

The Race Is On

ANNUAL REPORT | FISCAL YEAR 2023



THE MEADOWS CENTER
FOR WATER AND THE ENVIRONMENT

TEXAS STATE UNIVERSITY

MEMBER THE TEXAS STATE UNIVERSITY SYSTEM

Foreword

From our 100-degree days becoming a new summer normal to many cities' dwindling water supplies, the effects of a changing climate are no longer distant forecasts but an undeniable daily reality confronting Texans.

With the theme, "The Race is On," this year's annual report illustrates our proactive strides to provide the science and solutions to prepare Texas for our new climate reality. Throughout these pages, you will learn about our groundbreaking endeavors: from leveraging state-of-the-art 3-D technologies to support freshwater mussel reintroduction in the San Antonio River to catalyzing the climate conversation with one of the state's only climate-focused conferences.

These stories will shine a light on the dedication of our team who, day in and day out, put their best foot forward to preserve, protect, and plan for Texas' environmental future. As we forge ahead, our commitment remains unwavering: to use the power of science, collaboration, and Texas grit to navigate our changing environment and safeguard our state's future.

This is not a sprint but a marathon. The challenges posed by climate change demand sustained effort, long-term planning, and the combined energies of individuals and organizations alike.

Thank you for joining us in this important race. Together, let's make every mile count.

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Dive into the Digital Report

Scan the code with your phone's camera to view a digital version of this report, or visit meadowscenter.txst.edu/about.html#AnnualReports.

About the Cover

Spring Lake hosted the 60th start of the Texas Water Safari, AKA the "World's Toughest Boat Race."

A Message From the Executive Director



As the starting time approached, the teams checked their equipment one last time before systematically moving their canoes into Spring Lake. On that June day, the San Marcos Springs registered the lowest recorded flow since 1956, the result of a third year of drought. But the water was still cool, and spirits were high on what would be an unseasonably warm day and week.

With more than 150 teams, the lake quickly filled with boats and anticipation. Most boats had multiple rowers, with two land-bound team captains driving downstream to provide support as the teams rowed to the gulf. After

a few words from several dignitaries (and an inspired rap about rowing), university president Kelly Dampousse pulled the trigger of the starting gun, and—BANG!—they were off, racing to make it to Seadrift in less than 100 hours.

An event like the Texas Water Safari is an impressive team effort, both in organizing the event and getting down the river quickly and safely. We are also in a race to get Texas ready for a warming climate. That unseasonably warm June was a precursor to a flaming-hot, record-breaking summer, and a relentlessly continuing drought. The summer of 2023 was the warmest on record for the planet, with the highest ocean temperatures ever recorded. With fires, storms, and flooding, 2023 is already the worst year for billion-dollar disasters in the United States. Human-forced climate change is real; it is here, and we need to get ready. Fast.

For water, that means building resilience and planning for droughts worse than we have seen in the past. Increasing temperatures, even with increased rainfall, tend to mean less runoff to our streams, rivers, and lakes and less recharge to our aquifers (and less recharge to our aquifers means less discharge to our streams, rivers, and lakes). It means better understanding our water and environmental resources to help them adapt. It also means educating people about what's happening, what's coming, and what can be done.

Like the Water Safari, it takes teamwork at many levels to prepare Texas for climate change. Our oars are in the water, the starting pistol echoes in our heads, and there are many bends in the river before us. But Texas has no choice: We are rowing this river whether we like it or not. And we are rowing to win. If we want to keep Texas, Texas—we do not have a choice.

Your friend in water and the environment,

A handwritten signature in red ink, consisting of a stylized 'R' and 'M'.

Dr. Robert E. Mace





HABITAT FIELD CREW STUDENTS DURING A LITTER COLLECTION WORK DAY ON THE SAN MARCOS RIVER.



MEADOWS CENTER STAFF CELEBRATED TEXAS' FIRST WILDLIFE DOCUMENTARY, DEEP IN THE HEART, WITH A ROOFTOP MOVIE NIGHT AT SPRING LAKE HALL. THE FILM FEATURED THE SAN MARCOS SPRINGS.

Our Mission

The Meadows Center for Water and the Environment is committed to inspiring research, innovation and leadership that ensures clean, abundant water for the environment and all humanity.

We envision a world where all people understand and embrace the value of water and environmental stewardship.

We fulfill our mission by integrating activities across four pillars of action: research, leadership, education, and stewardship. Our work in each of these pillars begins at Spring Lake – one of the largest artesian springs in the world – and ripples outward across Texas and beyond.



RESEARCH

Conducting Solutions-focused Research



EDUCATION

Encouraging Life-long Learning



LEADERSHIP

Transforming Knowledge into Action



STEWARDSHIP

Cultivating a Stewardship Ethic



MEADOWS CENTER DIVE ASSISTANT, LISA FIELDS, HELPS THE EDWARDS AQUIFER AUTHORITY COLLECT SAMPLES AT SPRING LAKE.

2022-2023 Victory Lap: Our Year in Numbers

\$4,345,384

research dollars awarded to Meadows Center faculty and staff

14,578 m²

non-native plant species removed from Spring Lake and the San Marcos River

97,679

total visitors to Spring Lake

\$326,776

donations raised to support the Meadows Center mission

7,712

native plant species planted in Spring Lake and the San Marcos River

24,846

children and university students engaged in outdoor learning at Spring Lake

24

research grants awarded to Meadows Center faculty and staff

8,047

volunteer hours dedicated to conservation

614

new community scientists trained to monitor water quality across Texas

143

Texas State University students supported by our research and education projects

5,384

people reached through speaker engagements in Texas and beyond

222

volunteer divers trained to help preserve the habitats of Spring Lake



Setting the Pace: Program Highlights

The Meadows Center for Water and the Environment is committed to inspiring research, innovation and leadership that ensures clean, abundant water for the environment and all humanity.

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Running the Rapids

Texas' Relay Race to Climate Resilience

Texas is in a climate crisis

The evidence is overwhelming: temperatures are soaring, droughts are intensifying, and extreme weather is becoming more frequent. Yet, our state remains ill-equipped to tackle the profound implications of climate change on our environment, economy, and public health.

At the Meadows Center, we are not just observing these changes – we are acting. Our Climate Science program is paving the way, empowering Texans with the

tools and knowledge to face the future. Through education, applied science, and comprehensive policy analysis, we aim to equip communities to thrive amidst these challenges.

Our efforts were bolstered by a \$2 million federal grant and the appointment of our new Climate Science Director, Dr. Mona Wells. This year, under her leadership, we have taken significant steps in assisting communities throughout Texas to anticipate, plan for, and adapt to an evolving climate.

Exploring Regional Attitudes Towards Climate and Water Policy

Policy-making is, by design, a culturally influenced process. However, researchers tend to classify the culture of stakeholders, including policymakers, decision-makers, and communities, based on assumptions rather than thoroughly investigating the cultural choices of those being studied. This can lead to a lack of participation from specific groups, creating data gaps that could be used to aid in building resiliency for water resources. Understanding the approach of those at the helm of Texas' water resource decisions is critical. Are they accounting for climate change or focusing on resiliency and mitigation?

The Meadows Center is researching the attitudes and actions on climate change by water resource decision makers to gain insight into how members and leaders of these organizations perceive climate change and its possible impact on water in Texas. This is the first-ever study of its kind in Texas and one of the earliest worldwide. Our

focus includes two primary paths—one for those who acknowledge climate change and one for those who do not. Interestingly, early findings suggest that even those skeptical about climate change **are concerned** about the resilience of their water resources and seek assistance, including engagement with similar organizations, local governments, and the public, when making water management decisions that advance water resiliency.

“Those that do not recognize climate change can still express concern with the resiliency of the water resources under their care. This study shows us there are communication pathways we can further investigate to support adjustments in strategies to help stakeholders actively engage their communities, similar organizations, and the state in the pursuit of more resilient water resources,” said Andrew Adams, Meadows Center Climate Science Program Associate.

We are also conducting a historical policy analysis of passed and proposed state water planning legislation dating back to the 1960s to explore the integration of climate change into the policy landscape by examining the language and opportunities presented over time. A promising trend that has already emerged is that climate change has historically been included in state water planning and proposed legislation, but there are periods where it is not mentioned, only to re-emerge later with different phrasing.

The outcome of this research includes a blueprint for enhanced communication for scientists and policy makers and, in turn, a foundation for building more informed, resilient water policies in Texas.





CANYON LAKE BROKE ITS LOWEST WATER LEVEL RECORD THIS SUMMER.



THE DRY CONDITIONS RESULTED IN MORE THAN 1,000 WILDFIRES BURNING ROUGHLY 120,000 ACRES SO FAR THIS YEAR, ACCORDING TO THE TEXAS A&M FOREST SERVICE.



Texas suffered through one of its hottest, driest summers on record this year, leading to wildfires and record low levels in lakes and reservoirs across the state.

Decoding Texas Climate: A Tailored Approach

Texas is a complex state, and its varied landscapes mean that there is not a one-size-fits-all solution for predicting its climate. As global climate models evolve, providing a broader view of how rising temperatures might change our world, the nuances of Texas weather still require a closer lens.

The modern global climate models, enhanced by satellite and oceanic data, paint a more distinct macro picture of our changing climate. Yet, for Texans, it is the micro that matters: how do these overarching models translate to the specific conditions of the Lone Star State? This is determined using a technique called downscaling,

which can zoom the insights gleaned from global models into our backyards.

This year, the Meadows Center enlisted the help of Texas' State Climatologist, Dr. John Nielsen-Gammon, to provide recommendations for adapting global models to our state's unique setting. When studying extremes, the chosen method can hugely influence results. So, for a clearer picture, Dr. Nielsen-Gammon suggests it is best to use custom dynamical downscaling that incorporates multiple methods, factoring in everything from our diverse landscapes to our specific weather patterns.

With a recommended path forward now in hand, we will begin building downscaled models specific to Texas.

When complete, these specialized models will use custom simulations that pay special attention to Texas' unique environments and better predict issues like water supply. So, while the future will remain uncertain, Texans will be better equipped to understand and prepare for the changes ahead.

Equipped with innovation, the right tools, and a dash of Texas tenacity, 2023 was the first lap of the race to develop the state's first-of-its-kind localized climate models.

Climate Science: The Good, The Bad, and The Wicked Conference

The Meadows Center hosted the “Climate Science: The Good, The Bad, and The Wicked” conference on September 7, 2023, bringing together 300+ leaders from across the state to explore the lesser-known aspects of the complex, “wicked” climate problems facing Texas and the unique challenges and opportunities the state faces in the fight against climate change.

Through thought-provoking sessions, the event aimed to

bridge differences in thought and perspective to forge a common understanding of the challenges we face and empowered attendees to take meaningful action towards a resilient future.

Keynote speaker Michael E. Mann, a renowned climate scientist, science communicator, book author and distinguished professor, opened the event, sharing how lessons from Earth’s past can help pave the way for navigating our climate crisis.

Sessions following the keynote address featured a diverse mix of industry leaders sharing insights on environmental interventions, policy formation, and ways to foster further interdisciplinary collaborations.

