Western Cave Conservancy

Protecting the West's Last Frontier

Vol 19 No 2 Autumn 2026

Measuring CO_2 at Buckeye Root Cave

Alexander Tollman

Volcano Natural Preserve is a piece of karst property that the Western Cave Conservancy (WCC) purchased when it became available in Volcano, CA. It is a large property containing large areas of karst, very interesting hydrological features and a caver-relevant history to it. The property was the site of large-scale hydraulic mining by miners searching for gold about 150 years ago which significantly altered the natural landscape and buried much of the karst with washed-in dirt. What this means, however, is that new sinkholes have been forming and that Volcano is a perfect place to learn how to participate in a project in a low-stakes local environment.

Paul Greaves, the land manager, is very responsive and willing to accommodate permit changes or unique trips to Volcano. Paul has been incredibly open with project work on the property and has told me that there is more project work than he can do in his lifetime so there was no reason for him to gatekeep it. If you want to learn project caving or just are curious about Volcano, definitely reach out to him!

This writeup will mostly focus on Buckeye Root Cave, a 70-ft vertical cave with two entrances and a buckeye tree growing right above the cave. The main room is the Register Room, where the first new CO_2 sensor is located, and behind that is the Moonmilk Room where everything is coated in moonmilk and there are a few pretty stalactites. If you descend past the Register Room and past the knife's edge you will get to a room with a vertical dirt tube. This dirt tube has roots through the top of it, hence the name Buckeye 'Root.' The dirt tube leads down to a stream bed that has water flowing half of the year and a now accessible, beautiful washed marble stream tube.

I originally became interested in this cave because when I first visited it I could hear water flowing down the tube and wanted to go down to it. Our group didn't have enough rope. I thought water flowing at the bottom of a cave was super interesting and hadn't seen that in any other beginner caves I had visited at that point.

Published by the Western Cave Conservancy

P.O. Box 230
Newcastle, CA 95658

Telephone (831) 421-0485
Email mail@westerncaves.org
Web www.westerncaves.org

The Western Cave Conservancy is a California public benefit corporation and is tax-exempt under section 501(c)(3) of the Internal Revenue Code. Contributions to WCC are tax-deductible.

WCC Board of Directors:
Steven Johnson
President

Rafael Langer-Osuna
Vice President / Legal Counsel

Marianne Russo
Secretary

Neil Marchington
Special Projects Director

Mark Bowers
Finance Director / Land Research Director

Mike Spiess
Treasurer

Bruce Rogers
Science Director

CJ McKinley
PR Director

John Tinsley
Stewardship Director

The previous issue for this publication was Vol 19 No 1 Winter 2026.

All newsletter content copyright © 2026 by the Western Cave Conservancy, except for photos, which are used by permission of the original creator.

The Hydrological Picture

Long ago a valley and river channel were filled with volcanic deposits. Over time the river carved new channels but the buried channels still carry ground water. Miners found gold in the old river deposits under all those volcanic flows.

There is a series of sinkholes, both new and expanding old ones that have been observed over the last 50 years, that form a sinuous line beginning at the volcanic deposit/marble contact and lead past Buckeye Root Cave.

Another cave quite near Buckeye Root, called Rusty Pipe, which also has a stream flowing through it. We surveyed this cave to determine the stream elevation and slope and to compare the data against Buckeye Root Cave. The Buckeye Root stream is almost certainly the same stream as the one that flows through Rusty Pipe Cave. If the Buckeye stream connects all these different things, we could have a cave system with multiple entrances that is a kilometer long and potentially could connect to previously undiscovered caves whose surface entrances are plugged by mining debris.

A resurgence that is suspected to connect to the Buckeye stream is also of significant interest. Paul and I want to dig this open because it is very interesting, with flowstone and flowing water during rainstorms, and it too could be human passable. This connection is one of the reasons that John Tinsley, Paul and I want to run a dye trace to see what and is connected and how it is connected. The questions we're trying to answer: are there two hydrological systems (LuLu Bell and Buckeye) or are they connected? Does the Buckeye hydrological system connect the resurgence all the way to these sinkholes?

