PHOTO BY STEVEN ALVAREZ

The Future of Karst

A CLIMATE CHANGE ACTION PLAN

Executive Summary

2026

Prepared by the Southeastern Cave Conservancy, Inc. (SCCi)
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SCCi

Who We Are

The Southeastern Cave Conservancy, Inc. (SCCi) protects the worlds beneath our feet and the vital landscapes above them. By preserving 180+ wild caves and nearly 5,000 acres of forest and critical watersheds across the southeastern United States, SCCi ensures these interconnected ecosystems remain climate resilient. When we safeguard karst landscapes, we protect our drinking water, preserve historic artifacts, and provide a sanctuary where endangered species can thrive.

SCCi is a U.S. 501(c)(3) nonprofit conservation organization based in Chattanooga, Tennessee.
Visit www.SaveYourCaves.org for more information.






Why Caves Matter Now

Climate Lifeboats

Caves and karst sinkholes (dolines) function as microrefugia, providing stable microclimates that allow species to survive regional temperature spikes.

Carbon Sequestration

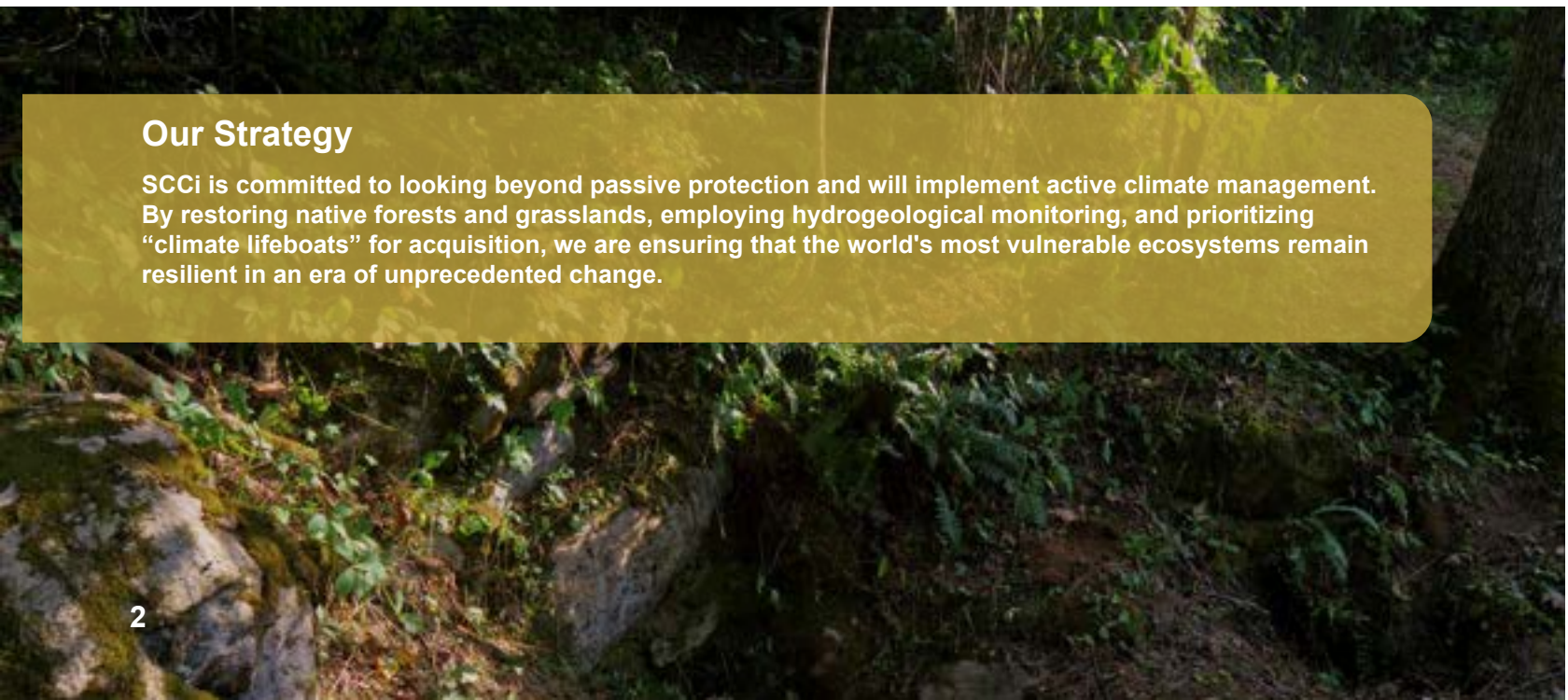
The process of karstification (rock weathering) is a highly stable geological carbon sink, removing carbon from the atmosphere on a ten-thousand-year timescale.

