GRDA
Grand River Dam Authority

2025 ANNUAL REVIEW

ECOSYSTEMS EXPLORATIONS

Research, Conservation, and Protection

Grand River Dam Authority

The Grand River Dam Authority is an agency of the state of Oklahoma, created by the Oklahoma Legislature in 1935 to be a "conservation and reclamation district for the waters of the Grand River". GRDA is Oklahoma's largest public power utility; fully funded by revenues from electric and water sales instead of taxes.

GRDA utilizes a diverse portfolio of assets to generate, transmit, and sell electricity to Oklahoma municipalities, electric cooperatives and industrial customers, as well as off-system customers across a four-state region. At the same time, GRDA manages over 70,000 surface acres of lake waters in Oklahoma, as well as the waters of Oklahoma's Scenic Rivers.

GRDA's Mission

We deliver affordable, reliable ELECTRICITY, with a focus on EFFICIENCY and a commitment to ENVIRONMENTAL STEWARDSHIP.

We are dedicated to ECONOMIC DEVELOPMENT, providing resources and supporting economic growth.

Our EMPLOYEES are our greatest asset in meeting our mission to be an Oklahoma Agency of Excellence.

If you are interested in learning more about the Grand River Dam Authority, please visit our website at www.grda.com or scan the QR code with your smartphone camera.

GRDA's 5E's of Excellence

Electricity: We will produce low-cost, reliable electricity for our customers.

Efficiency: We will operate in the most efficient manner possible, to benefit our ratepayers and the people of Oklahoma.

Environmental Stewardship: We will practice environmental awareness and promote conservation and reclamation of the natural resources under our control.

Economic Development: We will support economic growth and quality of life enhancement in Oklahoma.

Employees: We will be a diverse and energetic workforce, working together in a safe environment and treating each other with dignity and respect.

Ecosystems Explorations - 2025 Annual Review

Table of Contents

The following pages showcase the programs, projects, and research carried out by the Grand River Dam Authority's Ecosystems and Watershed Management Team. Collectively, these efforts reflect GRDA's ongoing commitment to conservation, environmental stewardship, and the responsible management of the natural resources entrusted to our care. This annual review highlight the partnerships, innovation, and scientific dedication that continue to guide GRDA as we protect and enhance our natural resources.

If you are interested in learning more about GRDA's research over the last 10 years, scan the QR Code with your smartphone camera.

GRDA's Scenic Illinois River

Ecosystems and Watershed Management

When the Grand River Dam Authority established its Office of Ecosystems Management in 2004, it recognized the scale of the work ahead. The Grand River and Scenic Rivers watersheds stretch across Kansas, Missouri, Arkansas, and Oklahoma before ultimately collecting into two of the region's most valued recreational and economical destinations, Grand Lake and the Illinois River.

Because only a small portion of the watersheds lie within Oklahoma, and much of it originates upstream in neighboring states, GRDA understood early on that effective stewardship would require strong partnerships. Since its formation, the department has focused on building collaborative relationships that support open communication, shared resources, and coordinated actions. These partnerships remain central to advancing GRDA's long-term conservation and restoration goals across it's diverse and interconnected watersheds.

If you are interested in learning more about GRDA's Ecosystems and Watershed Management department, scan the QR Code with your smartphone camera.

Ecosystems & Watershed Mgmt.
420 Highway 28
PO BOX 70
Langley, OK 74350

GRDA's Ecosystems and Education Center

The Ecosystems team at the 2025 OKGWC

State, Federal, & Private Partners & Collaborators

The Ecosystems and Watershed Management Department was born out of the spirit of collaboration and teamwork, and that sentiment carries through to today. See a list of just some of our collaborators below:

State & Federal Agencies:
Oklahoma Conservation Commission | Oklahoma Water Resources Board | Oklahoma Department of Wildlife Conservation | Oklahoma Department of Environmental Quality | Illinois River Watershed Partnership | George Misch Sutton Avian Research Center | National Ag in the Classroom | U.S. Fish & Wildife Service

Universities:
Northeastern Oklahoma A&M | Northeastern State University | Oklahoma State University | Rogers State University | University of Oklahoma

Higher Education Support & Collective Reach

Support for Higher Education Students

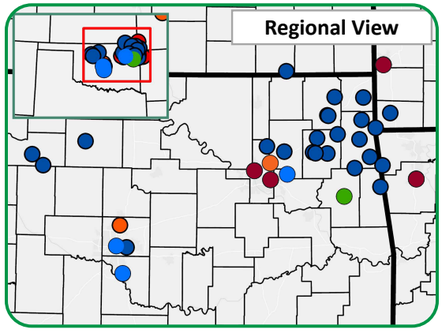
Over the years, GRDA fellowships and support programs have provided support for many students at all different levels of higher education. These fellowships, scholarships, and internships have provided GRDA with valuable insight while also providing rate payers countless savings and developing the next generation of natural resources professionals, all while earning GRDA and our university partners numerous awards.