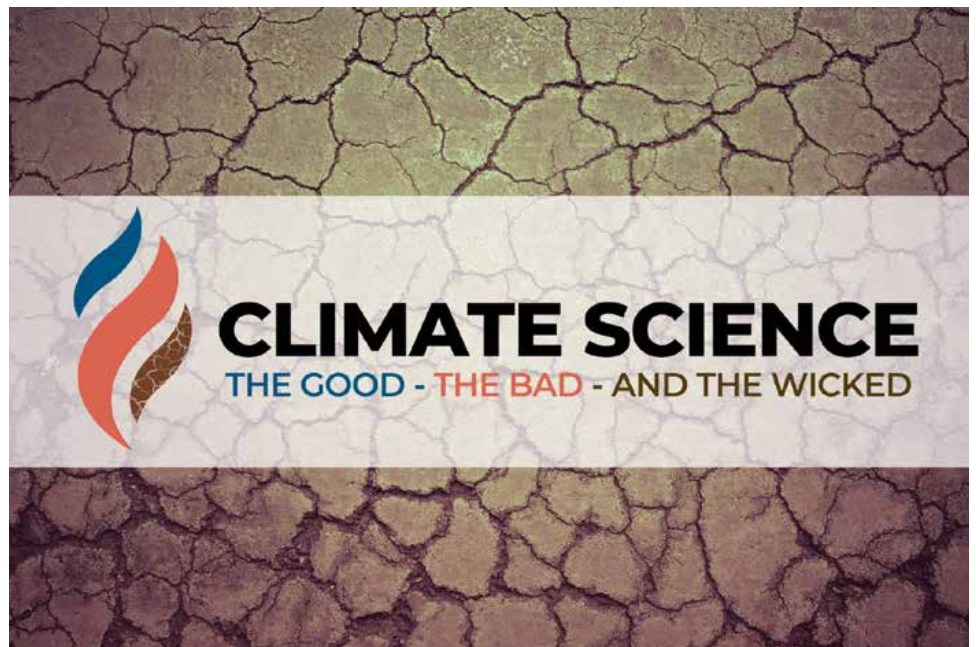
A special thank you to all of our sponsors who helped make the event possible, especially our Presenting Sponsors, Lyda Hill Philanthropies and The Meadows Foundation.



CONFERENCE ATTENDEES DURING THE MORNING SESSION.



MEADOWS CENTER FOUNDER, DR. ANDREW SANSOM, WITH TEXAS STATE PRESIDENT KELLY DAMPHOUSSE.



Taking the Lead: The Surprising Influence of Barton and Onion Creeks on the Colorado River

Our water experts are often called upon by local communities to help them understand the complexities of groundwater and surface water interactions that characterizes our state's water resources.

This year, our research led us to uncover how two small spring-fed streams, Barton and Onion Creeks, are playing an important role in keeping the lower Colorado River flowing for Central Texas and its downstream users.

The City of Austin is almost entirely reliant on the Colorado River and its system of dammed reservoirs for water. In years of severe drought, when flow in the Colorado River upstream of Lake Buchanan ceases, tributary flows from local rivers and creeks are likely the only contributors to the river. This is a huge concern for Austin.

As the river basin experiences pressures that jeopardize its supplies, identifying the most advantageous lands to protect with watersheds that contribute the most water is a top priority. To support efficient and effective resource allocation decisions to preserve contributing watersheds, researchers from the Meadows Center completed a study to quantify the relative flow contributions from the Pedernales River, Onion Creek, and Barton Creek watersheds to the Colorado River.

Wading through decades of daily discharge data provided by the U.S. Geological Survey, our findings were remarkable: **on a per-acre basis, an average acre of land conserved in the watersheds of Barton and Onion creeks contributed a substantial amount of flow to the Colorado River—twice as much, in fact, as the Pedernales River watershed.**

Although the Pedernales River experiences larger flood flows due to its larger catchment area, it contributes no water to the Colorado River 5.3% of the time. In contrast, Barton Creek consistently provides flow, even during the drought of record, thanks to groundwater flows from Barton Springs.

In a world where every drop of water holds immeasurable value, this study provides valuable insights to support and inform decisions that ensure a reliable water supply for the region's future. Yet, the significance of the findings extends beyond its scientific value — serving as a reminder that even the humblest of creeks can hold the power to sustain mighty rivers and that groundwater and surface water are inextricably linked.



BARTON CREEK AT ZILKER METROPOLITAN PARK
IN AUSTIN. ©TRONG NGUYEN

Full Throttle on Education:

Shaping Tomorrow's Conservation Champions

In the words of our Chief Education Officer, Dr. Rob Dussler, "Mindful engagement is a conduit for preparing and cultivating the next generation of environmental stewards. Without felt, personally relevant, and meaningful experiences in nature, the likelihood of a strong commitment to environmental stewardship and advocacy diminishes."

This philosophy is at the heart of our educational programming at Spring Lake. With over 120,000 annual visitors, our goal is not just education but fostering a meaningful bond with nature that inspires responsible stewardship of our precious natural resources. After a challenging period marked by COVID-19 closures, our educational programming has not only seen a 40 percent increase

in attendance but curriculum enhancements and our newly launched specialty programs have received an overwhelmingly positive response from visitors.

Our vision comes to life thanks to a dedicated team of more than 50 Texas State students who serve as environmental interpreters. This year, we made considerable improvements to our interpreter training. Upgraded materials and a refined approach empower our interpreters to help visitors create memorable connections with Spring Lake and its thriving ecosystem. We also integrated mindfulness principles to train interpreters to be thoughtful observers of the park and their field trip participants so that even the subtlest of curiosities can become the foundation of a shared experience.

In step with our commitment to ignite the climate change conversation in Texas schools, we launched the Climate Explorers Program, designed for students in grades 3-8. During the program, students delve into a series of immersive demonstrations to visualize the ripple effects of climate change: a heat capacity demonstration reveals how climate change affects our oceans and weather patterns, while the rainfall simulator emphasizes the pivotal role of land stewardship in water conservation efforts. The program culminates with a discussion on the implications of climate change in a broader environmental context.

We are also working to make Spring Lake a living laboratory for teaching methods to expand our educational reach far beyond



CLIMATE EXPLORERS PIONEERS IN THE WILD TOUR.



the headwaters. Working with the Texas State Department of Curriculum and Instruction, we are building an Environmental Science and Sustainability module into the STEM for Early Childhood Education course. Texas State students enrolled in this course will learn to facilitate nature experiences and its application to the public school structure. Then, they will develop environmental science activities to demo at the

Meadows Center as a service-learning project. Last year, these students led hands-on science lessons at our Earth Day San Marcos Festival as part of their service-learning project. This year, thanks to funding from H-E-B, we can take this course a step further by offering free field trips to 3rd-grade classes in San Marcos public schools. Texas State students enrolled in this semester's course will implement their science lesson

with San Marcos 3rd graders during their H-E-B-sponsored field trip.

The Meadows Center is committed to cultivating a generation that not only understands the importance of our natural resources but is also fiercely committed to its preservation. With our continued improvements, we are confident that the seeds of environmental stewardship planted at Spring Lake today will blossom for generations to come.

Celebrating H-E-B: A Partnership Going the Distance

The Meadows Center's ongoing partnership with H-E-B has enabled our team to increase access to the San Marcos Springs for school children, families, veterans, and underserved members of our community. Here's a snapshot of the splashes we made this year through their unwavering support:

Access For All: We are committed to updating our infrastructure (some of which is over 100 years old!) to ensure that every experience we offer is accessible to people of all abilities. This year, H-E-B funding helped us improve the access to our boat docks, making the experience safer and more accessible for visitors.

Salute to Our Heroes: We welcomed active military, veterans, and their families as the first visitors to explore Spring Lake by stand-up paddle board through free tours held throughout 2022. Plus, veterans and active-duty military now enjoy expanded discounts on all tours.

Celebrating Earth With a Splash: The 10th Annual Earth Day San Marcos Festival was a resounding success, providing a day of entertainment through hands-on activities, live performances, and 30+ eco-friendly exhibitors. This year included new features, like free glass-bottom boat rides and giveaways.

Nature For All: We continued our Title 1 initiative to provide free field trips to 3rd-grade San Marcos Independent School District students, ensuring that all children, regardless of socioeconomic status, can discover and connect with nature.

Family Fun Reloaded: Thanks to H-E-B, our monthly Family Fun Days made a triumphant return this year, providing free experiences to children and families within our local community that foster a connection with the natural world. Each event aligns with a scientific theme, such as conservation and watershed sustainability.



Sustainable Stormwater Management Track: Clean Coast Texas Teams Up With Coastal Communities

The Texas coast faces numerous water challenges: increased flooding, habitat loss, water quality issues, and the threat of natural disasters, to name a few. But amidst these difficulties, resilient communities are rising to the challenge, determined to protect their coastal treasures.

Leading the charge is the Clean Coast Texas Collaborative, an initiative born from and led by the Texas General Land Office's Texas Coastal Nonpoint Source Pollution Program and coordinated by the Meadows Center in collaboration with Texas A&M AgriLife, Texas Community Watershed Partners, Texas Sea Grant, Doucet & Associates, and Anchor QEA.

Launched in 2021, the program spent its first two years solidifying partnerships by conducting a coastwide survey to find which coastal communities had the greatest need for their services. Now in Year 3, Clean Coast Texas has selected an initial group of four partner communities to receive its support and services, including the City of Rockport, the Town of Fulton, Aransas County, and the Aransas County Navigation District.

Clean Coast Texas is more than just an initiative; it is a lifeline for coastal communities. The Collaborative stands shoulder to shoulder with these partner communities, offering technical support, practical solutions, and, ultimately, implementing tangible solutions for their unique challenges. Together, they tackle local issues head-on, guided by a toolkit of expertise and resources.

Green Stormwater Infrastructure Projects

Working with the City of Rockport and the Aransas County Navigation District, Clean Coast Texas is designing four demonstration-scale green stormwater infrastructure projects to educate the Rockport community and its visitors about alternative solutions for water quality improvements and flooding reduction.

After scouring Rockport to find the best spots to host these projects, considering parameters such as topography, soil type, proximity to pervious surfaces, and visibility, the Collaborative initiated four demonstration-scale projects, including a rainwater harvesting system, permeable parking lots, and a rain garden. Each project incorporates educational signage to capture the curiosity of passers-by and promote sustainable design. Construction is scheduled to begin in Year 4.

Ordinance Assistance

We are working to ensure the success of these partnerships by emphasizing community-driven planning and setting achievable goals. We host regular planning meetings with partners and help each partner community identify



Our hope is that, in a decade, these practices are not labeled as ‘new’ but recognized as the standard for Texas coastal communities.

DR. CHRISTINA LOPEZ, COASTAL COORDINATOR

common goals and opportunities for smart growth. Each interaction is guided by the principles outlined in the program’s Guidance for Sustainable Stormwater Drainage on the Texas Coast: For Nonpoint Source Pollution and Flood Management Manual, which promotes a green infrastructure-based approach to natural resource protection. By implementing these practices, communities can preserve the unique coastal resources from the negative impacts sometimes associated with land development and the resulting pollution. At the same time, strategies recommended by Clean Coast Texas promote more resilient designs that manage long-term costs while still promoting tourism, recreation, and economic development.

The manual also contains a model ordinance that serves as a blueprint for communities looking to incorporate stormwater management best practices into their local government regulations.

An ordinance is a law passed by a local political subdivision, such as a city, county, village, or town, and can play a crucial role in shaping the day-to-day life within a community.

This year, the Collaborative developed an ordinance evaluation, comparing ordinances between partner communities to better understand the changes needed to ensure adequate resource protection. As we step into Year 4, the Collaborative will focus on adopting ordinances that protect and improve their local water quality.

Looking Forward

Clean Coast Texas has much in store for in the years ahead. As we work to complete these first on-the-ground demonstration projects, we will continue establishing new partnerships and expanding educational opportunities to empower coastal communities to take control of their future.



STAKEHOLDERS DISCUSS GREEN INFRASTRUCTURE OPPORTUNITIES.