The Survey

This survey is the second survey I and my two survey helpers (David Allen and Caleb Christiansen) had done. Paul told me that Buckeye Root Cave had not been surveyed yet, which I felt was a perfect cave for learning the process of survey and cartography. I did not realize until we started surveying that Buckeye would be a brain-breaking cave for a beginner sketcher because of the rotating passages, extremely diagonal features and overlapping levels. This cave took us two survey trips to sketch, both about 8 hours with three people. This was our first time using a Bric5 which was super nice and we all liked it better than the analog gear.

Two lessons worth keeping for California vertical caves: use 1in:10ft scale on plan view, and separate levels for caves that overlap. The latter makes it a lot easier to actually view the levels while still showing them all in relation to each other.

The Dig

When we first surveyed Buckeye Root the stream was inaccessible. I put a GoPro on my helmet, wedged myself in as far as I could go and stuck my helmet through to see what was on the other side. What we saw was a body tube that looked like it went! The most time-consuming part of this whole process was removing stream-deposited debris from the stream passage because of the awkward haul situation. This took three total haul sessions so far, and I think there will be one last session needed to remove the last stream cobbles. After the second haul session we were able to stuff David 7 feet into the tube where he could see it went further and around a corner. This is California borehole right there. Soon we will know if it goes (or not)! The upstream direction, which we presume connects to the series of sinkholes, is more constricted but also could be worked on.



California Borehole. Photo: Alexander Tollman

The CO_2 Sensor Network

The origin of the CO_2 sensors is one fateful trip to Dragons Breath (DB) when Anastasiya Razumovska, Felipe Roz Barscevicius and I tried to go immediately after heavy rains to see if we could go into DB. We found an excessive concentration of CO_2 at the first drop so we couldn't go far into the cave. The CO_2 immediately went beyond the maximum reading of 5% that my sensor could read. We did the flame test and saw the flame separate at the hard air-CO_2 boundary. Felipe then offered that this was a safe and

perfect time to learn how my body reacted to high CO_2 . The idea was so that I could tell in the future when I didn't have my CO_2 meter on me. I sat in the CO_2 and the first thing I noticed was that the CO_2 tasted/smelled like pennies at the back of my throat. Within a minute or two my respiratory rate rose and in my conversation with both of them I realized I couldn't finish my sentences because I couldn't really piece words together. Walking away from the cave that day we talked about how amazing it would be to have a live measurement of the CO_2 at varying levels throughout DB and have all the historical data that comes with it so we could find out what factors concentrate or ventilate the CO_2.

Avik Dhupar had done some preliminary digging into what CO_2 sensors were usable for this task, and I then handed Avik's notes over to David who took this project and made it a reality. The sensing project is broken up into three different units: the sensor boxes placed in the cave at points of interest, a surface "hub" unit that collects the sensor data and transmits it over cellular to a server, and the server that receives sensor data over the internet and stores it in a database. The heart of the sensor boxes is the STC-31C by Sensirion, which measures the concentration of CO_2 gas in the air by measuring the thermal conductivity of the air — unlike other CO_2 sensors available, the measured % volume won't drift (much)



Janky Prototype. Photo: Caleb Christiansen

over time or need routine fresh air calibrations, and it can measure very high CO_2 concentrations, up to 25% or higher. The downside is that it's sensitive to air conditions like temperature, humidity and barometric pressure. An Arduino Nano powers and talks to the STC-31C and other sensors over a cat5e cable that carries 12V power and a low-speed CAN communication bus. The controller is a Teensy 4.0 microcontroller and the cellular radio is a Blues IoT Notecard. All of this is for the prototype, and the first real version will have many improvements ranging from deployment to longevity.

A brief aside about why we chose Buckeye Root as the cave for the CO_2 sensing: first of all it is easy to access. Secondly we wanted a cave that actually had a bad air season. Buckeye is perfect for this because it has some peculiar behaviors that I would like to understand — sometimes there is fresh air flowing up into the cave from the stream, sometimes there is fresh air being sucked from the cave down into the stream, and sometimes there is completely stagnant bad air all the way up to the entrance drop.

