus carbonic acid weathering of limestone. She presented her results at the New Mexico Geological Society annual spring meeting.

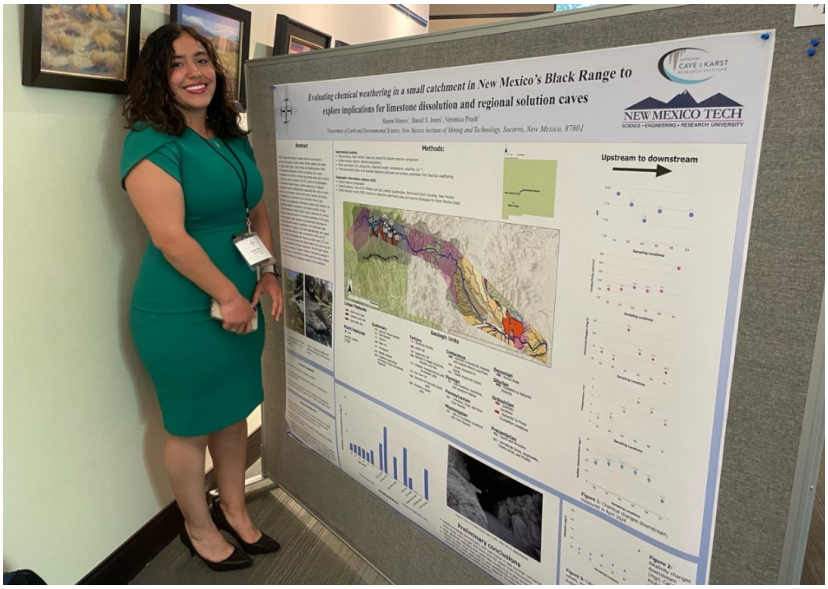
Students in Earth History (GEOL 206) on a field trip in February, 2024. On this field trip, students collected fossils and measured stratigraphic columns in Paleo zoic carbonates in the Quebradas area outside of Socorro.

Student Opportunities at NMT

New Mexico Tech is highly ranked among US universities in several important categories. It focuses on STEM (Science, Technology, Engineering, and Mathematics) programs, which makes it an ideal home for NCKRI. For students interested in caves and karst, great opportunities exist not just in geology and biology but also in engineering, chemistry, robotics, and other fields

For more information about New Mexico Tech, visit www.nmt.edu.

To learn more about NCKRI's Cave and Karst Studies Program at NMT, contact Dr. Daniel Jones at daniel.s.jones@nmt.edu



Sharon Minnix presented a poster on her independent study research at the New Mexico Geological Society annual spring meeting.

EDUCATION AND OUTREACH PROGRAM

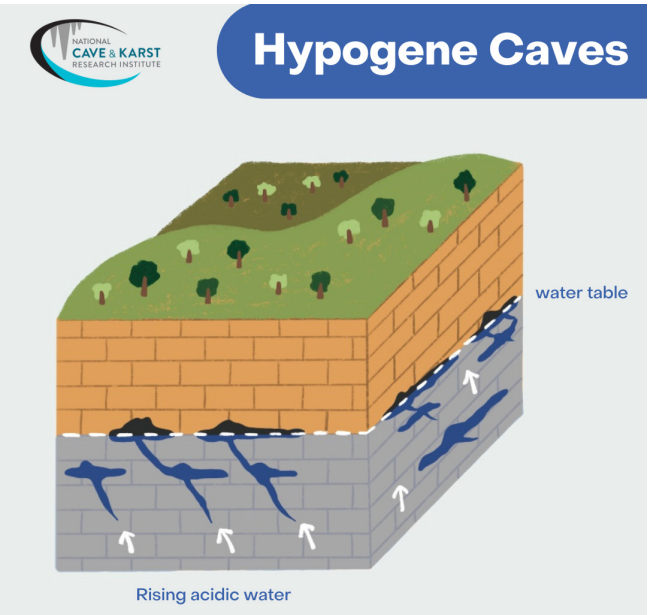
NCKRI was founded on several guiding principles, with one major tenet being promoting public education. NCKRI's efforts to work cooperatively with multiple agencies helps provide a central location for finding cave and karst information through diverse initiatives and multiple platforms. From local family events to online resources that are available around the world, NCKRI works to support the greater community, translate research and further our knowledge of speleology. NCKRI's overall reach between online presence and in person events was over 100,000 people. NCKRI has multiple online platforms to disseminate information such as facebook, instagram, Linkedin, Youtube, a mailing list, giphy accounts, X and a website. Through these platforms and in person events we try to reach our three target audiences:

1. Families that live on karst (which includes our K-12 audience and educators)
2. Cave and karst professionals
3. People who recreate on karst

Online presence

Social Media

NCKRI's online presence includes social media accounts for Facebook (@National Cave and Karst Research Institute), Instagram (@nckri) and X (@NCKRI). Each one of these accounts targets a slightly different audience which is mostly influenced by how people interact with the given platform. Overall, NCKRI's social media features educational content such as the weekly social media campaign of Cave and Karst Word of the Week, professional opportunities like grants and job openings, and updates about events and news.