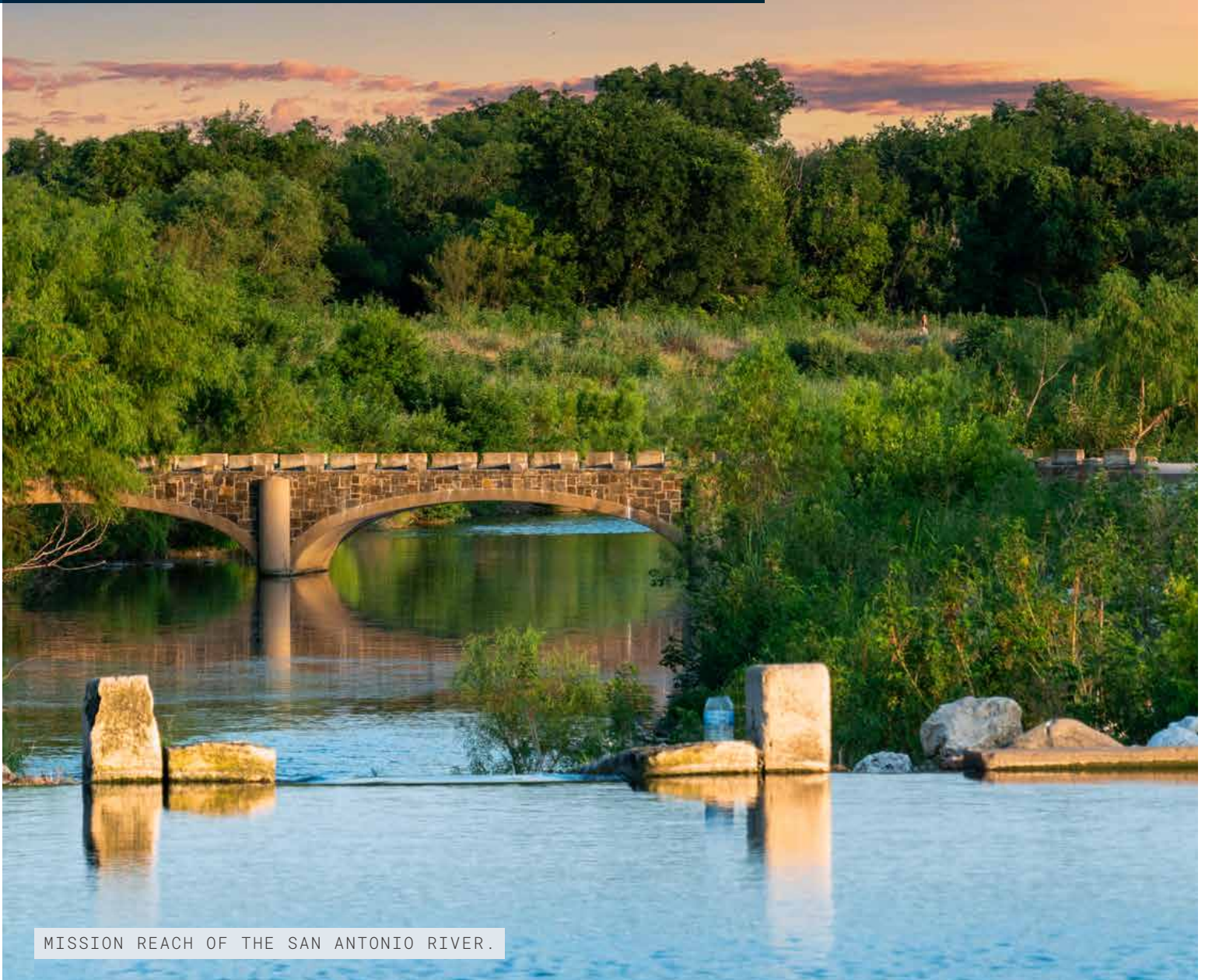


CLEAN COAST TEXAS WITH ITS COMMUNITY PARTNERS.

Ready, Set, Innovate! Artificial Mussels, Real Solutions for the San Antonio River

In the heart of the San Antonio River, just downstream of downtown San Antonio's hustle and bustle, lies an 8-mile stretch known as the Mission Reach. This area, having felt the embrace of a \$384 million restoration project, now brims with renewed vitality and serves as a shining example of an urbanized ecosystem.

However, this was not always the case. Channelized in the 1920s-1960s to assist in flood mitigation, the river's faster moving water scoured the river of native vegetation and changed river features and the wildlife habitats of the San Antonio River.



MISSION REACH OF THE SAN ANTONIO RIVER.



COLLECTING, TAGGING, DEPLOYING
AND TRACKING LIVE MUSSELS.



COLLECTING BATHYMETRY DATA ON THE SAN ANTONIO RIVER.

In partnership with the San Antonio River Authority (River Authority) and local leaders, the U.S. Army Corps of Engineers initiated a Ecosystem Restoration and Recreation Project in 2006 to restore the natural state of the Mission Reach. The project was successfully completed in 2013, adding hundreds of acres of riparian woodland vegetation and constructed aquatic habitat features to enhance ecological functions and provide better habitats for the area's native species.

The river's restoration efforts proved successful, leading to the revival of native wildlife and plant species that had previously thrived in the ecosystem. A few populations of native freshwater mussels also made a comeback. Although they are small, their contribution is significant. Freshwater mussels are exceptional creatures that play a vital role in improving water quality. They consume water through their gills, filtering out bacteria and pollutants like a living water purifier, processing as much as a bathtub's worth of water every day.

Recognizing their irreplaceable role, the River Authority is working to

reintroduce four native freshwater mussel species to the river and provide them with a home where they can thrive. But it is not as simple as just placing them back into the water. The habitat has to be just right. To ensure success, the River Authority enlisted a team of researchers, including the Meadows Center's Habitat Field Crew, to study the preferred homes of these species: Pimpleback (*Cyclonaias pustulosa*), Yellow Sandshell (*Lampsilis teres*), Pistolgrip (*Tritogonia verrucosa*), and Threeridge (*Amblesma plicata*).

Our Habitat Field Crew, working together with the Texas State Biology Department, Utah State University, Texas Parks and Wildlife, Texas A&M University, and the U.S. Army Corps of Engineers, collected data to decipher the physical factors, like water flow, sediment, and channel shape, that influence the living conditions of the four mussel species. The team investigated three size categories, juvenile, subadult, and adult, in order to account for the important life stages of each species. The data collected was then used to develop models to identify the optimal habitats for these mussels to survive in.

However, the work did not stop there. Given the rarity of young mussels, the team employed cutting-edge 3D technology. Using scanned mussel shells, they printed 3D replicas, accurately mimicking the real ones, even down to their weight. These faux mussels, embedded with tracking devices, act as proxies, helping to trace movement and optimal habitats.

Initial trials used only artificial mussels that were tracked throughout a season before being collected. Once initial assessments identified stable, suitable habitats, live mussels were introduced alongside the artificial mussels to assess how the natural behaviors of mussels might change the predictive patterns of the artificial mussels.

After rigorous trials, the researchers identified several promising habitats. And if all goes as planned, the River Authority is poised to introduce a new generation of mussels within the areas identified as stable, suitable habitat from this study, marking another chapter in the river's inspiring story of rejuvenation.

Revved-Up Research: Race to Uncover

Bacterial Hotspots and Origins in Cypress Creek

Winding through the heart of Wimberley, Cypress Creek is a beloved oasis cherished by locals and visitors alike. On a warm summer day, one often finds kids splashing, families picnicking, and nature lovers soaking in the scenery. But amidst this idyllic scene, a hidden menace lurks.

In the last decade, a concerning phenomenon has surfaced – elevated *E. coli* levels. In the lower reach of Cypress Creek (a one mile stretch from its confluence with the Blanco River to Wimberley Town Square) *E. coli* levels are above the water quality standard for contact recreation use, but the exact source of this bacterial pollution remains a murky mystery.

E. coli are bacteria found naturally in the environment, food, and intestines of people and animals. Some strains of *E. coli* can cause adverse human health effects, but high levels of the bacteria can indicate the presence of other harmful pathogens or disease-causing microorganisms in the water due to fecal contamination.

Determined to meet this challenge and backed by generous contributions from the Way Family Foundation, researchers at the Meadows Center set out to reveal the sources of *E. coli* pollution through a detailed 19-month monitoring study. The team collected data that spanned both time and space to identify high-

concentration zones and help trace potential sources of bacteria. Our researchers developed a novel way to screen for human waste in the water using ‘tampling’ (tampon sampling) methods to find the presence of optical brighteners – chemicals found in things like laundry detergent and toilet paper – in the water. We also used fluorometry, a method that measures light, alongside *E. coli* bacteria counts to discern indicators of sewage contamination from on-site septic systems.

The revealing narrative of the creek unfolded as data points painted a clearer picture, suggesting the pollution originates from a combination of sources: rainwater runoff, bat guano, and sewage contamination from on-site septic systems. Here’s what we discovered:

As land development increased, so did rainwater runoff, which likely carries bacteria into the creek. Between 2011 and 2019, development around Cypress Creek increased by nearly a square mile. Our data showed that when it rained, bacteria levels in the creek increased, suggesting that rainwater runoff is likely one source of the problem. Rainwater runoff, commonly known as nonpoint source pollution, is caused when rainfall, moving over and through the ground, picks up and carries natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters, and groundwater supplies.

Rainwater wasn’t the only suspect. We noticed a spike in *E. coli* levels near a bat colony



Jacob’s Well is the primary source of base flow to Cypress Creek, which courses through Woodcreek and Wimberley before joining the Blanco River. The iconic spring-fed swimming hole stopped flowing in 2022 and 2023 due to the ongoing drought and overpumping. The left image shows what Jacob’s Well should look like, and the right image shows the current state of Jacob’s Well.

under the Ranch Road 12 bridge, hinting at bat droppings as another source. A 56 percent increase in bacteria concentrations between the sites monitored upstream and downstream of the bridge indicates an impact on water quality from the bats. We found even more bacteria in the water during the fall, right before the bats migrate south for the winter. The storm drains located under the bridge also seem to facilitate transport of the bat droppings from the shoreline into the creek.

Then there's the matter of local septic systems. We found a strong link between *E. coli* bacteria and fluorescence (light emitted by the optical brighteners) in Cypress Creek, suggesting that local septic systems likely contribute to the pollution. Wimberley Stream, a tributary to Cypress Creek, had some of the highest *E. coli* bacteria counts and fluorescence values in this study.

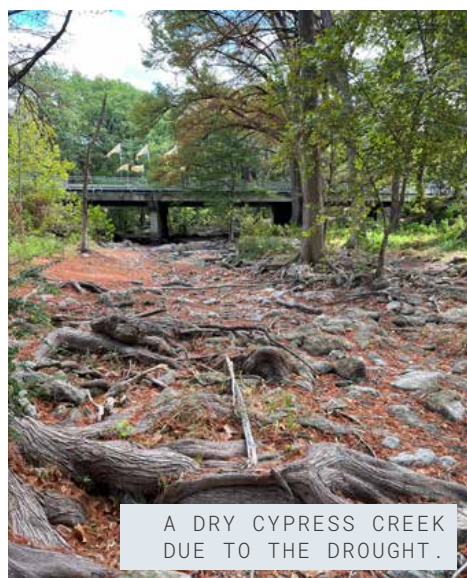
Many residential and commercial properties in the watershed still use on-site septic systems to treat wastewater that continue to pose a risk for bacterial contamination. If these systems are not properly permitted, installed, or maintained, untreated wastewater can migrate to aquifers or nearby surface waters and cause significant public health and environmental problems.

Taking a Closer Look at Septic Systems

We brought in David Venhuizen, an expert in wastewater management systems, to give us a deeper dive into the options for improving wastewater management in the study area. He found that many on-site septic systems around the creek should not have been permitted based on the soil conditions and requirements specified by the Texas Commission on Environmental Quality. Therefore, it's quite possible that some of these systems are failing, adding to the creek's woes.



WATER QUALITY SAMPLING AT THE STUDY AREA.



A DRY CYPRESS CREEK DUE TO THE DROUGHT.



INSPECTING AN ON-SITE SEPTIC SYSTEM.

David's study also gives us a roadmap of possible solutions to reduce or eliminate pollution from on-site septic systems. His recommendations include replacing or upgrading on-site septic systems, enhancing standards for on-site septic systems, installing collective systems providing improved pretreatment and drip irrigation dispersal, and connecting the study area to the wastewater system serving nearby areas.

Moving forward, the plan is to keep a close eye on the creek, the bats, and local septic systems. We're also coordinating with businesses to conduct dye tests for on-site septic systems to identify malfunctioning systems and better understand how they interact with the area's geology in the area. But in the grander scheme, expanding Wimberley's new centralized wastewater collection system to other areas of the watershed not currently serviced might be the key to a clearer Cypress Creek.



RIPARIAN EVALUATION COMMUNITY SCIENTIST TRAINING IN
 HOUSTON WITH THE BAYOU PRESERVATION ASSOCIATION.

Accelerating Ahead: Steering

Texas Stream Team to New Heights

The past year marked a watershed moment for Texas Stream Team, our flagship community science program, which celebrated an impressive roster of more than 12,000 trained community scientists across Texas. In the face of escalating environmental concerns and a deepening climate crisis, the Texas Stream Team's role in protecting the state's precious waterways grows ever more critical.