After a week of this testing we saw a perfect opportunity to go to Volcano and deploy it for real. We drove out on a beautiful Saturday morning to test the equipment. At first we powered up the hub to check cellular service. We then connected the ethernet and ran it into the cave down to where we expected the sensors to go, and soldered the ethernet strands in-cave at the correct lengths of cable. We had an issue where one of the sensors was not communicating, and this turned out to be because it was still in firmware flashing mode rather than being in normal operation. We saw live data that matched reality compared with our separate functioning CO_2 sensors. It was now deployed! Over the next four days, though, we noticed the battery voltage slowly going down. By Thursday midday we placed bets on how long the system would stay alive because the battery was rapidly falling off the voltage cliff. I drove over the next day and fixed the issue, which was simple: the solar panel disconnected itself because I used terrible bullet connectors. I soldered it this time so it won't disconnect. As of August 2nd we had just hit 20,000 ppm and have observed multiple different lead-lag behaviors between the upper and lower sensors.

We've already learned much in the time we've had this deployed. The first is that the temperature dependence of the STC-31C is no joke, and the built-in temperature compensation isn't enough — luckily the temperature of a cave is pretty stable, but it will require changing how we calibrate. This first deployment is also quite janky, cobbled together using breadboards and wire jumpers and dev kits. The next revision will use printed circuit boards that won't spontaneously unplug, can be water resistant, and allow us to reliably and easily make as many units as we want.

Thanks

Thanks to many people, but especially: Paul Greaves, Steven Johnson, Brit Wylie, Ernie Maier, Boof Truchan, Avik Dhupar, Felipe Roz Barscevicius, David, Caleb Christiansen, Matt Free, Matt Hazinski, Amelia Fatykhova, Carl Haken, and Joyce Mok.

Changes in WCC Leadership

Steven Johnson

There have been some changes in WCC leadership over the past year:

- Mark Bowers is stepping down from managing Windeler Cave, and is being replaced by Dave Brumbaugh. Dave Brumbaugh is a 3rd generation caver. His father, Marty, has worked at Penn's Cave since 1979, and still does. Dave became a cave guide there in 2002. Marty's mother was the first female cave guide at that historic show cave, and Dave's wife, Melissa, was the first African American cave guide there – so, caving runs deep in their family! In 2009 Dave and Melissa moved to Vancouver Island to work at Horne Lake Caves Provincial Park - a BC park with astounding vertical caves. After a few years in Canada, they were offered employment at the Caverns of Sonora - one of the most pristinely decorated caves in the world. While there, they visited Carlsbad Caverns National Park and Dave set his eyes on federal employment. They returned to Pennsylvania when Penn's Cave offered Dave a management position - 2015. In 2017 Dave accepted a Park Guide position at Carlsbad Caverns. While there he transitioned from guide to Cave Technician and Safety Officer, was their lead cave rescue technician, member of the survey team and cave restoration team, and served as the Pecos Valley Grotto Chairman. In 2022 Dave and Melissa moved to California to work at Yosemite. Since then he served a 3-year term as an NSS BOG Director, runs the NSS Speleoguest Program, and began contributing to the WCC when Mark Bowers offered to transition Windeler Site Manager duties. Dave is very excited to continue contributing to the beautiful and complex world of speleology.
- Mark Balcom is stepping down as Land Research Director, and Mark Bowers is taking his place. We'd like to thank Mark Balcom for his time and dedication during his term. (By the way... if you have thoughts about a property that the WCC should consider buying/managing, please let Mark Bowers know!)
- Finally, Marianne Russo is stepping down from a long term as Stewardship Director – we'd like to thank her for her tireless work as the Conservancy has expanded over the years. John Tinsley will be taking over her duties.

Grants and Special Projects Update

Neil Marchington

Your support for the Western Cave Conservancy is making a difference and supporting projects to protect caves. We recently funded several grant requests.

CaveSim is an educational cave simulator. This "cave" in a trailer travels around the country to educate caves are how fragile caves are. The "cave" has formations with sensors and over 60 feet of passage. Educational events are held regularly at schools, caver events and other public locations. The Western Cave Conservancy helped to fund a new tow vehicle to keep CaveSim moving to the next spot! Thanks for your support for this incredible project!