Biodiversity Hotspots

Karst areas are critical "hot spots" for endemic species that evolved in narrow, stable ranges of temperature and humidity.

Exposing the Hidden Frontier of Climate Resiliency

While climate strategies for forests and oceans are common, research has largely ignored the subterranean world. Caves and karst geology underlie 20% of the U.S. landscape and provide essential groundwater for millions. Despite this, research on climate-based management for these ecosystems is nearly non-existent. The Southeastern Cave Conservancy, Inc. (SCCi) hopes this first-of-its-kind Action Plan can begin to bridge this gap.



Our Strategy

SCCi is committed to looking beyond passive protection and will implement active climate management. By restoring native forests and grasslands, employing hydrogeological monitoring, and prioritizing "climate lifeboats" for acquisition, we are ensuring that the world's most vulnerable ecosystems remain resilient in an era of unprecedented change.

I. Surface & Vegetation Management

Restore Primary Cover
Prioritize protection and restoration of native forests and grasslands, as these maximize carbon sequestration and regulate the microclimate of the cave below.

Establish Buffer Zones
Plant deep-rooted native vegetation around impacted sinkholes, swallets, and cave entrances to filter sediment and slow floodwater entry.

Mitigate Deforestation
Work to minimize or eliminate logging and deep excavation on and around all Preserve properties to protect the epikarst—the "natural sponge" that regulates water recharge.

II. Hydrological Integrity

Promote Soil Health
Work with local agricultural partners to encourage no-till or reduced-till practices within the karst watershed to enhance water-holding capacity.

Regulate Runoff
Collaborate with planning authorities to avoid infrastructure that directly or indirectly channels large volumes of water into sinkholes.

Sustainable Extraction
Advocate for groundwater extraction limits that account for climate-driven changes in recharge rates.

III. Biodiversity & Microclimate Protection

Thermal Load Regulation
Monitor cave temperature and humidity. Adaptively regulate human visitation numbers and frequencies to reduce thermal load and carbon dioxide input.