With the leadership of our newly named Community Science Manager, Aspen Navarro, our program is not just keeping pace but expanding with renewed vigor. This added capacity has been central to cultivating a more

integrated community committed to water conservation and monitoring. The program now places significant emphasis on establishing meaningful relationships with local communities. Through this refined, community-centric strategy, we are fostering partnerships that are not just collaborative but are also deeply rooted in mutual goals and objectives.

Beyond this, we are deeply committed to enhancing the capabilities of our Texas Stream Team partner groups. Through robust training programs, access to resources, and technical assistance, we are working to ensure that all partner organizations are equipped to fulfill their roles effectively.



COMMUNITY SCIENTISTS COLLECTING
 DATA IN LONGVIEW, TEXAS.

Central to our efforts this year has been enhancing our data collection and quality control measures. We have streamlined our data-gathering techniques by making data entry easier and more accessible for all community scientists through electronic data entry. Coupled with newly launched instructional resources, including videos and expanded training manuals, we are ensuring our community scientists are well-versed in best practices and proper protocols.

We have also reinstated field audits to help identify any protocols that may have been overlooked by volunteers, ensuring consistency and accuracy in data collection.



TEXAS STREAM TEAM TRAINING WITH STUDENTS FROM THE TEXAS 4-H AMBASSADORS PROGRAM.



COMMUNITY SCIENTISTS MONITORING WATER QUALITY IN GRAPEVINE, TEXAS.

Celebrating BlueTriton Brands, Inc.: A Texas' Water Sustainability Champion

This year, we were thrilled to receive and kickstart a three-year collaboration with BlueTriton Brands, Inc. (BlueTriton). Together, we are amplifying community science across Texas and expanding sustainability education at Spring Lake.

We provide Texas Stream Team community scientist trainings free of charge, so the flexible support from partners like BlueTriton is critical to the program's resiliency and continued success.

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The state's water crisis is of such magnitude that collaboration across sectors, disciplines, and boundaries is the only way to drive lasting positive changes. This unique partnership shows what is possible when companies and conservationists work together to tackle growing freshwater challenges.

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DR. ROBERT E. MACE

Texas Stream Team's Fiscal Year 2023 Highlights

614

newly trained community scientists

4,483

hours community scientists monitored water quality

2,356

active sites monitored for water quality

2,885

samples collected by community scientists

64

new monitoring sites created at waterways throughout the state

76

community scientist trainings held across Texas

Crossing the Finish Line Together: Facilitating Stakeholder-Backed Solutions for Texas

The Meadows Center continues to build on its history as a trusted convener and expand its reputation for its expertise in stakeholder engagement and its ability to organize diverse groups of experts and stakeholders to achieve shared goals in natural resource management.

This year, we have been instrumental in facilitating science and stakeholder-backed solutions for flooding issues along the Texas coast, sustainability of river systems in West Texas, and groundwater policy in Bastrop and Lee counties.

Highlight on Lost Pines Groundwater Conservation District

You might be surprised to learn that Texas is the third-largest groundwater pumper in the nation, according to U.S. Geological Survey data. In fact, groundwater accounts for approximately 60 percent of water used in the state annually. As the state grapples with intensifying droughts, rising temperatures, and booming populations, ensuring the sustainable management of our groundwater is more significant than ever.

Under Texas law, a groundwater conservation district is the only tool available to manage groundwater usage. These districts are tasked by the Texas Legislature to develop and implement management plans that protect aquifers and manage groundwater supplies within their respective jurisdictions. While they face many hurdles to fulfilling their responsibilities, groundwater conservation districts have an ace up their sleeve: the power to establish Groundwater Management Zones that enable more restrictive pumping rules to protect vulnerable groundwater assets.

The Lost Pines Groundwater Conservation District (the District) manages the groundwater resources within Bastrop and Lee counties and has grappled with the implications of issuing permits for a contentious pipeline that began withdrawing 16.3 billion gallons of groundwater annually from the Carrizo-Wilcox Aquifer in Burleson County in 2020. As of 2022, these withdrawals were causing well owners in the District's Lee County to experience water level drops of 100+ feet in historic wells and changes to water quality. In the long term, Lee County users are predicted to experience drawdowns ranging from 50-200 feet, threatening historic use and access to domestic supplies. Other pending large-scale projects are expected to further extend the region's limited resources.

Since 2022, the Meadows Center has served as a neutral facilitator to help stakeholders identify, articulate, and make recommendations to the District's Board of Directors regarding the creation of a special groundwater



management zone for the Carrizo Aquifer in Lee County and now, district-wide curtailment rules. In these meetings, stakeholders familiarized themselves with local concerns, assessed existing and potential regulations, consulted with other groundwater districts (which has used a groundwater management zone and curtailment rules), and drafted recommendations and rules for the District's consideration.

Carrizo Aquifer discussions resulted in a stakeholder recommendation for the District to create a Lee County Groundwater Management Zone, encompassing an approximately 107 square mile area. Stakeholders also recommended several potential rules for the groundwater management zone to ensure minimal impacts on the Carrizo aquifer, even during drought or heavy usage conditions.

The journey of collaboration continues. The Meadows Center, in collaboration with Meadows Center Fellow Todd Votteler of Collaborative Water Resolution LLC, is working with the District and an appointed stakeholder group to recommend rules relating to production limits, historic use, curtailments, correlative rights, and the permit application process.

The unfolding narrative of the Lost Pines Groundwater Conservation District is emblematic of our broader challenge as Texans—protecting our invaluable water assets while balancing the complex needs of people and the economy. The Meadows Center stands strong in its commitment to bridge the gap between stakeholders and decision-makers, refine and interpret scientific insights, and foster proactive strategies that chart a course for sustainable water management. As we look to 2024 and beyond, we must remember that, with dedication and a collaborative approach, we can address all interests and provide a water-secure future for Texas.

Where We're Investing Next:

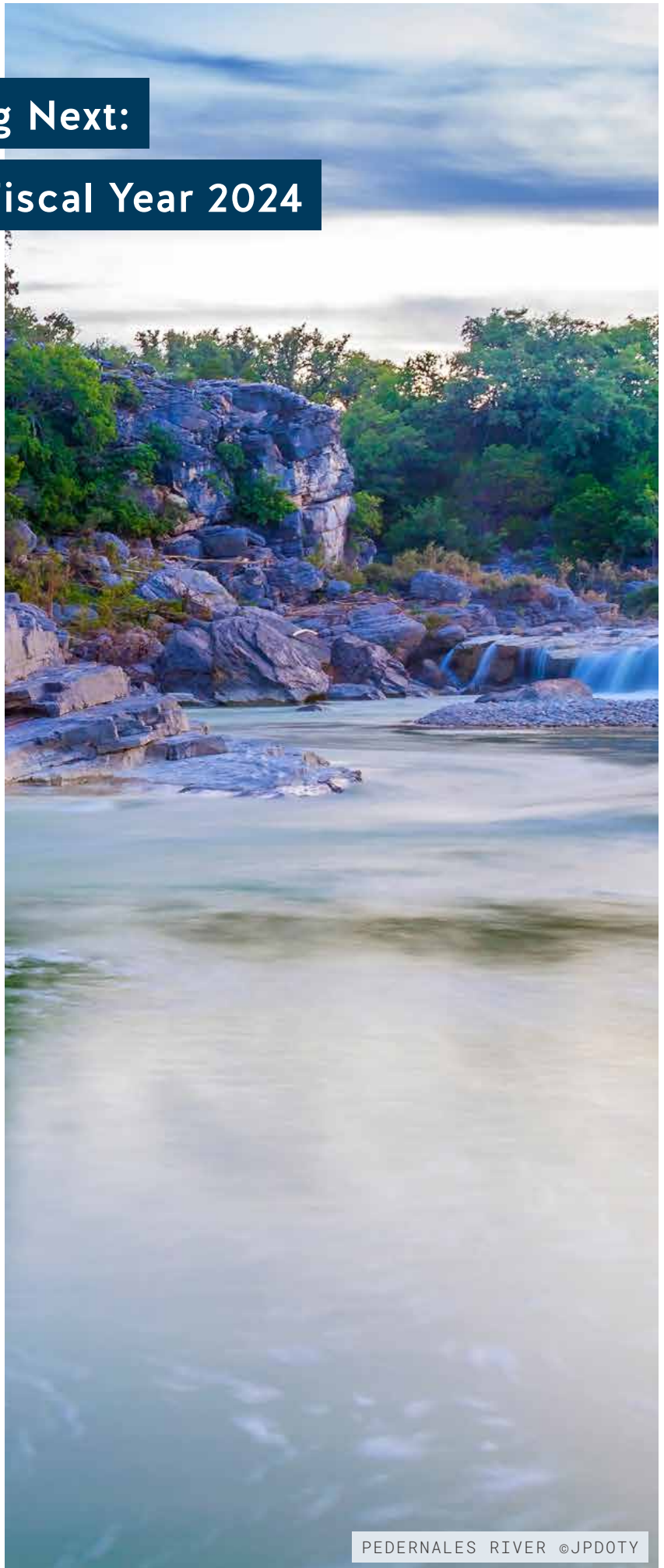
Funding Priorities in Fiscal Year 2024

Discovery Hall Maintenance and Modernization

The Discovery Hall is a central attraction at Spring Lake, catering to a diverse audience from school children to the public. However, its outdated exhibits and infrastructure require improvement to fulfill our educational mandate, and the 100-year-old building needs ongoing maintenance and upgrading to meet our obligations to provide safety for the endangered species housed there and the visitors who come to see them. Our vision for Discovery Hall includes a shared Virtual Reality experience dome, QR code-integrated exhibits, and modernized aquaria with technological advancements for immersive learning. We would also like to optimize the limited physical space, ensuring continuity in themes like endangered species, indigenous history, and conservation while offering visitors amenities like seating and temperature-controlled spaces.

Researching the Impacts of Rapid Development on Texas Waterways

As Texas experiences rapid development associated with record-breaking statewide population growth, communities are requesting our support in protecting Texas surface water and groundwater resources. Meadows Center leadership and research associated with water quality and baseflow monitoring of rivers, streams, springs, and aquifers plays an integral role in gaining a better understanding of the increased pressure on our aquifers and waterways and water quality degradation due to changes in land use and land cover, increased wastewater discharge activities, and nonpoint source pollution across the state. This research is a crucial component of improved water resource protection in the future. Each community we serve requires a minimum of \$50,000 yearly to staff the needed services of water quality data gap analysis and monitoring, community science, workshops and educational programs, stakeholder engagement, technical assistance, and socio-environmental research, including community surveys and analysis.



Access for All and ADA Compliance

The Meadows Center's offices, educational facilities, and historic glass-bottom boats are not ADA-compliant; therefore, mobility-challenged students and guests are not able to fully access facilities or experience a glass-bottom boat tour at Spring Lake. Over the last two years, the Meadows Center has raised hundreds of thousands of dollars to expand access for every member of our community, and we are still a long way from converting the historic facilities to accessible standards. Funds to expand access and improve interpretative experiences for all who visit the San Marcos Springs are a high-priority need.

Advancing One Water Policy and Research

The Meadows Center has emerged as a statewide leader in advancing One Water principles across the state. One Water is an integrated approach to water that promotes the management of all water—drinking water, wastewater,

stormwater, greywater—as a single resource. This integrated management approach can help communities achieve long-term resiliency and reliability for the benefit of both the environment and the economy. We have established networks with dozens of NGOs, governmental agencies, and local communities over the last three years to facilitate research and develop real-world solutions to water supply and water quality challenges. This year's drought prompted countless communities to contact us for technical and policy support to help address their diminishing water supplies. Additional funding is necessary to staff the center to respond to these urgent requests and develop One Water projects, policies, and infrastructure to transfer the expertise to urban and rural communities throughout Texas to implement this resource-optimizing approach.