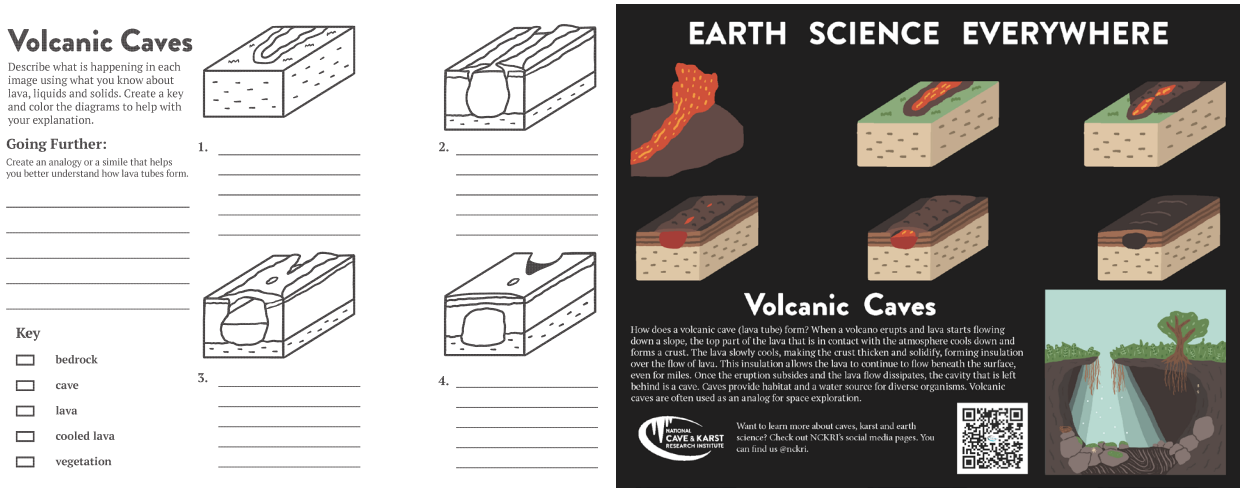
Example Cave & Karst Word of the Week social media post.

This fiscal year we have seen a 75% increase in Facebook followers, a 50% increase in Instagram followers, and a 2.7% increase in X followers. NCKRI's total reach for the year was over 50,000 for Facebook and 4,300 for Instagram. Popular topics for the social media campaign Cave and Karst Word of the Week included cave formations, minerals, and caving equipment. Content shared through X focused more on job postings, internships, grant opportunities and our monthly newsletter. With NCKRI's social media we hope to target students, educators and professionals within the cave and karst science and resource management community.

This year NCKRI's Youtube channel shared a Youtube Short on the decontamination station at the National Speleological Society Annual Convention 2023, an end of year thank you message that was emailed to our newsletter subscribers, and Cave Week webinars that included ways to celebrate caves and a reading of the book CAVES by Nell Cross Beckerman. In total we had a 30% increase in subscribers with the top watched video being the YouTube short for the decontamination station at NSS Convention. We are starting a new program to diversify the way in which cave and karst topics are shared through social media in fall 2024. This will consist of educational short format videos that visually explain scientific concepts.

Giphy

We are developing a new program to expand the audience reach on social media through the creation of cave and karst inspired GIFs. A GIF stands for "Graphic Interchange Format" and it's usually an animated video clip that is commonly shared through the internet via social media (Facebook, Instagram, X, text message, email, and more). NCKRI started developing short animated GIFs through GIPHY (@caveeducation) and Tenor (@nckri) as a way to convey cave and karst topics in a fun and engaging way. We created short animated GIFs for events like Bat Week and Cave Week as a supplement in the social media campaign. Additional GIFs were



NCKRI's contribution to the Earth Science Week toolkit.

done for circulating airflow in caves, phreatic and vadose cave passage and hypogene caves. In total, these animations received 629,600 views on GIPHY.

NCKRI News

NCKRI has a monthly Cave and Karst email newsletter that is sent to over 2500 people, which averages a 55% open rate. Most of the subscribers are cave and karst professionals or young professionals such as students. The newsletter includes information about upcoming events, deadlines and chronicles the NCKRI activities such as academic program updates, outreach events, and research projects. Please email info@nckri.org if you would like to receive this newsletter.

Website

The NCKRI website now has several new pages and navigational tools. One of the major improvements was the addition of a "grants" navigation button that leads to an overview of the NCKRI Seed Grants, which includes a summary of all the projects that have received funding by year. Another major addition is the "News and Events" section, which includes the Cave and Karst Calendar and links to our monthly newsletter. On average NCKRI's website receives over 3000 page views per month, with a total of 40,000 per year. The website has seasonal highs during the K-12 school year, and the top referring pages are sites such as google classroom and other similar teaching applications.

Outreach Events

National Events

NCRKI partners with other institutes for national events with similar missions. The American Geoscience Institute leads Earth Science week every year. This earth science week student activity pages were sent out as part of the Earth Science Week toolkit that goes out to 9000 educators. NCKRI also participates in Bat Week, and created a Bat week gif that had over 10,000 during October 2023.

Education Initiatives at NCKRI Headquarters

NCKRI's local in person events had a reach of over 2500 people, which mostly included people who live with karst and local cave and karst professionals. Many of these events were because of our partnership with Inspired by Science who organizes local family STEM events, often utilizing the NCKRI building. Some of these events included Cave Night (during Cave Week) and the Solar Eclipse Watch Party. NCKRI participated in other local events such as Cavernfest put on by the city of Carlsbad and STEM Earth Day put on by the Southeastern New Mexico College. In total NCKRI participated in 11 events that took place in the Carlsbad area.

Conservation and Cave Education Initiatives:

Decon station

Decontamination of gear to protect against the fungus *Pseudogymnoascus destructans* and other possible contaminants has become best practice before accessing a different cave or caving area. At many caving events, a decontamination and gear cleaning station is utilized to ensure that cavers are adhering to local and regional cave management best practices. This is the second year that National Cave and Karst Research Institute (NCKRI) took the lead in setting up the cleaning and decontamination station at the National Speleological Society (NSS) convention. This year a new decon station was fabricated and built by NCKRI staff member Jon Davis with assistance from other NCKRI staff and volunteers. The

Raquel Lugo assists cavers at the decontamination station during the 2024 National Speleological Society Convention in Sewanee, Tennessee

station modified Knutt Peterson's original design to make transport and function more efficient. The station and most associated materials were gathered at NCKRI headquarters in Carlsbad, New Mexico and transported by truck to Sewanee, Tennessee. This includes the contributions of materials from the US Forest Service.