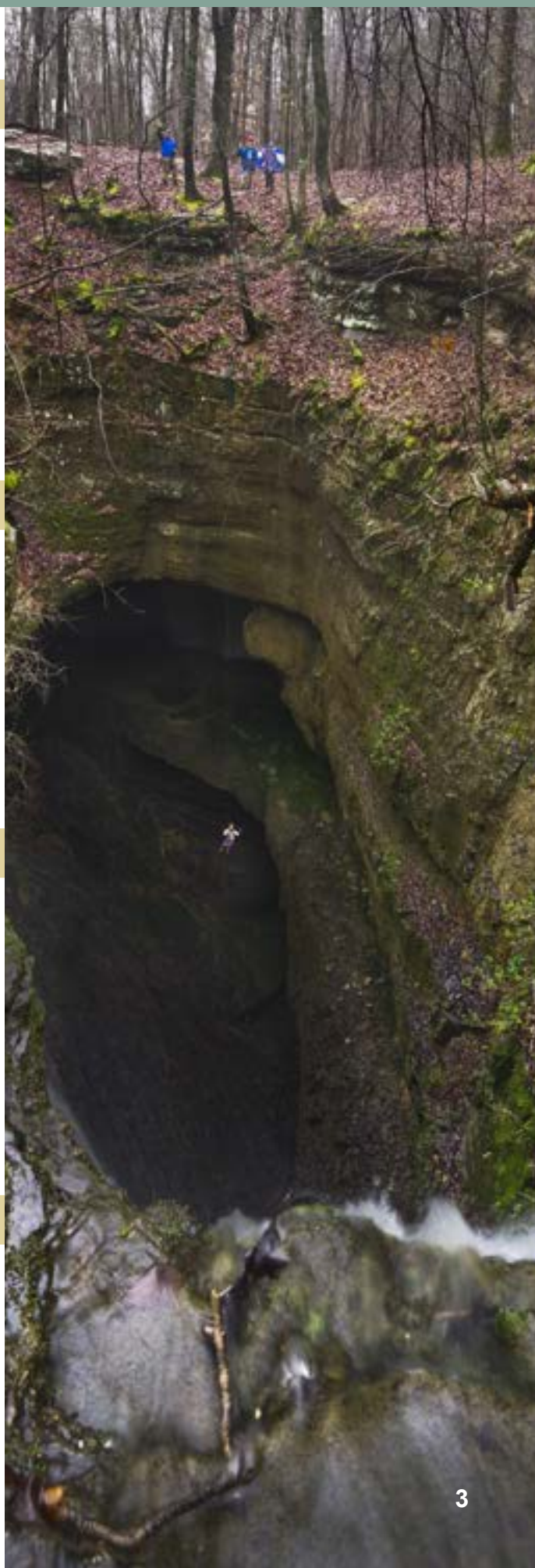
Refugia Prioritization
Identify and protect "climate lifeboats"—sections of caves decoupled from surface temperature spikes.

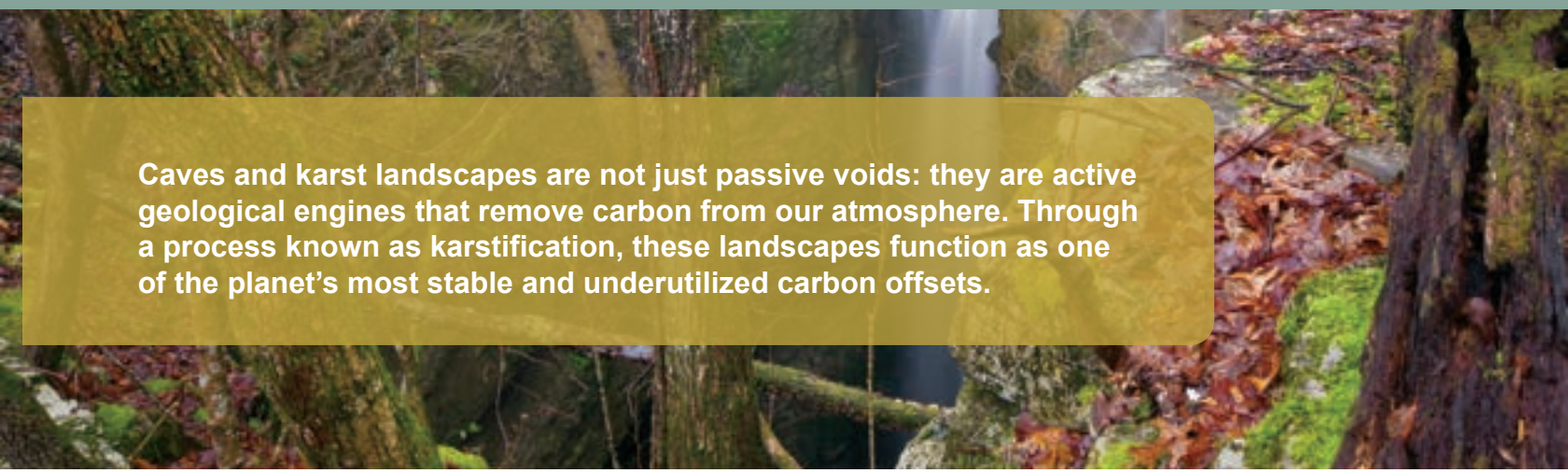
Bat Population Support
Prioritize protection for hibernacula with high microclimate variability, allowing bats (especially those with White-nose Syndrome) to select colder zones to save energy.