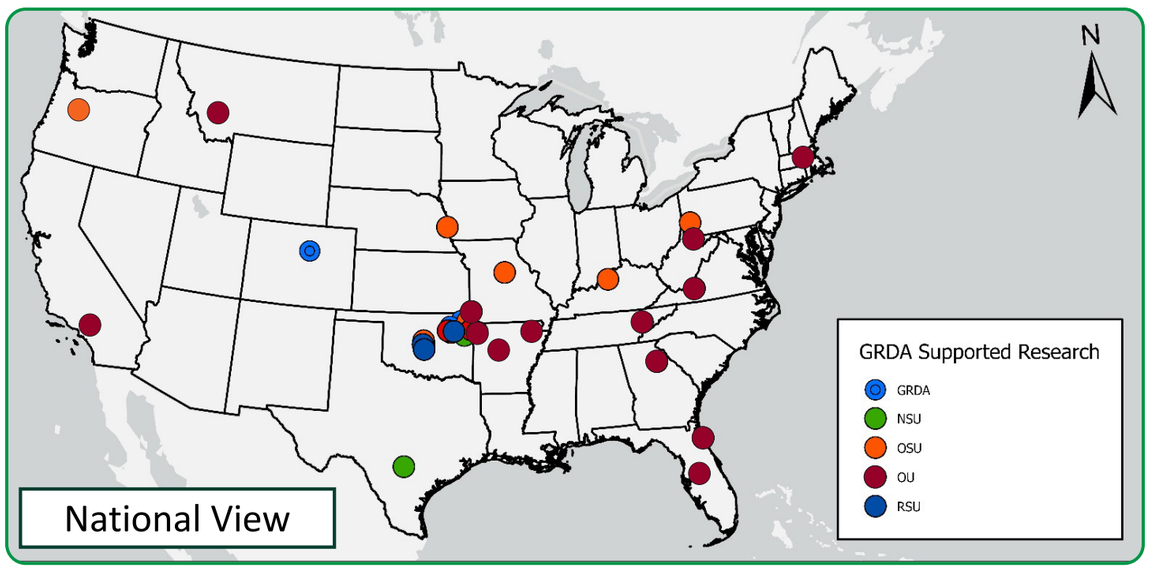
Northeastern Oklahoma A&M: 18 students supported through various functions of the partnership.
Northeastern State University: 23 students supported, 23 BS.
Oklahoma State University: 16 students supported, 8 MS, 8 Ph.D.
Rogers State University: 13 students supported through senior level research projects.
University of Oklahoma: 28 students supported, 15 MS, 13 Ph.D.