During the 6-day event, with over 1200 attendees, the decon station was staffed for 42 hours, generally from 8am-noon, 4pm-8pm, with the station closing early on Friday for the banquet and open until 10 am on Saturday, the last day of convention. During this time, 341 people utilized the decon station during operating hours. The station was set up so that the wash, chemical and drying stations could be utilized "after hours" of operating hours, so the total number of station users is likely much higher: each time volunteers went to the station to open it up for operation, there were already people utilizing it. Even after 10 pm people could be seen washing their gear!

Since most of the convention caving trips stayed within the same WNS management area, which is considered WNS positive, most users primarily washed their gear only and didn't utilize the hot water bath. However the full decon process, including the hot water bath, was still used frequently with around 100 bags of gear handled by volunteers during the week.

The decon station had a total of 22 different volunteers that helped throughout the week in varying capacities and amounts of time, resulting in 76 hours of volunteer service. Along with two NCKRI staff members, two people helped with unloading the NCKRI truck, 10 people helped with setup, nine people helped with staffing the station during the week and three people helped with the take down of the station. Some of the challenges for future success include finding enough volunteers to help run the decon station. This year, the two NCKRI staff members involved totaled 80 hours of work focused on the decon station between 6/28-7/6.

Clean Ups

NCKRI participated in several community clean ups in partnership with the city of Carlsbad and the Bureau of Land Management's Carlsbad Office such as River Blitz, Better Together and Public Lands Day. NCKRI's headquarters is located adjacent to the Pecos River which has multiple nearby karst springs that feed it. For each of these events NCKRI led a team or focused their efforts on cleaning these waterways.

Jon Davis and Devlin Willingham test the hot water bath setup for decontaminating cave gear.

Raquel Lugo participating in the clean up around NCKRI's headquarters for National Public Lands Day.

NATIONAL PARK SERVICE SUPPORT AND COLLABORATION

As a focal point in resource management and protection of cave and karst resources, NCKRI is funded by the National Park Service to achieve our goals. Effective resource management in karst requires a combination of research, policy, and education/outreach techniques to achieve the broader goals of improving resource protection. To this end, NCKRI has focused on a series of collaborations and support activities with the NPS this year.

Scientists in the Parks Internship

The Scientist in Parks (SIP) program is a joint internship program between the National Park Service, Conservation Legacy's Stewards Individual Placement Program, the Geological Society of America, and the Ecological Society of America. SIP interns work alongside mentors to gain experience, connections and learn valuable skills while helping the NPS achieve their mission. During the months of May - August 2023, SIP interns Anika Baloun, Joseph Hoberg, Jimmy Swift and Abigail Brown conducted summer research as part of Dr. Jones' Geobiology Lab. Through this research internship they developed cave maps, conducted fieldwork, and performed laboratory experiments to characterize cave microbial communities at Capulin Volcano National Monument. They also investigated gypsum precipitates and travertine hot springs in and around Valles Caldera National Preserve. After spending a great summer of research, they presented their findings at the 2023 Geological Society of America Annual Conference in October.

Cover of the Jr. Bat Biologist Activity Book featuring illustrations by Stephanie Ruiz.

NCKRI also mentored science communication SIP intern Raquel Lugo from May 2023 to May 2024. Raquel worked alongside staff to develop weekly social media postings and assisted on various outreach initiatives throughout the year. One of her projects consisted of the creation of the graphics and layout for the Jr. Bat Biologist Activity Book. This book is a collaborative initiative made up of engaging activities for different age ranges. Other projects focused on developing visual graphics for science education such as a GIF that shows one of the ways in which lava tubes form. Her work on science communication was presented at the 2023 Geological Society of America Annual Conference and at the 2024 New Mexico Bureau of Geology Spring Conference.

Several of our most popular national parks are based around caves, and caves and karst are present in many National Parks, Monuments, Preserves, Historic Sites, Parkways, and other NPS sites. Students interested in the SIP program should consider visiting the website below and browse for different opportunities in the National Park System: https://www.nps.gov/subjects/science/scientists-in-parks.htm

Jimmy Swift and Anika Baloun, SIP interns present their research at the Geological Society of America fall meeting in October, 2023.

Cave Week

NCKRI led the organizing committee for Cave Week for the first time in 2024. Since its inception, Cave Week has mostly been driven by the National Park Service. This year we saw 70 different organizations participate in Cave Week, 20 different organizations fell underneath the National Park umbrella and 20 organizations were members of the National Caves Association (NCA). This is an increase from the 18 organizations (16 of them NPS parks) that are known to have participated in 2022. We created a Cave Week logo and branding kit along with social media templates that were shared among Cave Week participants. The url caveweek.org was purchased along with the creation of a Cave Week facebook and instagram page. A Cave Week mailing list was created and several newsletters were sent out with information about webinars, the Cave Week toolkit, communications plan and other updates.

Another way Cave Week resources were distributed was through the National Speleological Society's NSS News, NPS Scientist in Parks' The SIP Scoop, The Caving Podcast, and NCA's Cave Talk both as a podcast and periodical. After Cave Week, a survey was sent out to get feedback on the provided resources, partner needs, and to start tracking metrics.

Only 9 out of 70 different organizations shared their metrics but this is a great starting point to determine Cave Week's reach.

Cave Week knot tying activity held at NCKRI's headquarters.