Operational Resilience

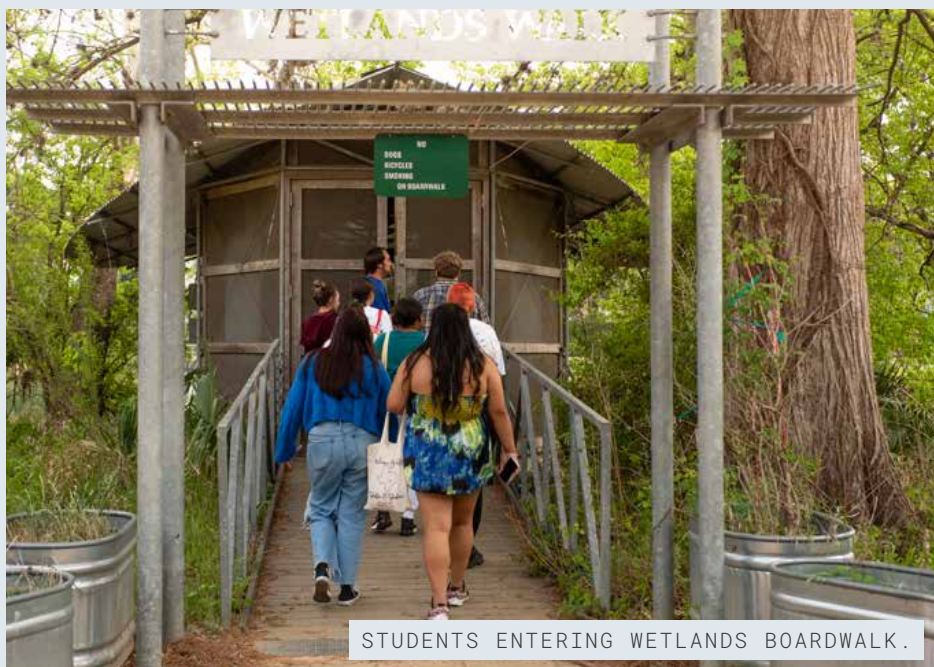
Like most organizations, the COVID-19 pandemic shined a light

on our financial resiliency – and areas that need bolstered resiliency. We are still recovering from the setbacks we experienced in 2020 and 2021. With 90% of our resources coming from federal and state grants, professional service contracts, donor support, and the revenues from our glass-bottom boat rides, we realize we remain too vulnerable to external factors.

The Meadows Center is developing an intentional, strategic, and diverse approach to fundraising that will ensure our staff is protected from external volatility, our research projects are carried through to their respective conclusions, and we never waver in pursuit of our mission, even in the most turbulent of financial times. As our organization grows in size and reach, we will strengthen our financial infrastructure and internal systems to scale up our impact. We will protect our supporters' investments and ensure that our organizations' essential functions are maintained in perpetuity.

A Sustainable Refresh of Our Wetlands Boardwalk Interpretive Education

With the help of BlueTriton Brands, Inc., we are working to update a key environmental education exhibit located along our Wetlands Boardwalk at Spring Lake. The focus will be on water sustainability, educating the public about the importance of protecting and enjoying this critical habitat. This “glow up” will allow us to work with experts specializing in interpretive signage who can bring our vision to life by conveying both the ecological and community values of wetlands. This will help meaningfully connect people with the natural world and encourage continued stewardship of this important ecosystem type found throughout Texas.



STUDENTS ENTERING WETLANDS BOARDWALK.

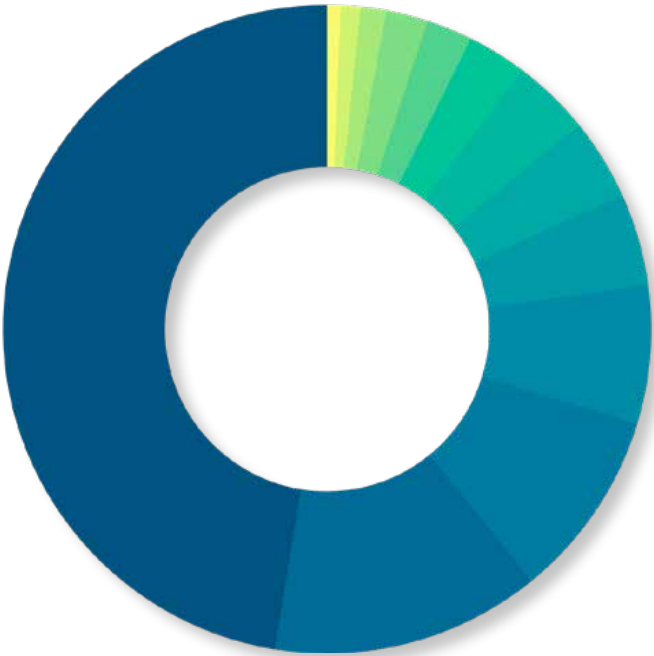


Financial Summary

Revenue

Grants Received – 47.4%	\$2,167,689
Spring Lake Education (tickets & tours) – 13.5%	\$615,182
Endowments – 9.4%	\$430,179
University – 6.9%	\$313,957
Federal – 4.6%	\$210,473
Foundation Gifts – 4%	\$185,000
Meadows Generated Income* – 3.9%	\$179,158
Dive Operations Revenue – 3%	\$135,156
Corporation Gifts – 2.3%	\$105,000
Professional Services Provided – 2.1%	\$95,000
Indirect Cost Recovery – 1.2%	\$58,428
Texas Research Incentive Program Match – 1%	\$45,000
Private Organizations and Individual Gifts – 0.7%	\$31,197

Total Revenue: \$4,571,418

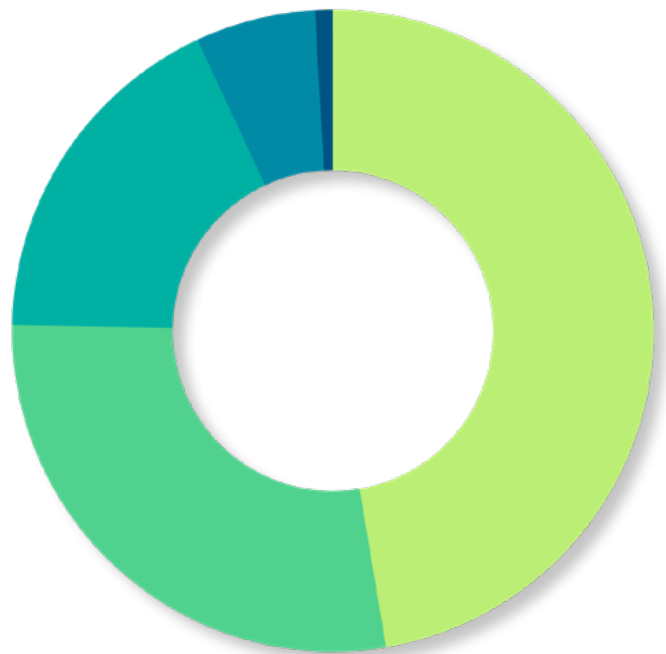


**Sources of income include book sales, hats, t-shirts, book royalties, and services rendered.*



Expenses

Professional Staff Salary and Benefits – 47.4%	\$2,167,689
External Contracts – 13.5%	\$615,182
Supplies and Facility Maintenance – 9.4%	\$430,179
Student Staff Salary – 6.9%	\$313,957
Travel and Meetings – 4.6%	\$210,473
Total Expenses: \$3,424,012	



Our Team



Robert Mace, Ph.D.
Executive Director & Professor of Practice, Department of Geography



Andrew Sansom, Ph.D.
Founder & Professor of Practice, Department of Geography



Carrie Thompson, M.P.A.
Director of Operations



Rob Dussler, Ph.D.
Chief Education Officer, Director of Spring Lake Education



Mona Wells, Ph.D.
Director of Climate Science



Miranda Wait, M.S.
Deputy Director of Spring Lake Education



Jenna Walker, M.A.Geo.
Director of Watershed Services



Soe Myint, Ph.D.
Chief Conservation Officer & Meadows Endowed Chair in Water Conservation, Department of Geography



Sandra S. Arismendez, Ph.D.
Senior Watershed Scientist, Watershed Services



Claudia Campos, B.S.
Administrative Coordinator, Texas Stream Team



Amy Crowell
Stewardship Coordinator



Synthia De Hoyos, B.A.
Procurement Specialist



Michael Flores
Dive Coordinator



Collin Garoutte
Wildlife & Fisheries Biologist, Habitat Field Crew



Sharla Gutierrez
Business Manager



Tom Heard, M.S.
Wildlife & Fisheries Biologist, Habitat Field Crew



Anna Huff, B.S.
Science Communications Manager



Christina Lopez, Ph.D.
Coastal Coordinator, Watershed Services



Emily Lorkovic, M.S.
Wildlife & Fisheries Biologist, Habitat Field Crew



Sam Massey
Glass-Bottom Boats Manager, Spring Lake Education



Erica Jane Meier, M.S.
Administrative Assistant II, Spring Lake Education



Aspen Navarro, M.S.
Community Science Manager, Watershed Services



Laura Parchman, B.A.
GIS & Data Management Associate, Texas Stream Team



Patti Pulis
Office Administrator



Bess Reisberg, B.S.
Education Manager, Spring Lake Education



Christopher Riggins, B.S.
Wildlife & Fisheries Biologist, Habitat Field Crew



Aaron Wallendorf, B.S.
Lake Manager

Students, Interns, and Part-Time Staff

Andrew Adams, M.S.	Garrett DiPalma	Clayton Klingberg	Val Rangel
Belle Alejandria	Faith Fabian	Nate LaRose	Valerie Reyes
Regina Allen, M.S.	Lisa Fields	Kainoa Lee	Morgan Richmond
Annabelle Bamberger	Shelby Fisher	Maggie Maine	Ankur Sagale
Stephen Barkalow	Alexandra Fleming-Patrick	Akayla Martin	Julie Sanchez
Braydon Batts	Jack Frank	Claudia Martinez	Carrie Sheffield
Leeland Batts	Homero Freixa	Miriam Martinez	Sarah Schultz
Eros Baua	Angela Gonzalez	Dakota McCallister	Amalia Sica
Esther Betts	Wilma Gonzalez	Alicia Miranda	Kaya Smiling
Allison Bigler	Madi Harris	Madison Mitchell	Destiny Smith
Priyanshi Bose	Tyler Hartwick	Julian Moreno	Lex Smith
Ricardo Briones	Jordan Hays	Hope Myers	Joey Sydney
Kannon Byckovski	Kate Hill	Joshua Neves	James Taylor
Kaylei Chappel	Alex Holmes	Aubrey Owen	Emily Williams
Sally Chavira	Priscilla Inostroza-Hernandez	Abygail Panther	Sarah-Grace Williams
Maddi Cole	Desiree Jackson	Riley Patrick	Tiffany Willrich
Madison Darwish	Thomas James	Kelsie Phelps	Sarah Wingfield, B.A.
Gisell De Alejandro	Sara Julian	Charolette Piel	Hannah Yetter
Marin DeBolt	Rachel Keese	Jessica Powell	
		Adriana Puzon	

Meadows Center Fellows

Kelly Albus, Ph.D.
Adjunct Professor, Biology For Educators, University of North Texas

Mike Abbott, Ph.D.
Fellow of the Meadows Center

James Dodson, M.P.A.
Principal/Consultant, GroundswellTX, Water & Coastal Resources Management

Mario Garza, Ph.D.
Principal Founder, Indigenous Cultures Institute

Ronald T. Green, Ph.D., P.G.
Technical Advisor, Earth Sciences Section, Southwest Research Institute

Sharlene Leurig
Chief Executive Officer, Texas Water Trade

Vanessa Puig-Williams
Director, Texas Water Program, Environmental Defense Fund

Warren Pulich, Jr., Ph.D.
Ecologist

Bill Reaves, Ph.D.
Independent Art Curator & Co-Editor, Joe & Betty Moore Series on Texas Art, Texas A&M University Press

Linda Reaves, Ph.D.
Independent Art Curator & Co-Editor, Joe & Betty Moore Series on Texas Art, Texas A&M University Press

Rudolph Rosen, Ph.D.
Director, Texas A&M University Institute for Water Resources Science and Technology

Carlos Rubinstein
Principal, RSAH2O, LLC

Todd Votteler, Ph.D.
President, Collaborative Water Resolution, LLC

Douglas A. Wierman, P.G.
President, Blue Creek Consulting, LLC

Water Wizards

Christopher Brown, Ph.D.
Associate Professor, Department of Political Science

Joni Charles, Ph.D.
Associate Professor, Department of Finance and Economics

Richard Earl, Ph.D.
Professor, Department of Geography

Sangchul S. Hwang, Ph.D., P.E.
Associate Professor of Environmental Engineering, Ingram School of Engineering

Keisuke Ikehata, Ph.D.
Assistant Professor, Ingram School of

Engineering

Jason Julian, Ph.D.
Professor & Associate Chair, Department of Geography

Kimberly Meitzen, Ph.D.
Associate Professor, Department of Geography

Ken Mix, Ph.D.
Associate Professor, Department of Agricultural Sciences

Benjamin Schwartz, Ph.D.
Associate Professor, Department of Biology & Director, Edwards Aquifer Research and Data Center

Fellows Feature: Douglas A. Wierman



The Meadows Center collaborates with many partners throughout Central Texas to study the complex interconnectedness of groundwater and surface water of river and spring systems as part of our “How Much Water is in the Hill Country?” research

series. This year, Meadows Center Fellow Doug Weirman assisted us in completing studies on the Little Blanco River in Blanco County and the Little Cypress Creek in Burnet County. Learn more about this work online at <https://bit.ly/hc-studies>.