The Collective Reach of our Efforts

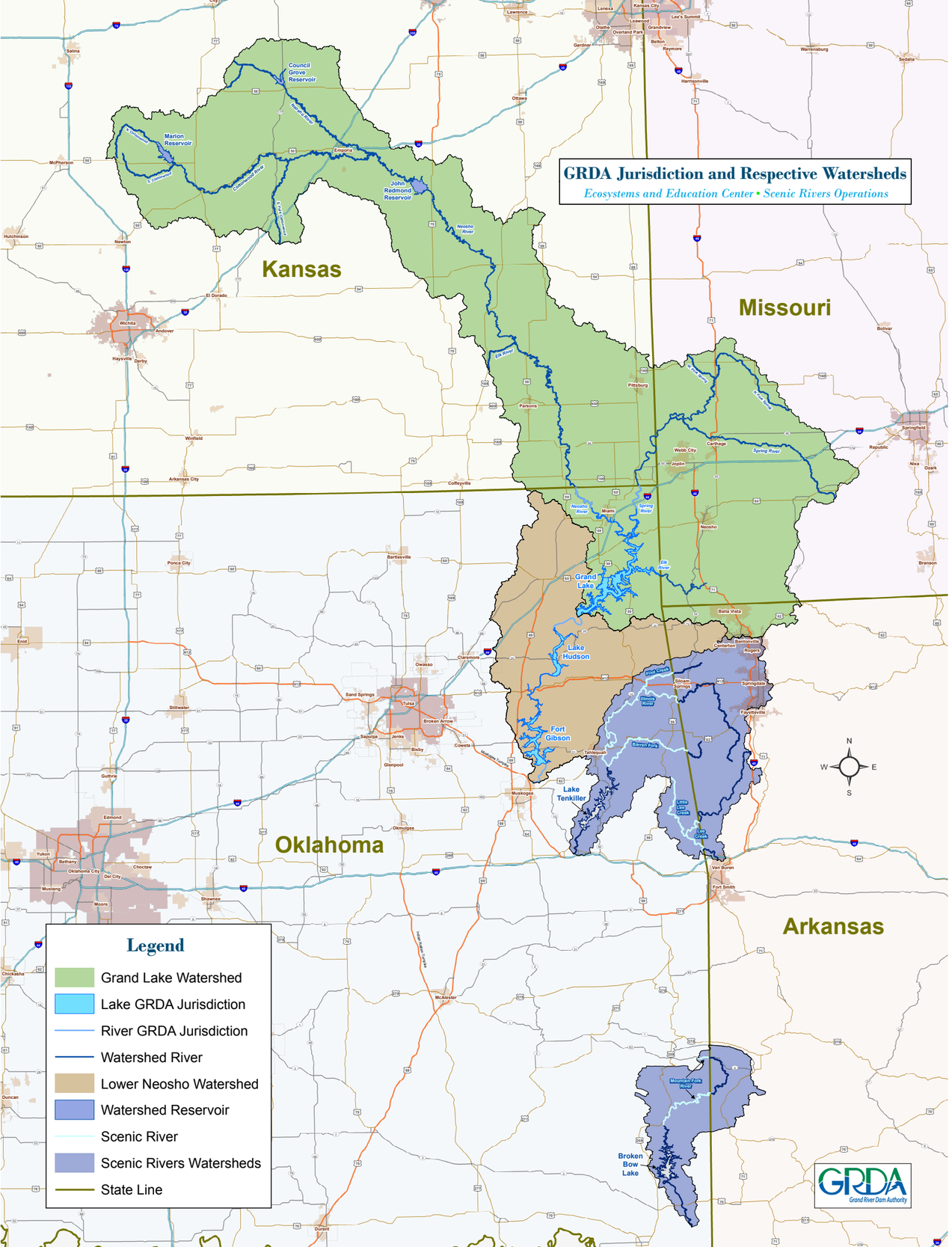
GRDA's research and conservation efforts have far reaching impacts not only within the State of Oklahoma and our respective watersheds, but outside of their borders as well. In the last two years, GRDA supported research and outreach efforts have reached 20 states and 3 countries.

On a regional level, GRDA's Ecosystems team has hosted or attended 102 events supporting 34 communities across 17 counties in GRDA affiliated communities and watersheds.





GRDA's Watersheds



What is a Watershed?

A watershed is defined as an area that drains all of its rivers, streams, creeks, and runoff to a common outlet. This outlet may be the outflow of a reservoir, or the mouth of a bay, depending on your geographic location. A watershed consists of all of the surface water - lakes, rivers, reservoirs, and wetlands as well as subsurface groundwater.

The Grand River Watershed

The Grand River watershed is a collection of rivers, streams, creeks, and runoff that stretches across a roughly 10,300 square mile area and eventually flows into the Grand River in Oklahoma's northeast corner. It rests in four states, straddles two EPA regions and impacts the lives of hundreds of thousands of people.

Most of the watershed lies in the state of Kansas, with the water eventually making its way to Oklahoma by way of the Neosho River. In Missouri, another large portion of the watershed drains into our state mostly through the Spring River. The confluence of the Neosho and Spring rivers, near the heart of Ottawa County, is the beginning of the Grand River. Impounded by three separate dams, this river then gives us Grand Lake (Pensacola Dam), Lake Hudson (Robert S. Kerr Dam) and the Fort Gibson Lake (Fort Gibson Dam). Together, these lakes provide not only the "fuel" for hydroelectric generation and a valuable water supply across a large region, but also serve as a foundation for economic development tied to multiple industries, including manufacturing, tourism, recreation and more.

GRDA's Scenic Rivers Watersheds

Currently, Oklahoma has six scenic rivers that collectively extend 161 miles through six counties. The scenic river designation affords these valuable resources the highest protection and priority available through Oklahoma's environmental agencies. Specific requirements of this designation include a strict prohibition on additional pollutants, dams, and wastewater treatment plants, and a close monitoring of construction activities alongside the river.

The GRDA is invested with the power to establish minimum standards for planning and other ordinances affecting scenic rivers. As the Oklahoma Scenic Rivers Commission had done since its establishment in 1977, GRDA continues to work with communities, businesses and individuals to mitigate their impact on scenic rivers. We strive to educate the public about scenic rivers and also to provide everyone the opportunity to enjoy the features that make these water resources so special.

The partnership with Northeastern State University to create the GRDA-NSU Scenic Rivers and Watershed Research Lab is meant to help protect and better understand the Illinois River and its watershed, as well as the rest of the scenic rivers. The Ecosystems & Watershed Management department is ready to carry out the provisions of the Scenic Rivers Act through protection, preservation, and education.