Mechanism of Reach	Total Reach
Cave Week Webinars	200
Cave Week websites	7,048
Cave Week Facebook	684,388
Cave Week Instagram	58,190
Cave Week in person events at NCKRI	674
IG #caveweek used	733

CARLSBAD COMMUNITY COLLABORATIONS

One of NCKRI's local partners, Inspired by Science, is a 501(c)(3) non-profit organization located in Carlsbad, New Mexico that promotes local and regional STEM education. Founded in 2013 by Deena and Mike Antiporda, the organization coordinates summer STEM camps, workshops, educational table events, and community events for kids and families. This year Inspired by Science held multiple events at the NCKRI headquarters including STEM Night on June 6th, during Cave Week. This event featured cave-related activities where summer camp participants learned about knot tying, echolocation and compass navigation. The activities helped kids foster their critical thinking skills, creativity and excitement towards STEM topics.

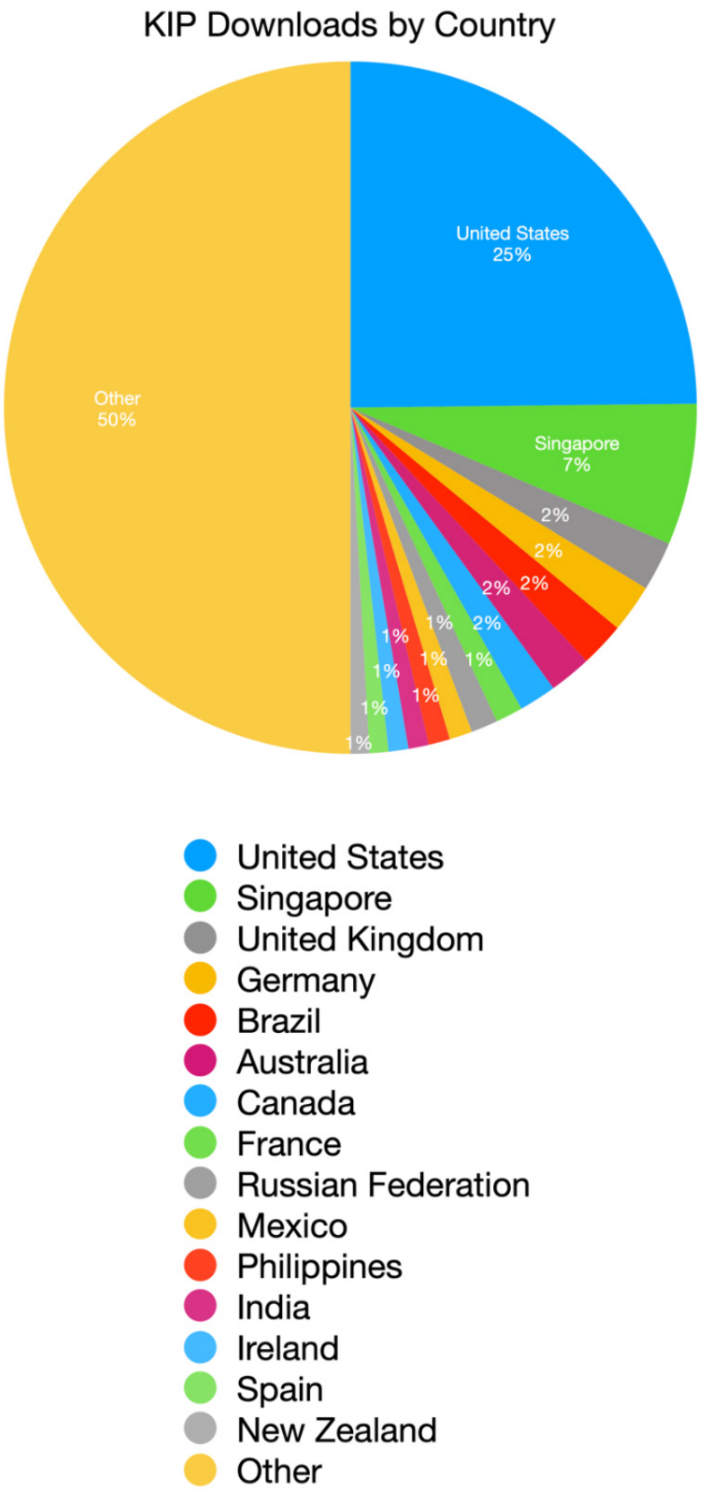
Inspired by Science Solar Eclipse Watch event at NCKRI's headquarters.
Photo courtesy of Inspired by Science

Devra Willingham teaches Inspired by Science participants how to use a compass during Cave Night.
Photo courtesy of Inspired by Science

KARST INFORMATION PORTAL

The Karst Information Portal (KIP) is hosted on the Digital Commons at University of South Florida platform: https://digitalcommons.usf.edu/kip/. The portal serves as a one-stop shop for open, online access to cave and karst research. KIP is a NCKRI project in partnership with the USF Libraries, University of New Mexico, and the International Union of Speleology (UIS). NCKRI volunteers send citations to the USF Libraries team, and the USF Libraries staff do copyright clearance on these items to determine which ones can be posted with full-text and which need to just be citations. Metadata is created for each item, and these are uploaded to the KIP portal. This year, we added 2,482 items to the portal, bringing us to a total of 11,469 in the Portal—a 27% increase over last year, well recovering from last year's decrease after removing duplicate items.

The Karst Information Portal usage is measured through the Digital Commons Dashboard. This year there were 61,916 full text item downloads and 25,351 metadata page hits. Digital Commons has automated their statistics platform to ensure all reported usage is actual use by excluding duplicate loads or probable robot traffic from the numbers. KIP usage is coming from 185 countries, with most of the usage being in the United States, followed by Singapore and the United Kingdom. KIP is truly reaching a worldwide audience! The image below shows the top 15 countries of usage for the Karst Information Portal, with these countries representing 50% of the total usage. Remaining countries are grouped in a category of "other."