Research Grants & Contracts

Research is the foundation of all we do. It informs our programs in stewardship, education, and service. The following list details research grants and contracts awarded to our team in Fiscal Year 2023.

Access for All Initiative

Funder: H-E-B, Environmental Affairs

Principal Investigator: Rob Dussler

Glass-Bottom Boat Restoration

Funder: The Burdine Johnson Foundation

Principal Investigator: Miranda Wait

BlueTriton Sustainability Partnership (Year 1)

Funder: BlueTriton Brands, LLC

Principal Investigator: Carrie Thompson

Glass-Bottom Boats Restoration

Funder: The Powell Foundation

Principal Investigator: Carrie Thompson

Bobcat Stream Team and Texas Stream Team Chapter Collaboration (Phase II)

Funder: Texas State Environmental Service Committee

Principal Investigator: Aspen Navarro

Habitat Conservation Planning and Management of Key Recreation Areas

Funder: City of San Marcos

Principal Investigator: Tom Heard

Climate Change Impact on Water Initiative

Funder: National Oceanic and Atmospheric Administration

Principal Investigator: Robert E. Mace

Identifying the Sex-Determining Regions in Suckermouth Armored Catfish

Funder: Texas Parks & Wildlife Department

Principal Investigator: Tom Heard

Clean Coast Texas Collaborative Years 3 and 4

Funder: Texas General Land Office

Principal Investigator: Christina Lopez

Living Shorelines Program Website Maintenance

Funder: Texas General Land Office

Principal Investigator: Anna Huff

Correlative Rights for Sustainable Groundwater Management and Spring Restoration

Funder: The Jacob and Terese Hershey Foundation

Principal Investigator: Robert E. Mace

Lost Pines Groundwater Conservation District Stakeholder Facilitation

Funder: Collaborative Water Solutions LLC

Principal Investigator: Carrie Thompson

Developing a Refined Engagement Strategy for Clean Coast Texas Program Resources

Funder: Texas General Land Office

Principal Investigator: Christina Lopez

PMAPS TX: Using Citizen Science and GIS in the Classroom to Help Our Communities

Funder: Texas A&M Agrilife Extension Service

Principal Investigator: Miranda Wait

Dye Tracing for Cypress Creek

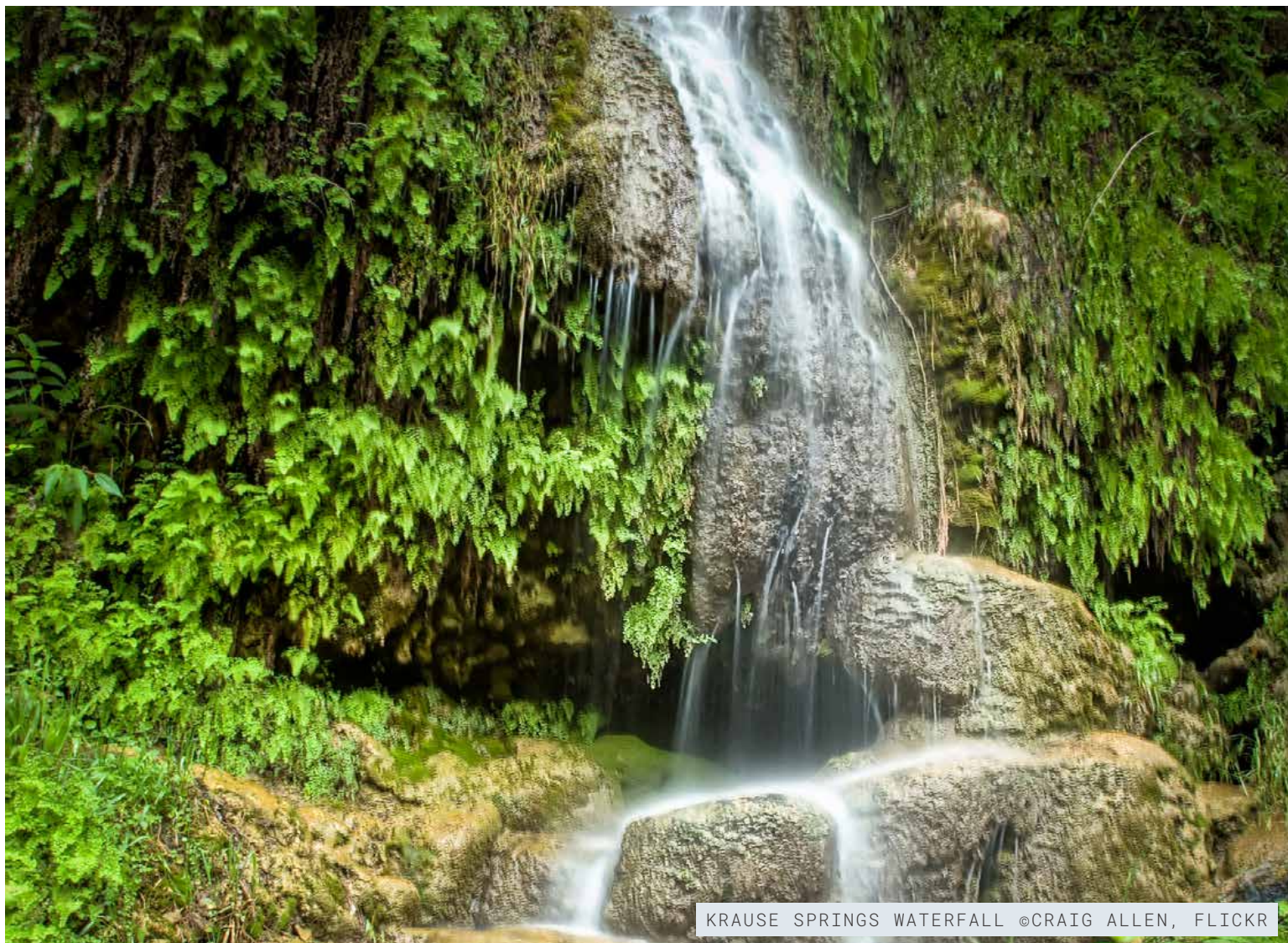
Funder: Way Family Foundation

Principal Investigator: Robert Mace / Jenna Walker

Roy D. Sedwick Research Stipend Endowment

Funder: Texas Floodplain Management Association

Principal Investigator: Robert E. Mace



San Marcos River Litter Collection

Funder: San Marcos Lion's Club

Principal Investigator: Tom Heard

Texas Stream Team Program Funds

Funder: Texas Commission on Environmental Quality

Principal Investigator: Jenna Walker

San Marcos Earth Day Festival 2023

Funder: Texas State Environmental Service Committee

Principal Investigator: Miranda Wait

Texas Stream Team Gulf Coast Initiative

Funder: The Trull Foundation

Principal Investigators: Sandra Arismendez / Aspen Navarro

Spring Lake Education Trails, Trees, and Interpretive Improvements

Funder: Texas Commission on Environmental Quality

Principal Investigator: Jenna Walker

Upper San Marcos River Invasive Species Removal

Funder: Texas State Environmental Service Committee

Principal Investigator: Aspen Navarro

Texas Hill Country Headwater Heterelmis Genetics and Morphology

Funder: San Angelo Area Foundation

Principal Investigator: Carrie Thompson

Watershed Restoration Conservation Planning

Funder: Devils River Conservancy

Principal Investigator: Carrie Thompson

External Research and Creative Projects

at Spring Lake

Spring Lake is an environmentally, culturally, and archaeologically significant resource that serves as a living laboratory for researchers across the state.

As the entrusted stewards, the Meadows Center is committed to providing external researchers with access to this world-class platform for research—including access to programs, infrastructure, and resources. The following list details external research activities that we supported at Spring Lake in Fiscal Year 2023.

Classroom Instruction

ANTH 3361 Field Methods

ARTS 4361: The Photographic Project

BIO 1331: Organismal Biology

BIO 3320: General Science

BIO 3460: Aquatic Ecology

BIO 4400: Plants Important for Wildlife

BIO 4408: Earth Science for Educators

BIO 4410: Field Biology of Plants

BIO 4418: Field Ornithology

BIO 4435/5435: Wildlife Techniques

BIO 5410: Field Biology of Plants

ENG 3303: Technical Writing

GEO 2310: Global Environmental Change

GEO 3434: Water Resources

GEO 4313 Environmental Management

GEO 4326/5326: Parks & Protected Places

PHIL 1320: Field Environmental Philosophy

PHIL 3320: Environmental Ethics

US 1100: University Seminar

Research & Creative Projects

Interpretation and Preservation of the Dwindling Remains of Aquarena Springs Dissertation Research

Isabel Gonzalez – History Department

Quantifying Oak and Juniper Trees Groundwater Use

Evan Simons – Biology Department

5K Fundraiser – “Trick or Trot”

Exercise & Sports Science Department

60th Annual Texas Water Safari

Texas Water Safari

Status of freshwater turtles in the San Marcos River and its Headwaters

Dr. Forstner – Biology Department

Creating a genotype-phenotype-fitness map for a single, massively pleiotropic gene in *Astyanax mexicanus*

San Antonio Zoo

Assessing aquatic vegetation – Edwards Aquifer Habitat Conservation Plan

Edwards Aquifer Authority

Austin Opera Photoshoot

Erich Schlegel

Bass Collection – Edwards Aquifer Habitat Conservation Plan

Edwards Aquifer Authority

Climate/Water Documentary Filming

Ava Studios Paris



TEXAS STATE PRESIDENT KELLY DAMPOUSSE ON GLASS-BOTTOM BOAT TOUR. @NILES DAVIS

Impacts of Place-Based Pedagogy and Environmental Mindfulness at an Informal Science Institution

Ryan Spencer – Biology Department

Geospatial Water Quality Sensor Collection Platform Development

Joel Warner – PadlMe LLC

Edwards Aquifer Habitat Conservation Plan

Edwards Aquifer Authority

Effects of aquatic nitrite on maternal immune transfer and offspring development in a live-bearing species

Ashley Hendrix – Biology Department

Environmental Impact on Cognitive Function and Stress in Adult Learners: A Comparison of Natural and Artificial Learning Environments

Department of Counseling, Leadership, Adult Education & School Psychology

Spring Lake Ground Penetrating Radar

Heather Smith – Anthropology Department

Headwater Heterelmis Genetics and Morphology

U.S. Fish and Wildlife Service

High School NASA Summer Camp Experiments

Engineering Technology Department

Instructor Dive Training

Dive West

Invertebrates Sampling

U.S. Fish and Wildlife Service

Sediment sampling – Edwards Aquifer Habitat Conservation Plan

Edwards Aquifer Authority

SMTX 360 Video

San Marcos Convention & Visitors Bureau

Texas Blind Salamanders and San Marcos Salamanders Collection for the Edwards Aquifer Refugia Program

U.S. Fish and Wildlife Service; San Marcos Aquatic Resources Center

Texas State Triathlon

Texas State Triathlon Club

Use of Phenotypic Variation in Asexual Fish

Allison Davis – University of Texas

Water Quality Collection for the Edwards Aquifer Water Quality Monitoring Program

Edwards Aquifer Authority

We Met At Texas State Promo Video

B17 Entertainment Production Co.