Water Quality Programs

Water is an essential resource, from the glass you drink to the lake where you spend a sunny afternoon. That's why the Grand River Dam Authority (GRDA) works every day to protect and enhance the waters of Grand Lake, Lake Hudson, the W.R. Holway Reservoir, and Oklahoma's scenic rivers. As one of the state's leading stewards of natural resources, GRDA combines hands-on science, community partnerships, and modern technology to keep these waterways healthy, safe, and enjoyable for everyone.

GRDA's commitment starts with a strong foundation in research. Across two dedicated water quality research laboratories, one on the shore of Grand Lake in Langley and another in Tahlequah near the Illinois River, GRDA scientists monitor everything from algae blooms to bacteria levels. These facilities are equipped with state-of-the-art tools including real-time water quality buoys, algae toxin analyzers, and high-tech microscopes designed to quickly identify potential problems. These tools allow GRDA teams to respond quickly to potential issues like fish kills, toxic algae, and waterborne illnesses while ensuring safe conditions for recreation, wildlife, and community use.

Because most of the water flowing through GRDA reservoirs originates outside Oklahoma, caring for these systems requires collaboration that stretches across state lines. GRDA works with its vast network of partners to monitor conditions throughout the Grand Lake and Scenic Rivers watersheds, working to understand how land use, storms, and upstream activities influence water quality. Through long-term datasets and continuous innovation, GRDA has built a clearer picture of these dynamic aquatic systems, knowledge that helps guide better decision-making for everyone who relies on them.

GRDA regularly partners with universities, local communities, state and federal agencies, and landowners. These collaborations help advance conservation practices, improve habitat, reduce pollution, and ensure long-term sustainability. Whether through educational programs, habitat enhancement efforts, or watershed restoration projects, GRDA continues its long-standing mission of environmental stewardship while empowering residents to help care for the waters they enjoy.

As Oklahoma's largest public power utility and a leader in environmental stewardship, GRDA remains committed to preserving the natural resources that support local communities, recreation, wildlife, and the regional economy. By blending innovation and collaboration, GRDA continues to protect its water resources, ensuring they remain safe, vibrant, and accessible for generations to come.

Dustin Browning works to prepare a bacteria test

Intern Caden Lyons performs a TSS Analysis

Fisheries Enhancement and Monitoring Programs

GRDA's Rush for Brush Program

The Rush for Brush program began on Lake Hudson in the spring of 2007 with a small workshop of dedicated volunteers. With the goal of improving fish habitat, GRDA staff and community members spent the day building artificial brush structures from materials provided by GRDA. Designed to mimic natural brush piles, these long-lasting structures give fry and fingerlings protection and nursery habitat, supporting healthier fisheries and reinforcing GRDA's commitment to responsible natural resource management.

Nearly 18 years later, the program's mission remains the same, but its reach has grown dramatically. Hundreds of volunteers have participated in dozens of workshops, and the program has earned statewide and national recognition, including the "State Government Program" award from Keep Oklahoma Beautiful in 2017 and the "Outstanding Stewards of America's Waters" award from the National Hydropower Association in 2018. Today, roughly 19,000 habitat structures have been placed in GRDA managed waterbodies, covering more than 11 acres of lakebed and benefiting countless species of fish across the region.

Other Fisheries Efforts

GRDA also collaborates with the Oklahoma Department of Wildlife Conservation (ODWC) and the U.S. Fish and Wildlife Service to develop and conduct creel surveys on GRDA lakes. To maintain high-quality fisheries, GRDA also stocks Lake Hudson with hybrid striped bass each year.

This year, GRDA expanded its role in fisheries work by purchasing a backpack shocker and other equipment allowing us to better conduct surveys and collect taxonomic samples from scenic river sites. This work helps us establish a long-term dataset to understand how fish communities change over time. Collectively, these efforts improve our understanding of stream health and ecological integrity while building a reference collection that benefits academic pursuits, environmental emergency response, and educational outreach efforts alike.

Cale (GRDA) and Cheyanne Olson (NSU) leading a fish survey

A logperch (*Percina caprodes*) collected by GRDA

Threatened and Endangered Species

Bald Eagle Monitoring

The Ecosystems and Watershed Management team conducts aerial bald eagle surveys each year in January and April, flying 400–500 feet above the treetops at speeds of 50–60 mph. Each survey is carried out by a GRDA pilot and at least one trained observer. During the January flights, the team records adults, juveniles, paired eagles, and active nests. They also revisit known nesting sites from previous years to check for activity and document any newly discovered nests.