PERSONNEL, EVENTS AND PUBLICATIONS

NCKRI Volunteers

Many of our programs and projects rely on the help of our volunteers. We thank the following individuals for supporting NCKRI, most of whom worked on the Decontamination Station at NSS:

- Gretchen Baker
- Phyllis Boneau
- Martha Bryant
- Jenna Crabtree
- Rebecca Gebb
- Maureen Handler
- Chad Harrold
- Forest Hunt
- Walter King
- Deb Lassister
- Zach Normile
- Ryan Palmer
- Mark Skove
- Adia Sovie
- Deanna Steaver
- Ben Tobin
- Janice Tucker
- George Veni
- Michael Jones
- Hunter Klein
- Kevin Liow
- Brandon Kowalis
- Nelia Dunbar
- Nels Iverson
- Matthew Zimmerer
- Bob Osburn
- Rachel Saker
- Dante Fenolio
- James St. John
- Carol Hill

NCKRI STAFF

NCKRI has a small, but growing and excellent staff. Following is a list of our staff during this report period, followed by training programs and publications. Biographies are available on the NCKRI website.

Dr. Benjamin Tobin
Director
Valerie Davis, MBA
Interim Director/Operations Division Director
Dr. Daniel Jones
Academic Director
Dr. Patricia Seiser
Cave and Karst Management Science Director
Dr. Lewis Land (retired December 1, 2023)
Karst Hydrogeologist
Devra Willingham (nee Heyer)
Education Program Manager
Raquel Lugo
Science Communication Intern

Community Involvement

NCKRI is always excited to show community support and stays involved in many ways. We have hosted the monthly meetings of the Pecos Valley Grotto of the National Speleological Society for 13 years on the third Thursday of each month at 7 p.m. Anyone interested in cave exploration and cave research is welcome to attend.

NCKRI also partnered with local cavers and cave management organizations on a variety of projects:

- Partnered with the Carlsbad field office of the Bureau of Land Management and the city of Carlsbad for community clean up events along the Pecos River.
- Participated in the National Speleological Society Southwest Regional Meeting

Continuing Education

NCKRI staff polish and expand their skills whenever possible. Formal training during the past year included:

- *Communication, Product and Experiment Design* (PCOM5006), NMT course part of the MS in Public Engagement. Professor Becci Spruill taken by Devra Willingham.
- *Media Communication and Public Engagement* (PCOM5004), NMT course part of the MS in Public Engagement. Professor Dr. Beth Kramer-Simpson taken by Devra Willingham.

Professional Conferences

NCKRI attended professional conferences during the past year:

- Southwest Regional Meeting, Mckittrick Hill, NM, September 2-3, 2024
- New Mexico Geological Society Fall Field Conference Carlsbad, NM, September 17-20, 2023
- Geological Society of America Fall Meeting in Pittsburgh, PA, October 15-18, 2023
- Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- 2024 Grading Conference (https://www.centerforgradingreform.org/grading-conference/), June 13th – 15th, 2024, Online
- National Speleological Society Convention, Sewanee, TN, July 1-5, 2024

Conferences Organized

- Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.

Conference Sessions Convened

- Karst Sedimentary, Paleoclimate, and Historical Records (Posters) (with Natasha Sekhon) at the Geological Society of America 2023 Fall Meeting in Pittsburgh, PA
- Karst Ecosystems and Biogeochemistry (with Jeanne Sumrall and Natasha Sekhon) at the Geological Society of America 2023 Fall Meeting in

Pittsburgh, PA
- Karst Hazards and Monitoring (Posters) (with Jeanne Sumrall) at the GSA Fall Meeting in Denver, CO.
- Karst Hydrology and Hydrogeology (Posters) (with Natasha Sekhon and Lewis Land) at the Geological Society of America 2023 Fall Meeting in Pittsburgh, PA

NMT Courses taught

Dr. Dan Jones:
- Introduction to Cave Geology (GEOL 289), 3 cr., New Mexico Tech, Fall Semester, 2023
- Earth History (GEOL 206), 4 cr., New Mexico Tech, Spring Semester, 2024
- Environmental Microbiology (BIOL 3043), 3 cr., New Mexico Tech, Spring Semester, 2024
- Environmental Microbiology Lab (BIOL 3043L), 1 cr., New Mexico Tech, Spring Semester, 2024

National Involvement

- NCKRI is an Associated Society of the American Geosciences Institute and the Geological Society of America and meets with those organizations regularly.
- Dr. Pat Seiser represents NCKRI on the Steering Committee for the National Cave and Karst Management Symposium, which is held every two years.
- Devra Heyer is not only NCKRI's Education Program Manager but is also the Education Division Chief of the National Speleological Society, building synergy to better support both organizations.
- NCKRI is an organizational member of the US Fish and Wildlife Service's White-nose Syndrome Stakeholder Committee.
- NCKRI staff serve three major positions in the Geological Society of America's Karst Division: Dr. Lewis Land, Past-Chair; Dr. Daniel Jones, Secretary; Dr. George Veni, Advisor.

NCKRI in the Media

This year, NCKRI was featured in the media in several ways. Devra Heyer (Education Program Manager) was featured in the Cave Talk podcast, about Cave Week 2024. In addition, Devra was selected for Carlsbad's "40 under 40" class by the Carlsbad Current-Argus newspaper. Devra was also interviewed by the Current-Argus for a piece on white-nose syndrome in Carlsbad caves ("White-nose Syndrome in the Area", July 2024 v3 pg 5).

During her time as a Scientist in the Park intern, Raquel Lugo (now a NCKRI Communication Intern) was interviewed on episode 98 of The Caving Podcast about Cave Week. After completing her Scientist in the Park intership, Anika Baloun wrote a piece for the NSS News about her experience, entitled "Exploring Capulin Volcano: National Parks SIP program cave and microbe survey" (NSS News, December 2023).