Adventure Trip Leader Training

Outdoor Campus Recreation

Staff Published Works

The Meadows Center supports responsible water and natural resource policy in Texas and convene stakeholders to address the grand challenges that we will face in the decades to come. The following list provides a snapshot of the presentations and publications from our staff, faculty, and students in Fiscal Year 2023.

Published Papers, Abstracts, and Manuscripts

- Rubinstein, C., Seaton, C., & Mace, R. E., 2022, [Beyond Senate Bill 3: How to Achieve Environmental Flows in Texas Under Prior Appropriation](#): Texas Water Journal, v. 13, n. 1, p. 13-26. <https://doi.org/10.21423/twj.v13i1.7115>
- Mace, R. E. 2022, [Book Review: The Water Recycling Revolution: Tapping into the Future](#). Texas Water Journal, vol. 13, no. 1, pp. 64-65, [doi:10.21423/twj.v13i1.7154](https://doi.org/10.21423/twj.v13i1.7154).
- Heard, T.C., 2022, [Habitat Field Crew 2022 Annual Report](#): The Meadows Center for Water and the Environment – Texas State University.
- Zhang, Y. 2022, [Combined Impacts of Hydraulic Conductivity Heterogeneity and Pumping Intensity on Seawater Intrusion in Coastal Aquifers: A Numerical Investigation Using a Henry Problem with a Pumping Well](#): American Geophysical Union Fall Meeting; Chicago, Illinois; December 13, 2022. [30]
- Dussler, R., Williams, J., Massey, S., 2023, [Mindfulness and Reconnection with Freshwater Ecosystems at the Meadows Center Education Program](#): Field Environmental Philosophy. Ecology and Ethics, v. 5., p. 503-518.
- Mace, R.E., and Jones, C., 2023, [Frac sand facilities and their potential effects on the groundwater resources of the Monahans-Mescalero Sand Ecosystem, Permian Basin, Texas](#): Texas Water Journal, v. 14, n. 1, p. 62-80.
- Jamie Hand, Jamie Christina Hwang, Wren Vogel, Christina Lopez, Sangchul Hwang, 2023, [An exploration of market organic sanitary products for improving menstrual health and environmental impact](#): Journal of Water, Sanitation and Hygiene for Development, v. 13, n. 2: p. 63–77. doi: <https://doi.org/10.2166/washdev.2023.020>
- Fisher, S., Garoutte, C., Malone, N., and A. Navarro. 2023, Management of Floating Invasives in the Upper San Marcos River: Texas State University Sustainability Exposition, April 13.
- Arismendez, S., Busse, H., Jackson, D., Navarro, A., and L. Parchman 2022, [East Fork Trinity River – Lavon Lake Watershed Data Report](#). Texas Stream Team – The Meadows Center for Water and the Environment, San Marcos, Texas.
- Mace, R. E. 2022, [Groundwater Sustainability—Birth, Development, Application](#): Palgrave Studies in Environmental Sustainability, Palgrave Macmillan.
- Venhuizen, D., 2023, [Cypress Creek/Blanco Watershed One Water On-Site Sewage Facilities Study](#). San Marcos, Texas: The Meadows Center for Water and the Environment – Texas State University.
- Zhang, Y., Mace, R.E., 2023, [Comparative Flow Analysis between the Pedernales River and Barton and Onion Creeks](#): The Meadows Center for Water and the Environment – Texas State University.
- Wierman, D.A., Walker, J., Arismendez, S.S., Busse, H., 2023, [Little Blanco River Occurrence of Flowing Water Central Texas Hill Country, USA](#): The Meadows Center for Water and the Environment – Texas State University.
- Lopez, C.W.; Wade, M.T.; Julian, J.P. Nature–Human Relational Models in a Riverine Social–Ecological System: San Marcos River, TX, USA. *Geographies* 2023, 3, 197–245. <https://doi.org/10.3390/geographies3020012>
- Zhang, X.; Wells, M.; Zhu, Y.; Li, B.; Boris, T. Wang, Z. 2023, The X-Press Pearl Disaster Underscores Gross Neglect in the Environmental Management of Shipping: Review of Future Data Needs: Marine Pollution Bulletin, vol. 189, p. 114728, <https://doi.org/10.1016/j.marpolbul.2023.114728>
- Zhang, X.; Wells, M.; Jiang, M.; Zhu, Y.; Li, B. 2023, We Need to Plan Streamlined Environmental Impact Assessment for the Future X-Press Pearl Disasters: Marine Pollution Bulletin, vol. 188, p. 114705, <https://doi.org/10.1016/j.marpolbul.2023.114705>
- Zhang, J., Wang, D., Jinghui, G., Yunwei, R., Tian, H., Wang, H., Tong, X., Zhang, Y., Shi, J., Chang, Q., Xiang, Z. 2023, Petrogenesis of the ca. 2.5 Ga dioritic-TTG and granitic gneisses from the Huai'an Complex and its implications for crustal evolution and tectonic settings of the North China Craton: Lithos, v. 444–445. <https://doi.org/10.1016/j.lithos.2023.107104>
- Arismendez, S. and D. Jackson. 2023, [Lower Cypress Creek Pilot Project - Assessment of E. coli and Optical Brighteners](#): The Meadows Center for Water and the Environment, Texas State University, San Marcos, Texas. 60 pgs.
- Arismendez, S., H. Busse, D. Jackson, A. Navarro, and L. Parchman. 2023, [Upper Cibolo Creek Watershed Data Report](#): The Meadows Center for Water and the Environment, Texas State University, San Marcos, Texas. 32 pgs.
- Mitchell, M., and A. Navarro. 2023, [Upper San Marcos River Watershed Protection Plan Implementation - Riparian Restoration for Windmill Branch of Sessom Creek and Outreach and Education Programs Final Report](#): Texas State University, San Marcos, Texas.
- Nielsen-Gammon, J.W., 2023, [Climate Model Downscaling for Texas](#): The Meadows Center for Water and the Environment, Texas State University, San Marcos, Texas. 28 pgs.
- Boggan, K., Campos, C., Navarro, A., and Parchman, L., 2023, [Texas Stream Team Monitoring](#): Texas Commission on Environmental Quality, Nonpoint Source Pollution Management in Texas: 2022 Annual Report, Austin, Texas. 52 pgs.
- Wesley A. Arend, Rebecca D. Mangold, Christopher L. Riggins, Collin Groutte, Yeyetzi Rodriguez, Thomas C. Heard, Nick Menchaca, Janaye Williamson, Dusty McDonald, Daniel Daugherty, Monica McGarrity, Kevin W. Conway, and Joshua S. Perkin, 2023, [Sexual dimorphism in an invasive population of suckermouth armored catfish: Implications for management](#): North American Journal of Fisheries Management, v. 43, issue 4. <https://doi.org/10.1002/nafm.10951>

Presentations

Dussler, R. 2022, "Mindfulness and Nature Connection": presented to PHIL 3323 Environmental Ethics at Texas State University; San Marcos, Texas; October, 5, 2022. [30]

Mace, R.E., 2022, "Water—Dynamics, Trends, and Innovation": presented at the Texas State Innovation Series, San Marcos, Texas, October 11. [30]

Mace, R.E., 2022, "Managed aquifer recharge in Texas": presented virtually at Storing the Future—Managed Aquifer Recharge Seeps In, hosted by The American Groundwater Trust; October 12. [150]

Mace, R.E., 2022, "Revisiting Gunnar Brune's Springs of Texas": presented at the 2022 Texas Groundwater Invertebrate Forum hosted by the Edwards Aquifer Research & Data Center, San Marcos, Texas; October 21. [60]

Parchman, Laura M. 2022, "Stream-Powered: Texas Stream Team & the MS Power Platform": presented at TXST Microsoft Champions hosted by Division of Information Technology; San Marcos, Texas; October, 21, 2022 [25]

Mace, R.E., 2022, "Welcome to Texas!": presented at the Annual Meeting of the National Habitat Conservation Plan Coalition; Austin, Texas; October 25. [200]

Mace, R.E., 2022, "The future of water—Drought, climate, and one water": presented at the Lende Lecture Series hosted by the Cibolo Center for Conservation; Boerne, Texas; October 28. [70]

Arismendez, S. 2022. "Texas Stream Team Riparian Evaluation Training": presented at The Meadows Center for Water and the Environment, San Marcos, Texas. October 29 [~15]

Arceneaux, L., Navarro, A., and S. Simpson. 2022, "The San Marcos Green Alley Initiative": presented at the Texas Downtown Association Conference hosted by The City of San Marcos; San Marcos, TX; November 3. [~30]

Reisberg, B., Navarro, A. 2022, "Texas Stream Team Riparian Evaluation Citizen Scientist Training": presented at the Riparian Evaluation Texas Stream Team training hosted by Texas Stream Team; San Marcos, TX; November 9. [~15]

Dussler, R. 2022. "A Pedagogy of Place in a Contested Border Region": presented at the Association of Experiential Education International Conference; Black Mountain, North Carolina; November 12. [25]

Albus, K., and Reisberg, B., and Simmons-Brooks, P. 2022, "Active Community and Citizen Education for Science and Stewardship (ACCESS) Water Workshop": presented at CAST 2022 hosted by Science Teachers Association of Texas (STAT); Dallas, Texas; November 12. [50]

Lopez, R., and Mace, R.E., 2022, "Land trends and water": presented for a TREAD Talk hosted by the Texas Real Estate Advocacy and Defense Coalition, virtual, November 14.

Puig-Williams, V. (moderator), Leurig, S., Mace, R.E., Marex, J., and Marin, C., 2022, "Building Sustainable Solutions for Texas Communities": held at Water and Wastewater Infrastructure Opportunities in Texas, hosted by Water Finance Exchange and RSAH2O; San Antonio, Texas; November 15.

Navarro, A. 2022, "Upper San Marcos River Watershed Protection Plan Committee Meeting": presented at the Watershed Committee Meeting hosted by The Meadows Center For Water and the Environment; online presentation; November 16. [~12]

Navarro, A. 2022, "The Meadows Center: Stakeholder Engagement in the World of Water": Presented to Texas State University's Public Administration 4362 class (Government Nonprofit and AM Business) hosted by Miha Vindis, Ph.D.; online presentation; November 21. [~20]

Wait, M. 2022, "Connecting Interest in and Awareness of the Environment with and Informal Experience": Poster Presentation at the Texas Informal Science Educator Association Conference; Abilene, Texas; November 16, 2022 [95]

Thompson, Carrie L. 2022, "Lee County Carrizo GMZ Stakeholder Recommendations": presented at the Lost Pines Groundwater Conservation District Board Meeting; Giddings, Texas; December 14, 2022. [40]

Arismendez, S. and D. Jackson, 2022, "Lower Cypress Creek Pilot Project: Assessment of E. coli Bacteria and Optical Brighteners": presented at the Cypress Creek Stakeholder Meeting hosted by The Meadows Center; Wimberley, Texas; December 15, 2022. [~25]

Reisberg, Bess. 2023, "Macroinvertebrate Odyssey": presented at Goodnight Middle School Science Night; San Marcos, TX; January 11. [200]

Berglund, A., Navarro, A., and A. Schlandt. 2023, "Texas Stream Team Advanced Water Quality Community Scientist Training": presented at the Advanced Texas Stream