The spring survey focuses on locating new nests and revisiting earlier sites to assess activity levels and count both juvenile and adult eagles. New nests are marked with GPS coordinates, which are then evaluated to determine whether they fall within the project boundary. All collected information is shared with the George Miksch Sutton Avian Research Center in Bartlesville, Oklahoma, where it contributes to the statewide bald eagle nesting database as part of GRDA's role in the Bald Eagle Survey Team (BEST). In 2024, GRDA received Google's Geo for Good award in recognition of its innovative bald eagle survey program.

As of 2025, Grand Lake has 10 active nests within the project boundary, while Lake Hudson has 11.

Bat Species Monitoring

With support from The Nature Conservancy and the U.S. Fish and Wildlife Service, GRDA manages three bat caves in the Grand Lake area, two located inland and one situated directly on the shoreline. These caves provide important maternity habitat for the endangered, cave-dependent Gray Bat (*Myotis grisescens*), while the surrounding shoreline areas also support the threatened, tree-roosting Northern Long-Eared Bat (*Myotis septentrionalis*).

GRDA carries out a variety of conservation activities in partnership with state and federal agencies as well as university researchers. These efforts include population estimates, nighttime emergence counts, acoustic monitoring, and surveillance for White-Nose Syndrome. In recent years, GRDA has significantly expanded its acoustic monitoring program, confirming that at least 14 bat species call GRDA-managed waters home. To help safeguard these unique residents, protective measures have also been incorporated into shoreline management plans to reduce disturbance, prevent habitat loss, and promote long-term conservation.

GRDA's Eagle barricade signage for protecting nests


The entrance to a GRDA monitored bat cave

Bioassesment Program and STE

Macroinvertebrate Bioassessment Program

GRDA's biological assessment program using aquatic macroinvertebrates was implemented on the scenic rivers in 2025. Bioassessment is a tool for identifying the current functions of a given habitat by quantitatively sampling the biological community associated with a given site and comparing that community with a suitable reference site. It is a tool that utilizes the macroinvertebrate community structure as an overall meter stick for evaluating overall habitat health and functionality, and the data from this effort will inform watershed management practises.

GRDA's bioassessment effort is part of a long term monitoring program to determine the ecological health and functionality, as well as potential impacts to habitat and associated wildlife on GRDA's conservation easements from variations in annual weather, flood regimes, public use, or land management. Bioassessment techniques and methods focus on assessing the biological components that characterize environmental quality. Typically, macroinvertebrate communities are sampled because invertebrates are typically less motile (i.e., they stay in a particular area), they produce numerous generations within a single season, and they generally have the highest diversity in the smallest sampling area. Thus, macroinvertebrate community structure is often a good measure of environmental circumstances.

STE: Standard Taxonomic Effort List

GRDA and the Oklahoma Conservation Commission (OCC) are partnered to standardize benthic macroinvertebrate (BMI) taxonomic data for bioassessment. The water quality regulatory agencies in the state (state, federal, tribal) as well as other agencies and organizations, are increasingly relying on bioassessment data. The result is the need for BMI efficient data management standards. Comparisons between bioassessment datasets are not possible without standardization; without data standardization the data become subjective. Therefore, it is paramount that taxonomic practices are standardized as they apply to bioassessment. Actions based on biological data require standards of comparability and repeatability. Therefore, there is a pressing need to formalize the rules for defining and updating standard taxonomic effort levels.


Interns Zoe Pippin and Caden Lyons retrieving a Hester-Dendy

A Standard Taxonomic Effort (STE) list will promote stability, uniformity, and reproducibility of results among workers identifying aquatic invertebrates. Working together, GRDA and OCC will be able to use the STE to standardize state bioassessment data, making our data sets comparable across the state, across watersheds, and across laboratories. The STE will inform resource managers and provide ecological guidance to all entities conducting bioassessment in the state

Community Involvement Programs

GRDA's outreach and education program continues to expand beyond the Grand Lake watershed. This year, we worked with the Oklahoma Conservation Commission, Oklahoma Water Resources Board, Oklahoma Department of Environmental Quality and 15 local conservation districts to help protect water quality. We helped Oklahomans in 19 counties by replacing 34 failing septic systems. This provided water quality protection in 15 water bodies and helped to address a stinky problem for not just the homeowners, but their neighbors as well.

We held workshops and/or youth events in Collinsville, Pryor, Tahlequah and Sallisaw. We also continue to work with the City of Tahlequah and the City of Pryor on parks in each community to improve pollinator habitat and provide outdoor education experiences.

We held our annual teachers' workshop in Tahlequah again this year. We took a driving tour of the Illinois River watershed and visited Cave Springs to experience the headwaters of one of the streams that feeds the Illinois River. We again partnered with Blue Thumb, OSU Extension and Ag in the Classroom. We have 21 educators from across Oklahoma participate this year.