George Veni, NCKRI's former Executive Director, was interviewed for several pieces about sinkholes and caves, including an article on sinkholes in Central Florida (https://www.dailycommercial.com/story/news/local/2024/12/13/60-foot-wide-hole-by-clermont-dunkin-under-repair-will-there-be-more-in-sinkhole-alley/76944944007/), multiple pieces about a forest discovered in a massive sinkhole in China (e.g., https://www.earth.com/news/giant-sinkhole-found-in-china-contains-an-untouched-ancient-forest/), and caves in Texas (e.g., https://www.texasmonthly.com/travel/extreme-cavers-texas-grottos/).

Specific links and episodes
- Part 1: https://podcasts.apple.com/us/podcast/3-cave-week-2024-special-part-1/id1729445590?i=1000657842363
- Part 2: https://podcasts.apple.com/us/podcast/4-cave-week-2024-special-part-2/id1729445590?i=1000658202326
- The Caving Podcast Episode 98 Mike Drake, Interview about Cave Week: https://www.podomatic.com/podcasts/cavingpodcast/episodes/2024-04-01T00_00_00-07_00
- Meet the Carlsbad 40 Under 40, Class of 2023 (Carlsbad Current-Argus October 26, 2023): https://www.yahoo.com/lifestyle/meet-carlsbad-40-under-40-035755003.html
- Deep—Very, Very, Very Deep—in the Heart of Texas (Texas Monthly, December 2023): https://www.texasmonthly.com/travel/extreme-cavers-texas-grottos/

Refereed Publications and Preprints

- Havlena ZE, Hose LD, DuChene HR, Baker GM, Powell D, Labrado AL, Brunner B, Jones DS (in review at Geobiology). Origin and modern microbial ecology of secondary mineral deposits in Lehman Caves, Great Basin National Park, NV, USA. Geobiology, 22, e12594. https://doi.org/10.1111/gbi.12594
- Hobart KK, Greensky Z, Hernandez K, Feinberg JM, Bailey JV, Jones DS (2023) Microbial communities from weathered outcrops of a sulfide-rich ultramafic intrusion, and implications for mine waste management. Environ Microbiol, 25(12), 3512–3526. https://doi.org/10.1111/1462-2920.16489
- Dora D, Lazaridis G, Vouvalidis K, Tokmakidis K, Veni G. (2024). Cave morphometric

analysis: A review. Progress in Physical Geography: Earth and Environment, 48(4), 615-636. https://doi.org/10.1177/03091333241269199

- Dora D, Lazaridis G, Vouvalidis K, Tokmakidis K, Veni G. (2023). Morphometric Analyses of Greek Caves: How Morphology Predicts Cave Origin. Bulletin of the Geological Society of Greece, 60(1), 14–26. https://doi.org/10.12681/bgsg.34887

Conference Presentations

- Heyer D, Jones DS (2023) *Learn, connect, protect: the National Cave and Karst Research Institute's education and outreach program.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Lugo R, Heyer D, Jones DS, Davis V (2023) *Improving accessibility of cave and karst science: communication and outreach activities aimed at reducing jargon and supporting public stakeholders.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Jones DS, Best M, Mainiero M, Montanari A (2023) *Microbial communities and secondary mineral features in an artificial sulfidic cave stream.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Jones D, Mattaini K, Lenahan M, Gray A, Misra G (2023) *Improving student confidence, comprehension, and communication of primary literature with real-world, authentic science communication stakes.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Havlena Z, Best M, Mainiero M, Recanatini S, Jones D (2023) *Microbial communities inhabiting aging secondary mineral deposits in a former sulfidic stream passage from a moderately thermal cave.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Hoberg J, Baloun A, Swift J, Brown A, Schneider G, Seiser P, Jones DS (2023) *Reconnaissance geobiology survey of a potential mars analogue site, Capulin Volcano National Monument, NM.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Green K, Best MB, Jones DS (2023) *Using high-throughput nifH sequencing to characterize nitrogen-fixing microorganisms in sulfuric acid caves: Implications for nitrogen cycling in subterranean chemosynthetic ecosystems.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Best MB, Wankel SD, Graham HV, Stern JC, Macalady J, Mainiero M, Atudorei N-V, Jones DS (2023) *Isotopic signatures of nitrogen cycling in sulfuric acid caves.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Brown A, Huff C, Swift J, Baloun A, Hoberg J, Jones DS (2023) *Extremely acidophilic microorganisms across pH and temperature gradients in Valles Caldera National Preserve.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Baloun A, Hoberg J, Swift J, Brown A, Schneider G, Seiser P, Jones DS (2023) *Culture-based analysis of cave wall microbial communities from Capulin Volcano National Monument.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Swift J, Brown A, Hoberg J, Baloun A, Jones DS (2023) *Culture-independent analysis of microbial biofilms from travertine hot springs near the Valles Caldera volcanic complex, New Mexico.* Geological Society of America 2023, Pittsburg, PA, October 15-18, 2023.
- Best MB, McLemore, VT, Jones DS (2024) *Molecular assessment of metal-cycling microbial communities associated with critical mineral resources in historic mine waste.* 2024 Society for Mining, Metallurgy & Exploration (SME) Annual Conference & Expo, Phoenix, AZ, February 25-28, 2024.
- Stern JC, Chung AH, Graham HV, Jones DS, Best MB, Havlena Z *(2024) δ15N of Amino Acids in Sulfidic Caves — Preservation of Biological Nitrogen Cycling in an Acidic Mars Analog Environment.* 55th Lunar and Planetary Science Conference, The Woodlands, TX, March 11-15, 2024.
- Jobe NE, Skaar CH, Kieft T, Huff C, Jones DS (2024) *Culture-dependent and -independent analysis of ancient viromes from deep groundwater accessed via Moab Khotsong Mine, South Africa.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Baloun A, Hoberg JR, Swift J, Brown A, Schneider GN, Seiser PE, Jones DS (2024) *Geobiology of small primary and secondary volcanic caves at Capulin Volcano National Monument, NM*. Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Brown A, Huff C, Swift J, Green B, Jones DS (2024) *Extremophilic microorganisms in volcanically-influenced springs in the Valles Caldera National Preserve, Northern New Mexico.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.