IV. Monitoring & Research

Baseline Data
Install long-term monitoring for water quantity, temperature, chemistry, and soil pH.

Biosecurity
Monitor the shift of the "transition zone" at cave entrances to detect and prevent the intrusion of invasive species like fire ants or opportunistic pathogens.





Caves and karst landscapes are not just passive voids: they are active geological engines that remove carbon from our atmosphere. Through a process known as karstification, these landscapes function as one of the planet's most stable and underutilized carbon offsets.

The Mechanism of Sequestration

The Process

Karstification occurs when slightly acidic water flows over and through carbonate rocks, dissolving them and capturing carbon in the process.

The Impact

This chemical weathering is responsible for approximately 94% of the total rock-weathering carbon sink on Earth.

The Timeline

Unlike forests, which can release carbon during fires or decay, karst stores carbon on a 10,000-year timescale, providing long-term geological stability.

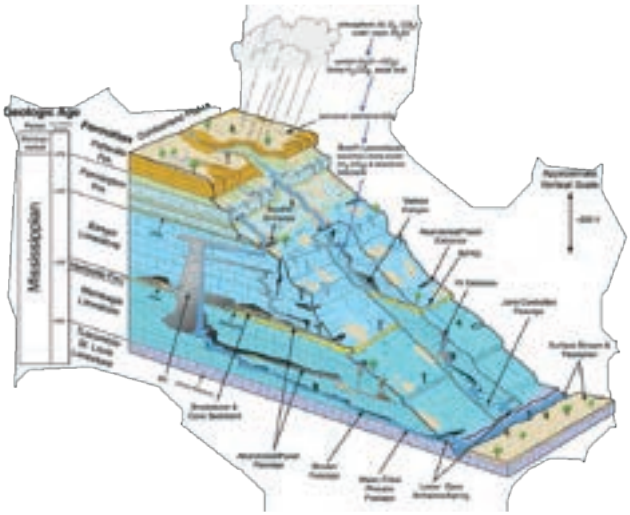


IMAGE AND TEXT BY ROBERT HANDFORD, PHD.

The Role of Biology & Management

Our research shows that the efficiency of this "carbon engine" depends heavily on how we manage the surface:

Microbial Allies

Bacteria like Serratia sp., found in karst ecosystems, can facilitate and even accelerate the karstification process under specific pH and temperature conditions.

The Forest Connection

Carbon sequestration is most effective in primary forests and grasslands. It is significantly less effective in secondary shrublands and at its weakest in croplands.

The Chemical Threat

The application of nitrogen fertilizers can interfere with this natural cycle, decreasing the amount of CO_2 sequestered by carbonate weathering.

Climate Lifeboats

As regional temperatures in the Southeastern continue to rise, many species face an existential threat: their "thermal envelope" is disapearing. However, caves and deep karst features offer a unique solution. They are decoupled from the surface, creating stable environments that act as "Climate Lifeboats."

Management Actions for a Carbon-Capturing Preserve

Soil pH Monitoring

Soil acidity, aiming for a range of pH 7–9 to optimize sequestration.

Ecosystem Restoration

Prioritize the transition of croplands back to native forest or grassland to "recharge" the karst carbon engine.

Fertilizer Advocacy

Work with the agricultural community to eliminate winter nitrogen applications and promote applicator certifications to reduce nutrient pollution.

The Power of Decoupling

The Buffer
Deep cave environments maintain a temperature roughly equal to the mean annual surface temperature. While the surface swings wildly between seasons, the deep cave remains a constant, predictable sanctuary.

Thermal Inversion
Sinkholes (dolines) act as cold-air traps. On hot summer days, dense, cool air pools in these depressions, allowing mountain plants and cool-weather insects to survive hundreds of miles south of their typical range.

Protecting Our Most Vulnerable

Our management must prioritize species that are reaching their "Lethal Limit"

The 25°C Threshold
Some cave-dwelling arthropods (insects and spiders) have a lethal upper temperature limit of just 25°C (77°F). A surface heatwave that penetrates a poorly managed cave entrance can wipe out an entire endemic population in days.