We again offered workshops in the Grand Lake watershed as part of the Guard the Grand program. We held two rain barrel workshops, one at the Eastern Shawnee Tribe of Oklahoma's Earth Day festivities near Wyandotte and one in Grove in conjunction with the Lake O' the Cherokees Subwatershed Association. Our display at the Oklahoma Aquarium is getting a facelift! Working with their designers, the Aquarium and GRDA are updating the GRDA display. Check it out in 2026!

We presented at the National Ag in the Classroom conference in June and shared our latest animated presentation titled A Swim Through a Watershed with Poly and Don. You can watch the short video by scanning the QR code below. This, paired with some questions for teachers to use, helps students better understand their relationship with their watershed and how to protect it.

Our staff was able to reach over 5,000 people in 2025. The dedication of our staff exemplifies our commitment to education and the importance of protecting our water resources.

Education Programs

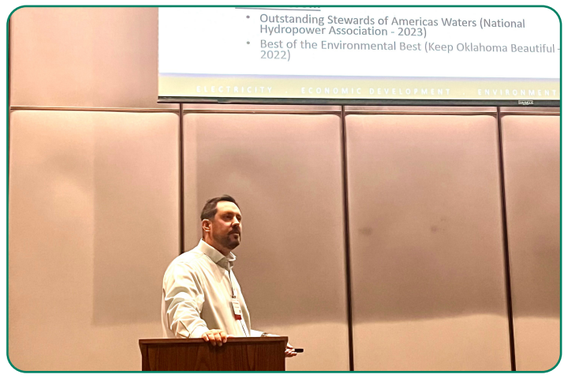
GRDA's Ecosystems & Watershed Management department provides many educational opportunities to local K-12 schools, universities, and stakeholders in our watersheds. Educational outreach is an important part of GRDA's mission by teaching others about environmental stewardship. Through this outreach, the public can gather knowledge firsthand from professionals and are exposed to a variety of career opportunities. Our team strives to promote engaging and meaningful lessons and activities that will get not only students, but the general public excited about STEM education.

GRDA offers a variety of educational outreach opportunities for schools. For example, schools can contact GRDA to request a guest speaker to come to their classroom to discuss a variety of topics. Including water quality, water management, conservation, stream health and staff can even bring live creek bugs to your location. The speaker will bring hands-on resources to your students and use them to connect to Oklahoma's Academic Standards for Science. Schools can also travel to our Ecosystems and Education Center for an engaging, educational field trip. Students will have hands-on learning experiences, tour our state-of-the-art Water Quality and Research Laboratory and tour Oklahoma's first hydroelectric facility – the Pensacola Dam. The Center has a large conference room and a patio to accommodate large groups and a place to eat lunch with a view of Grand Lake!

GRDA also hosts a youth camp in the summer at the Ecosytems and Education Center. At this camp, GRDA partners with other agencies to have two full days of activities for 9–12-year-olds. The students learn about the water cycle, water pollution, erosion, what lives under the water, and how to seine for bugs and fish while wading in the creek. Each year, GRDA participates in multiple outreach events around our watersheds. These events include: The MidAmerica STEM Alliance Showcase, The Lost Creek Water Festival, Earth Day Events, the Wyandotte Nation and local career fairs, among many others.

In 2025, it is estimated that our team reached over 5,000 people through these outreach programs! These folks spanned across our jurisdictional watersheds. Educating the public and youth on environmental protection creates a direct impact on the environment by changing the behaviors and attitudes of the people reached, while allowing them to influence those around them. To schedule outreach with our team, please email Jacklyn Smittle at Jacklyn.Smittle@grda.com.

GRDA hosted a river cleanup with the Thunderbird Academy



Dustin Browning speaking at the 2025 OCLWA Conference

Conservation Easements

One of Grand River Dam Authority's foundational objectives was to create a conservation and reclamation district. Thus, good stewardship of natural resources has always been at the core of the GRDA mission. GRDA has 62 conservation easements (CEs) in northeastern Oklahoma, all owned by private landowners or rural water districts. These conservation easements are legally binding although voluntary agreements to maintain the ecological quality of landscapes within the easements. The goal of this program is to keep the land and forested areas surrounding our water bodies as natural as possible. By doing this, the water quality in these areas will be better off and we our scenic rivers will stay scenic.

The landowners work with GRDA staff and program resources to manage the easements in ways that will benefit water quality and ecological functionality. These agreements include best management practices (BMPs), such as: no new construction, keeping out livestock, and maintaining riparian forest. These naturalized riparian areas can filter as much as 80% of pollutants such as bacteria, nutrients, and sediments before they enter streams, and are one of our best and least expensive tools to help protect water resources in our scenic rivers. Since GRDA's absorption of the Oklahoma Scenic Rivers Commission in 2016, 2020.98 acres have been added to the conservation easement inventory.