- Huff CJ, Green KM, Regberg AB, Graham HV, Dworkin JP, Lalime EN, Congedo AB, Chung AH, Pugel DE, Jones DS (2024) *Microbial bioburden on NASA cleanroom surfaces: cell counting and fluorescence in situ hybridization.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Best MB, Green K, Wankel SD, Graham HV, Stern JC, Macalady J, Mainiero M, Atudorei N-V, Jones DS (2024) *Isotopic signatures of volatized ammonia gas in the Frasassi Caves, Italy, and broader implications for nitrogen cycling in the shallow subsurface.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Hoberg JR, Weber AN, Hargather MJ, Graham HV, Regberg AB, Jones DS (2024) *Evaluating forward contamination using field experiments in planetary analog environments.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Jobe N, Cattaneo J, Monde S, Skaar C, Brown A, Jones D (2024) *Cultivation and analysis of autotrophic, lithotrophic, and organotrophic microorganisms from Cottonwood Cave, NM.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Locke H, Gallegos N, Garcia M, Hensley B, Spence T, Brown A, Jones D (2024) *Isolation and identification of microorganisms from Cottonwood Cave, NM.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Montoya T, Tetrault C, Henderson E, Mackowski K, Brown A, Jones D (2024) *Cottonwood Cave Chronicles: The metabolism of iron, sulfur, nitrite, and anaerobic microorganisms.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Green KM, Brown AR, Havlena ZE, Best MB, Northup DE, Jones DS (2024) *Nitrogen, sulfur, and carbon-cycling capabilities of microbial communities from desert cave systems.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Skaar CH, Huff CJ, Kieft TL, Jones DS (2024) *Characterization of bacteriophages in acidic lakes in Valles Caldera National Preserve.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Havlena ZE, Graham HV, Stern JC, Weiss GM, Chung AH, Mojarro A, Wankel SD, Jones DS (2024) *Utilizing high-throughput DNA sequencing and organic geochemistry to assess microbial colonization and biomarker presence in acidic cave gypsum.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Swift J, Brown A, Baloun A, Hoberg JR, Jones DS (2024) Culture independent analysis of *sulfur-cycling microbial communities from a hydrothermal travertine spring in Northern New Mexico.* Rocky Mountain Geobiology Symposium, Socorro, NM, April 20, 2024.
- Lugo R, Heyer D, Jones DS, Davis V (2024) *Developing accessible visualizations of geophysical and geochemical processes for cave and karst education.* New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Heyer DE, Jones DS (2024) *Learn, Connect, Protect: The National Cave and Karst Research Institute's 2024 education and outreach program.* New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Best MB, Jones DS, McLemore V (2024) *Assessing microbial communities associated with critical minerals in historic mine waste in central New Mexico.* New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Green KM, Brown AR, Havlena ZE, Best MB, Northup DE, Jones DS (2024) *Nitrogen, sulfur, and carbon-cycling capabilities of microbial communities from desert cave systems.* New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Hoberg JR, Baloun A, Swift J, Brown A, Schneider GN, Seiser PE, Jones DS (2024) *Reconnaissance survey of volcanic caves and cave microbial communities at Capulin Volcano National Monument, NM*. New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Minnix SB, Jones DS, Prush V (2024) *Evaluating chemical weathering in a small catchment in New Mexico's Black Range to explore implications for limestone dissolution and regional solution caves*. New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Runyan DM, Heyer D, Lugo R, Jones DS (2024) *Developing accessible resources for education and training in cave science.* New Mexico Geological Society Spring Meeting, Socorro, NM, April 19, 2024.
- Hoberg JR, Weber AN, Hargather MJ, Graham HV, Regberg AB, Jones DS (2024) *Field experiments on forward contamination in planetary analog environments.* Astrobiology Science Conference, Providence, RI, May

Environmental Microbiology students on the hike in to Cottonwood Cave.

5-10, 2024.

- Havlena ZE, Graham HV, Stern JC, Weiss GM, Chung AH, Mojarro A, Wankel SD, Jones DS (2024) *New insights into biosignature preservation in acidic cave gypsum using rRNA analysis, metagenomics, microscopy, and organic geochemistry.* Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- Best MB, Green K, Wankel SD, Graham HV, Stern JC, Macalady J, Mainiero M, Atudorei N-V, Jones DS (2024) *Unusual nitrogen isotopic signatures in the Frasassi Caves, Italy, and implications for subsurface nitrogen cycling.* Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- Jones DS, Mattaini KR, Lenahan M, Gray A, Misra G (2024) *Design, implementation, and evaluation of a real-world science communication activity in undergraduate and graduate science courses.* Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- Jones DS, Best MB, Green K, Rodríguez LC, Mainiero M, Auch B (2024) *Relationship between energy availability and circumneutral wall communities in a subterranean sulfidic karst system.* Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- Stern JC, Chung A, Graham HV, Jones DS, Best MB, Havlena Z, Wankel SD (2024) *Preservation of Biological Nitrogen Cycling Signatures in an Acidic Mars Analog Environment.* Astrobiology Science Conference, Providence, RI, May 5-10, 2024.
- Heyer D. 2024. *Lessons and Successes at the National Speleological Society's Annual Convention Gear Cleaning and Decontamination Station.* White-nose Syndrome Symposium, Online, June 11-13, 2024.
- Havlena ZE, Graham HV, Stern JC, Weiss GM, Chung AH, Mojarro A, Wankel SD, Jones DS (2024) *Leaving no (molecular) trace: insights into microbial inhabitation and biosignature presence in acidic cave gypsum.* Astrobiology Graduate Conference, Ithaca, NY, June 10-14, 2024.
- Willingham D. and Lugo R. 2024. Cave Week: *A chance to celebrate and protect caves!* National Speleological Society Convention, Sewanee, West Virginia