- Team training hosted by Texas Stream Team; San Marcos, TX; January 15. [15]
- Berglund, A., Jackson, D., and A. Navarro. 2023, "Texas Stream Team Riparian Evaluation Community Scientist Training": presented at the Advanced Texas Stream Team training hosted by Texas Stream Team; San Marcos, TX; January 15. [35]
- Lopez, Christina. 2023, "Texas Stream Team: Motivations and Benefits of Environmental Volunteerism": presented at Bobcat Stream Team meeting, San Marcos, Texas; February 9. [14]
- Arismendez, S., Campos, C., Navarro, A., Parchman, L., and A. Schlandt, 2023, "Texas Stream Annual Updates": presented at the Texas Stream Team Annual Statewide Trainer Meeting hosted by Texas Stream Team; San Marcos, TX; February 9. [36]
- Berglund, A., Jackson, D., and A. Navarro.. 2023, "Texas Stream Team Riparian Evaluation Community Scientist Training": presented at the Advanced Texas Stream Team training hosted by Texas Stream Team; San Marcos, TX; February 11. [35]
- Berglund, A., Jackson, D., and A. Navarro.. 2023, "Texas Stream Team Riparian Evaluation Community Scientist Training": presented at the Advanced Texas Stream Team training hosted by Texas Stream Team; San Marcos, TX; February 11. [35]
- Thompson, C.L., Walker, J.J., and Huff, A.L. 2023, "Devils River Watershed Planning Project": presented at Devils River Technical Expert Kickoff Meeting hosted by The Meadows Center for Water and the Environment; Virtual; February 13. [22]
- Wait, M. 2023, "Connecting Interest In and Awareness Of the Environment with and Informal Experience": Poster Presentation at the Texas Informal Science Educator Association Conference; Abilene, Texas; February, 16, 2023. [55]
- Enders, M., Navarro, A., and E. Weeks. 2023, "Annual Upper San Marcos River Watershed Protection Plan Meeting": presented at the Watershed Stakeholder Meeting hosted by The Meadows Center for Water and the Environment; San Marcos, TX; February 23. [11]
- Lopez, Christina. 2023, "Watershed Protection Planning in Texas": presented at River Basin Management Course, Department of Geography and Environmental Studies, San Marcos, Texas; February 28. [30]
- Mitchell, M., and A. Navarro. 2023, "The Meadows Center Watershed Services Project Updates": presented at the monthly meeting hosted by Texas State University's Environmental Service Committee; online presentation; March 9. [10]
- Zhang, Y. 2023, "Impact of Pleistocene Continental Glaciations on Pore Pressure Evolution, Brine Migration, Rock Failure, and Earthquake Triggering, for Integrity Assessment of Nuclear Waste Storage in High Latitude Countries": Department of Earth and Planetary Sciences, University of Texas at San Antonio; San Antonio, TX; March 10. [50]
- Arismendez, S. 2023. "2023 Clean Rivers Program Coordinated Monitoring Meeting": presented at the Guadalupe Blanco River Authority; Seguin, Texas; March 15. [30]
- Reisberg, B. 2023. "Sustainability at the Springs": presented at the Discovery Center; San Marcos, Texas; April 1. [1,000]
- Reisberg, B. 2023. "Environmental Education for Pre-Service Teachers": presented to CI 2355 STEM in Early Childhood and Elementary Education at Texas State University; San Marcos, TX; April 5. [26]
- Reisberg, B. 2023. "Interpretation in Nature": presented to CI 2355 STEM in Early Childhood and Elementary Education at Texas State University; San Marcos, Texas; April 12. [26]
- Arismendez, S. 2023. "Texas Stream Team Riparian Evaluation Training": presented at The Bayou Preservation's Riparian Evaluation Citizen Scientist Training; Houston, Texas; April 12. [24]
- Reisberg, B. 2023. "Implementing Nature-Based Learning with EC-6th Grade Students": presented to CI2355 STEM in Early Childhood and Elementary Education at Texas State University; San Marcos, Texas; April 19. [26]
- Arismendez, S. 2023. "Clean Rivers Program Monitoring Protocols Training": presented at The Meadows Center for Water and the Environment; San Marcos, Texas; April 20. [5]
- Albus, K., S. Arismendez, and D. Jackson. 2023. "Volunteer Monitoring of Optical Brighteners in Texas Waterways; Education and Research Opportunities": presented at the 13th National Monitoring Conference; Virginia Beach, Virginia. April 24-28. [~1,000]
- Mace, R.E., 2023. "The Future of Water in Austin and the World!": [invited] presented at the 20th Central Texas Infrastructure Design + Construction Symposium hosted by the Austin Contractors and Engineers Association; Austin, Texas; May 11, 2023. [100]
- Mace, R.E., 2023. "The Relationship Between Land and Water—Conserving in Comal County": [invited] presented at the CCCA Community Program, hosted by the Comal County Conservation Alliance; New Braunfels, Texas; May 16. [85]
- Albus, K., B. Hendrickson, D. Jackson,, S. Arismendez, L. O'Gan, P. Simmons-Brooks, and T. Nguyen. 2023. "Tamplng for ACCESS: Low-cost Water Quality Monitoring using Tampons for K-12 Education and Community Science Engagement": presented at C*SCI 2023; Phoenix, Arizona; May 22-26. [200]
- Arismendez, S. 2023. "Summer 2023 Watershed Services Research and Development Projects": presented at MCWE quarterly staff meeting; San Marcos, Texas; May 22 [-30]
- Mace, R.E., 2023. "Climate change and Water in Central Texas": presented to the Metropolitan Breakfast Club; Austin, Texas; May 24. [50]
- Thompson, Carrie L. 2023, "Tools for Understanding & Addressing Conflict in Water": presented at Texas Water Leaders hosted by Texas Water Foundation; Austin, Texas; May 24. [30]
- Mace, R.E. , 2023, "Water in the 22nd Century—What We Can Learn From Austin's 100-Year Water Plan" [invited]: presented to the 30th Texas Groundwater Program: Everything Aquifers and Groundwater Management—Legal, Policy, Management, Scientific, Engineering, and Technical Issues about Texas' Aquifers hosted by the American Groundwater Trust; Austin, Texas; June 7. [200]
- Mace, R.E., 2023, "Sustainability signaling in Aquifers": 2023 UCOWR/NIWR Annual Water Resources Conference, hosted by the University Council on Water Research and the National Institute on Water Resources; Fort Collins, Colorado; June 15. [30]
- Walker, J. 2023, "Texas Stream Team Riparian Evaluation Community Science Program": presented at the Community Science Committee Webinar hosted by National Water Quality Monitoring Council Community Science Committee; Virtual; June 13. [120]
- Walker, J. 2023, "Cypress Creek Watershed Protection Plan Sustainability Plan": presented at the Watershed Protection Plan Stakeholder Committee Meeting hosted by The Meadows Center for Water and the Environment; Wimberley, Texas; July 14 [20]
- Moss, A., and A. Navarro. 2023. "Texas Stream Team Riparian Evaluation Community Scientist Training": presented at the Riparian Evaluation Texas Stream Team training hosted by Texas Stream Team; Houston, TX; July 21. [-15]
- Mace, R.E., 2023, "State of Water" [invited]: Texas Public Power Association, July 25, 2023.
- Thompson, Carrie L., "Science Collaboration and Governance In the Absence of Trust":

presented at University Network for Collaborative Governance Retreat hosted by the Ruckelshaus Institute at the University of Wyoming; Jackson Hole, WY; July, 31. [25]

Cook, R., Mace, R., and Westbrook, G., 2023, "Desired Future Conditions History: Milam and Burleson Counties": Groundwater Summit hosted by the Post Oak Savannah Groundwater Conservation District, Caldwell, Texas, August 17.

Dupnik, J. [moderator], Howe, B., Mace, R., Porter, C., Westbrook, G., 2023, "The Vista Ridge Project—A case study on groundwater rights and regulation":

presented at the Milam and Burleson Counties Groundwater Summit hosted by the Post Oak Savannah Groundwater Conservation District, Caldwell, Texas, August 17. [TBD]

Navarro, A., and J. Walker. 2023, "Water Quality Monitoring: Practical Guidelines & Lessons Learned": presented at the Texas Watershed Planning Short Course hosted by the Texas Water Resources Institute; Bandera; Texas; August 23. [~25]

Mace, R.E., 2023, "Climate-water interconnection: What it is & what it means

for our future" [invited]: Sunday Evening Conversations on Creation, August 27.

Mace, R.E. [moderator], Beach, J., Britten, B., Cochran, K., and Fancher, K., 2023, "Correlative Rights or Correlative Wrongs?": presented to the Texas Alliance of Groundwater Districts, August 29.

Navarro, A. 2023, "Texas Stream Team San Antonio": presented at the National Rivers Month Texas Stream Team Meet and Greet Day hosted by the San Antonio River Authority; San Antonio, TX; August 31, 2023.



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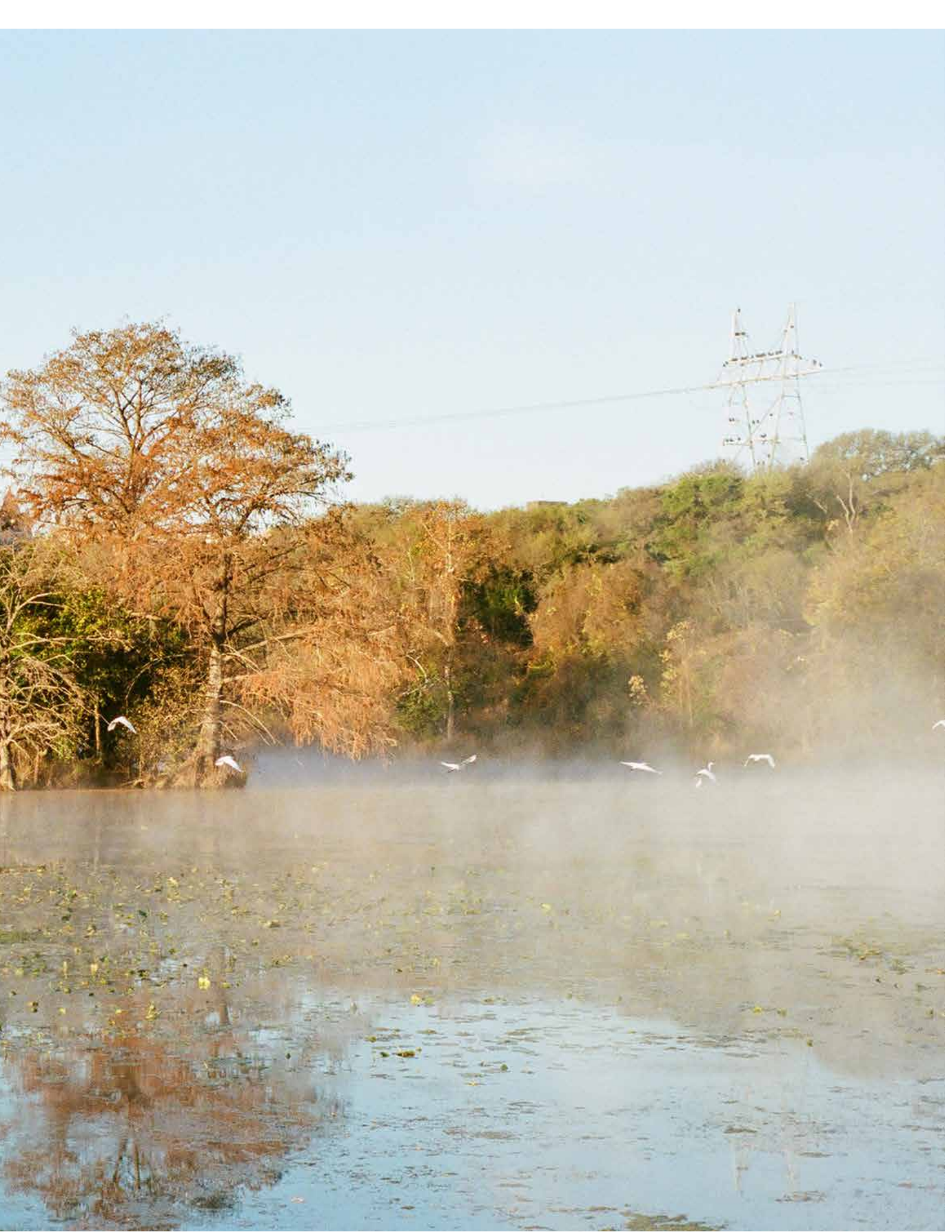
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