In 2025, all 62 CE parcels were visited and cursorily assessed for legal compliance, ecological diversity, ecological stressors, biodiversity, and invasive species. A simple scoring method was used to rank all CEs. The scoring values tend to reflect acreage and biodiversity: the greater the acreage, the greater the ecological and biological diversity. Analyses were limited by the strong seasonal variations in the biodiversity data, as the CEs were not all accessible at the same seasons. A proposed strategy for future CE monitoring and management for future years is in development.

Also in 2025, six CE parcels were especially selected for quantitative monitoring. Pollinating insects and terrestrial insect biodiversity were measured once per month for five months. Specific randomly selected fixed sites on each CE parcel were selected for bimonthly sampling of the vegetation community, canopy cover, and soil attributes. This data will be used to evaluate the ecological health and functionality of the conservation easement, as well as inform management efforts and programs to restore or enhance the easement.

Steve Nikolai and Cale Corley performing a vegetation survey

Interns Zoe Pippin and Caden Lyons processing samples

NEO A&M Partnership

In the summer of 2016, GRDA and NEO A&M College (Miami, OK) entered into a partnership that created new opportunities for pecan production, livestock grazing, and hands-on agricultural education. Originally, GRDA leased 1,600 acres in Ottawa County to the college for just $1 per year, but the collaboration has grown significantly. Today, NEO A&M has access to nearly 3,000 acres for its agricultural programs. GRDA continues to support the effort by helping manage the land through controlled burns and other best management practices that promote healthy pastures and orchard productivity.

This partnership also gives NEO A&M the ability to sublease portions of the pecan orchards to local growers, creating an additional revenue source for the school. It's an example of how thoughtful public-private collaborations can help educational institutions navigate financial challenges while strengthening ties with the surrounding community.

Beyond land management, GRDA staff work closely with the college to enrich student learning. This includes offering drone-related instruction, guest lectures, and research support, providing students with valuable, real-world experience in natural resource management and environmental stewardship.

Controlled Hunts

In addition to its partnership with NEO A&M, GRDA has opened roughly 2,000 acres along the Neosho River for controlled hunts managed directly by the Authority. Members of the public can register online, and hunters are selected through a random draw, with priority given to residents of GRDA's municipal customers and public power communities.

These controlled hunts include opportunities for deer, waterfowl, and turkey. GRDA has also designated specific hunting areas for the Mid-America Chapter of the Paralyzed Veterans of America (PVA), providing accessible outdoor recreation for individuals with mobility impairments. Since 2014, approximately 1,000 acres have been reserved for PVA hunts, helping ensure that veterans who might otherwise face barriers to public hunting lands have meaningful access to the outdoors.

A group of veteran hunters at Neosho Bottoms

During the 2025 season, GRDA hosted about 20 veteran hunters and an additional 70 hunters selected through the conventional drawing process across turkey and deer seasons.

GRDA's Neosho Bottoms team is also collaborating with the Quapaw Tribe to conduct prescribed fire trainings and Chronic Wasting Disease (CWD) testing on deer harvested through these controlled hunts, supporting landscape and wildlife health along with responsible herd management.

A look back at 2025 through photos

A look into the odds and ins of life as an Ecosystems and Watershed Management employee, the activities we partake in, and the projects and programs that we help support.