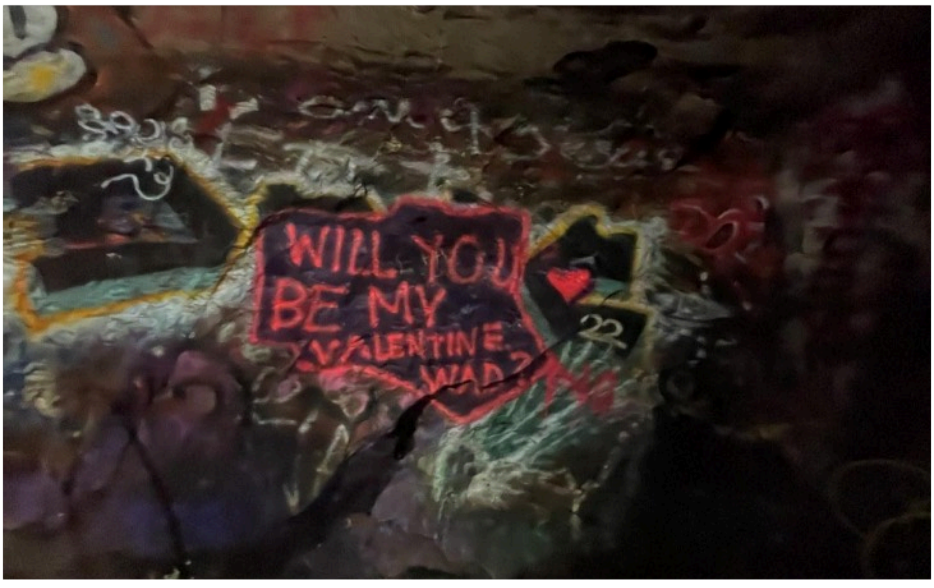
REPAIR is a film in production about Mike Mansur's amazing work fixing broken cave formations in New Mexico. The Western Cave Conservancy approved a grant to help with the editing and sound of the film. This film is expected to air widely educating the public and cavers on the efforts needed to fix formations. Cave softly and thanks for your support!



Sling loads of gear leaving Spence Cave Wyoming after the graffiti removal project. Photo: Aidan Harrington

Western Cave Conservancy continues to help fund the Cave Graffiti Project. We cleaned the graffiti out of Empire Cave, CA in August 2025. We finished an absolutely epic cave graffiti clean-up as Spence Cave Wyoming last year with our partners with Bat Conservation International and the Bureau of Land Management. We used a helicopter to bring the sand blasting equipment to a knife blade ridge below a cave. Many volunteers helped make this amazing project happen! We cleaned all graffiti out of Redmond Caves in Oregon in April. We cleaned up the graffiti in the massive Wind Cave near Bend Oregon at the end of August with help from volunteers from all over the Western US!

Thanks for your continued support and volunteerism! You are making a difference!



This graffiti no longer exists! Photo: Neil Marchington

WCC Preserve Visitation Report

Steven Johnson

Ever wonder about how many trips are taken to WCC Preserves? Well, wonder no more! Here's a summary of the trips and visitor counts from September 2025 through August 2026:

Preserve	*Activity*	*Trips*	*Adults*	*Children*
Mountain Ranch	Catacombs	0	0	0
Peninsula Open Space Trust	Caves	15	92	0
Volcano Natural Preserve	Caves	23	241	5
	Trails/Surface	15	48	0
Volcano Natural Preserve Total		38	289	5
Weller Natural Preserve	Rippled Cave	15	196	28
Windeler Cave	Windeler Cave	3	18	0
Grand Total		**71**	**595**	**33**

As you can see, we're getting a lot of trips – 71 total in the past year. Volcano Preserve has been especially popular (as you can probably guess from another article in this issue), with 38 total trips (including surface-only). On the other hand, Cave of the Catacombs got no visitation at all – it's a small but interesting cave, give it a visit!

We'd like to thank all our members for their generous support in enabling us to provide this level of access to the caving community. We look forward to another year of fun access to the underground!