The Bat Paradox
For bats like Myotis sodalis, the cave is a refrigerator. They need specific cold zones to lower their metabolic rate during hibernation. If the cave warms even slightly, bats that use caves will burn through their fat stores too quickly and starve before spring.

MANAGEMENT ACTIONS FOR REFUGIA PRESERVATION

Identify "Cold Spots"

Use high-resolution thermal sensors to map the coolest parts of our caves. These "micro-refugia" are our highest priority for total exclusion zones.

Entrance Integrity

Avoid any modifications to cave entrances (like clearing brush or altering airflow) that could lead to "thermal leakage" into the deep cave zones.

Triage Modeling

We must accept that we cannot save every cave. We will use Anthropogenic Displacement Modeling to focus our limited resources on the caves most likely to remain stable over the next 50 years.

The Science of Proxies

Nature's Rain Gauge
Every layer of a stalagmite acts like a tree ring. By analyzing oxygen and carbon isotopes trapped in the calcite, scientists can reconstruct rainfall patterns and temperature fluctuations dating back hundreds of thousands of years.

The Soil Connection
Speleothems do not only record cave weather; they record the health of the surface. Changes in the organic matter in the stone tell us when the surface above was a lush forest, a grassland, or a barren desert.

The Threat of "Signal Noise"

Climate change does not just threaten caves, it threatens data.

Hydrogeological Disruption
Rapid, extreme flood events (driven by climate change) can "wash out" or contaminate the delicate chemical signals being laid down in new growth of speleothems.

CO_2 Interference
Rising atmospheric carbon dioxide levels can alter the rate of calcite precipitation, effectively "smudging" the record that future scientists will need to understand our current era.

Management Actions for Data Preservation

Minimize Anthropogenic Carbon Dioxide
Limit large group visitation in caves with active research-grade speleothems. Human breath raises carbon dioxide levels, which can temporarily halt the growth of these "climate clocks."

Preserve the Drip
Protect the surface vegetation above known "proxy" caves. The soil and roots act as the filter that ensures the water remains pure for the record.

Coordinate with Researchers
Before installing any infrastructure, identify and protect active research sites to avoid potential harm.

PHOTO BY STEVEN ALVAREZ

Triage and Anthropogenic Displacement Modeling

In a changing climate, we must face a hard biological truth: we cannot save every cave. Success requires triage—the strategic allocation of resources to the landscapes with the highest probability of long-term survival.

The Next Human Migration

Climate change will inevitably drive anthropogenic displacement. As coastal areas and arid regions become less habitable, human populations will shift toward the water-rich, thermally stable landscapes of the Southeast.

The Threat
Increased development pressure on karst watersheds, higher demand for groundwater, and the risk of “recreational over-saturation” as more people discover caves.

The Strategy
We must use predictive modeling to identify which preserves are in the path of “climate-driven sprawl” then move to acquire and protect buffer lands today.

Implementing the Triage Framework

We will categorize our preserves into three management tiers:

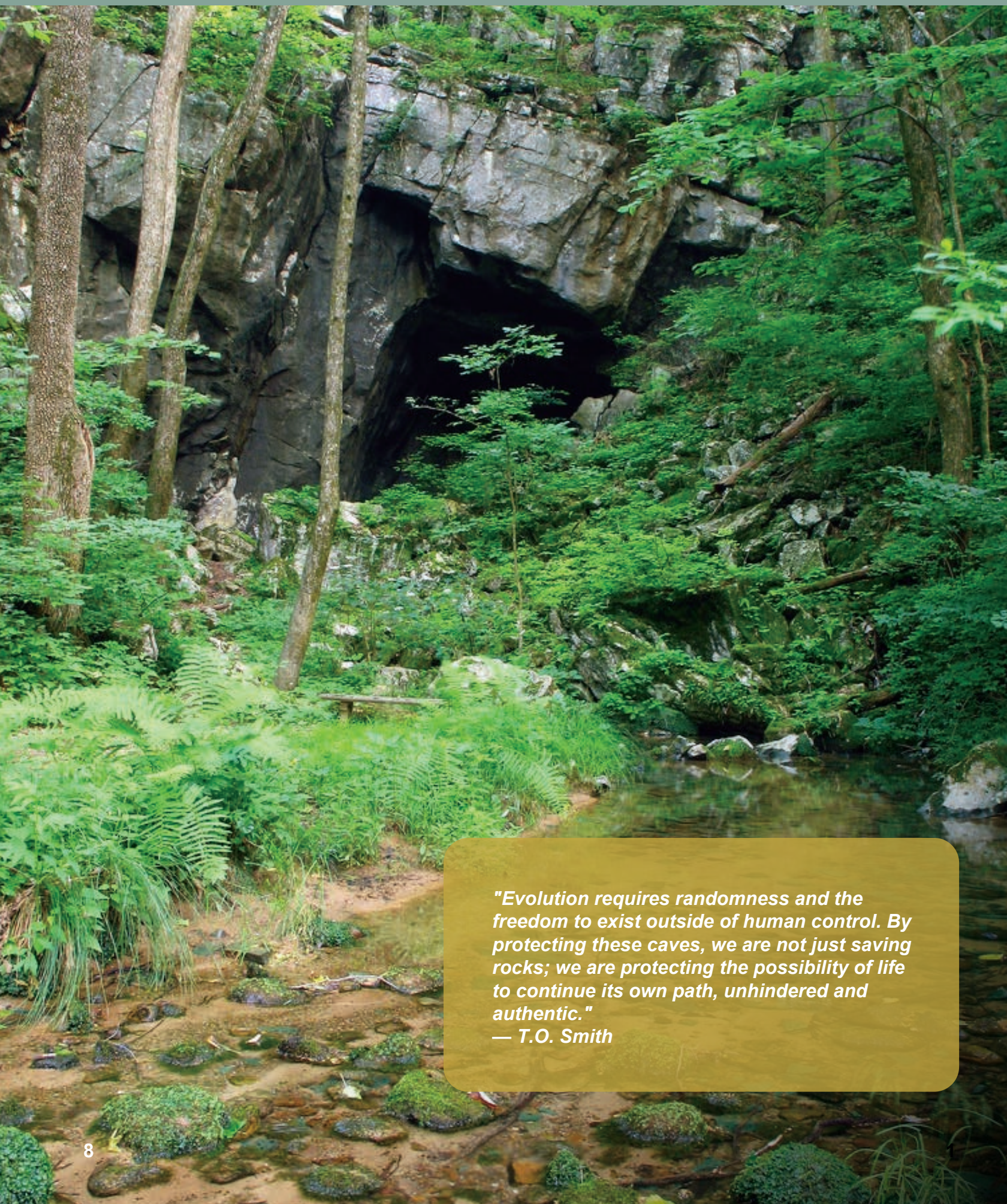
Tier 1
Climate Strongholds - Large, deep systems with high decoupled and healthy surface forests. These are “low disturbance” zones.

Tier 2
Adaptive Reserves - Systems showing moderate climate sensitivity which is manageable through surface restoration such as reforestation.

Tier 3
Educational Sites - Caves already heavily impacted or thermally coupled. These can serve as the primary sites for public engagement and “Climate Impact” education.

PHOTO BY MIKE HOLE

“We do not protect caves for our own curiosity; we protect them because they are the anchors of a resilient planet. By ensuring the ‘wild’ remains wild, we provide a future for the species that have lived in the dark for eons, and we preserve the very engine that cleans our water and breathes our carbon.”



"Evolution requires randomness and the freedom to exist outside of human control. By protecting these caves, we are not just saving rocks; we are protecting the possibility of life to continue its own path, unhindered and authentic."
— T.O. Smith

SCCi Climate Change Action Plan (CCAP)

The complete document is designed for donors, government agencies, partner land trusts, and those in need of guidance for on-the-ground management of caves and karst taking into account climate change. To view SCCi's full length Climate Change Action Plan, please scan the QR Code below:

Scan to view the SCCi's full length
Climate Change Action Plan

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