Other Presentations

- D. Jones, *Sulfuric acid caves (and the microbes that make them)*, October 11th, 2024, NMT Faculty Development Seminar Series, New Mexico Tech
- D. Jones, *Sulfuric acid caves and the microbes that make them, or, How microbes made Carlsbad Cavern.* March 13th, 2024, Rotary Club, Socorro, NM

Panel Discussion Participation

D. Jones was a panelist for the presentation Building Support for Alternative Grading: Communities of Practice Beyond the Institution (led by Marney Pratt, Katie Mattaini, & Jayme Dyer), 2024 Grading Conference (https://www.centerforgradingreform.org/grading-conference/), June 13th – 15th, 2024, Online

Guest Lectures

- Multivariate analysis of complex microbial community datasets, (BIOL 5089-01: Statistical Methods in Biology), New Mexico Tech, March 12th, 2024

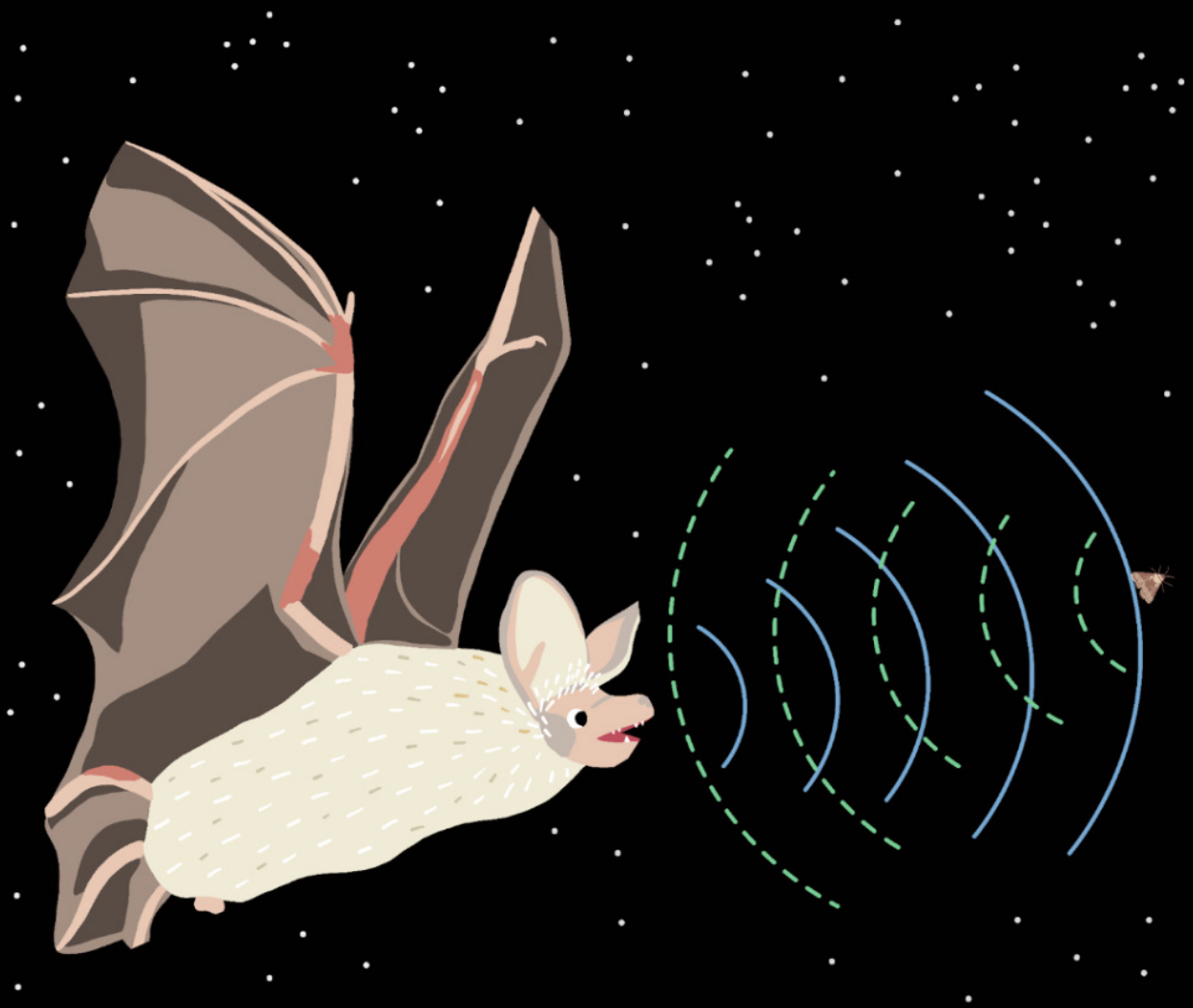
FISCAL REPORTING

FY 2023-24 NCKRI Funding Report			
Revenue Source	**Type**	**FY2023-24 Allocations**	**FY2023-24 Expense**
State of New Mexico	Carry forward	$ 156,156.00	$ 156,156.00
	Current Funding	$ 416,690.00	$ 328,682.00
National Park Service FY22	NPS Carry forward	$ 314,492.00	$ 180,506.00
National Park Service FY23	Current Funding	$ 794,000.00	$ 549,936.68
National Park Service FY24	Funding awarded May 2024	$ 789,000.00	-

During FY 23-24, NCKRI had a series of retirements that led to lower overall expenses during the FY. We look forward to utilizing these carry forward funds to continue to grow NCKRI in the coming years.

Bat counts being conducted at Mckittrick Hill as part of the NSS Southwest Regional Meeting activities.

SIP intern Raquel Lugo participates in cave formation repairs as part of the NSS Southwest Regional Meeting activities.



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