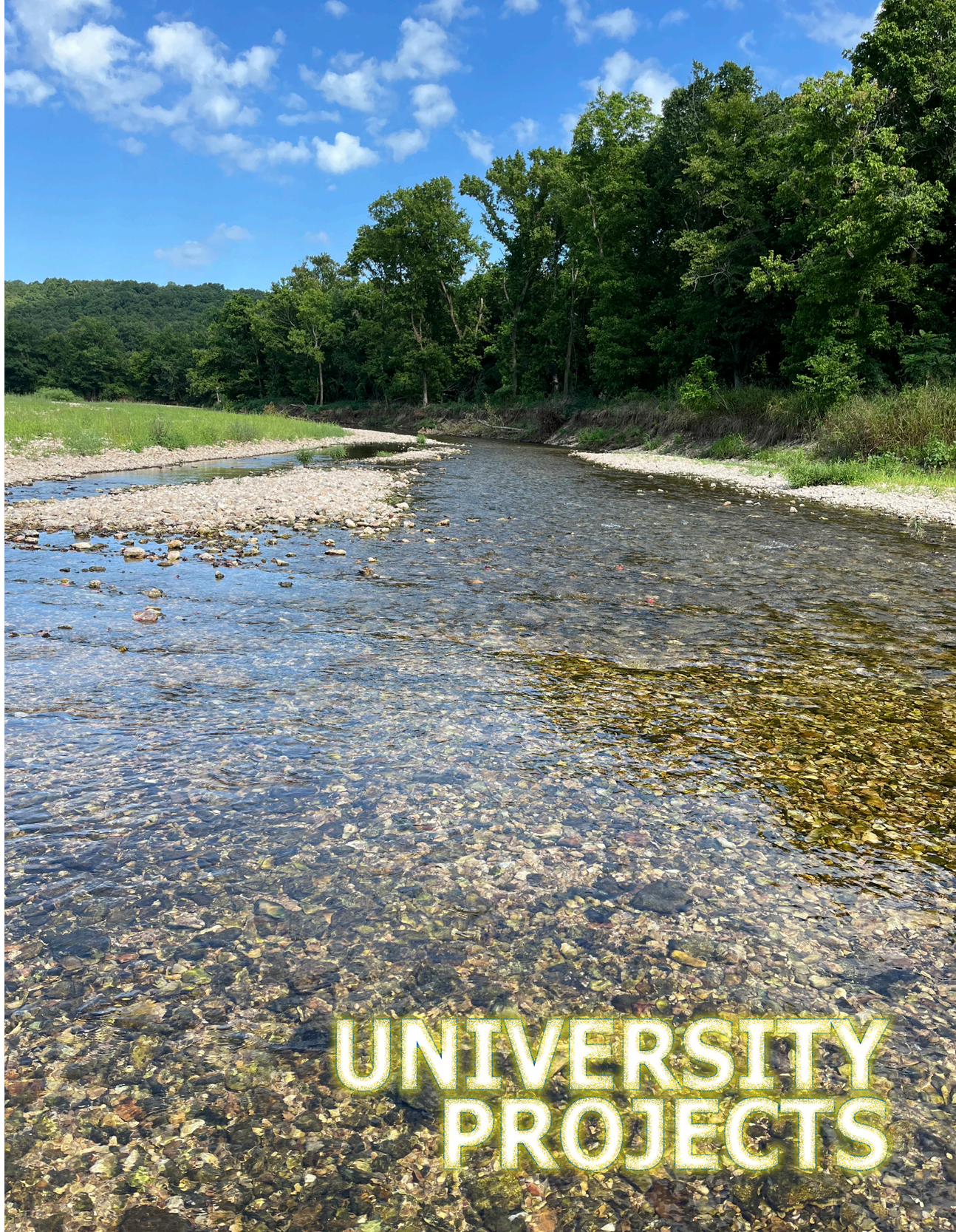
Joel Barrow works to geo-locate fish structures

Intern Josie Moore with fish collected from the Illinois River

A Great Blue Heron searching for its next meal

Intern Zoe Pippin piloting GRDA's research vessel

The Ecosystems team heads out to dinner in Stillwater



An Assessment of Carbon Sequestration of Forested Conservation Easements in Sparrowhawk, Okla.

Kaitlin Branson & Lizz Waring
Northeastern State University
College of Science and Health Professions

Carbon dioxide is being discharged into the atmosphere by the burning of oil and coal for industrial purposes and by large scale deforestation efforts. Forests play a major role in slowing climate change and offsetting industrial pollution by removing carbon dioxide (CO_2) from the atmosphere and storing it in tree trunks, branches, leaves, and roots. It is important that forests and the individual trees that compose those forests can be quickly assessed in order to determine their carbon sequestration potential and their subsequent economic value. This study, supported by the Grand River Dam Authority (GRDA) and conducted by Northeastern State Univeristy set out to measure how much carbon is being captured and stored within GRDA's conservation easements in northeastern Oklahoma. It also explored the cultural importance of these forests to Cherokee communities, whose lands overlap with several of the study areas

During summer 2024, researchers measured 164 trees across four of the six Sparrow Hawk Village easements. Each tree's diameter, height, species, and overall health were recorded. Twenty-five species were identified, with Mockernut Hickory (*Carya tomentosa*) and Slippery Elm (*Ulmus rubra*) being the most common. Many of the trees found on GRDA's conservation easements have deep cultural, medicinal, and nutritional value to Cherokee people. Once identified, tree measurements were entered into the U.S. Forest Service's I-Tree Design tool, which estimates how much carbon each tree stores now and how much it will absorb in the future. Results show that the trees within sparrowhawk village are currently storing 74,620 kg of carbon and have a 50 year carbon storage projection of about 843,873 kilograms. This currently represents about $52,000 of carbon storage with the 50 year sequestration value being about $5.9 million. When we zoom out and look at all of GRDA's easements, we see that the total carbon stored is around 78 million kilograms which translates to an economic value of around $36.8 million.

The GRDA conservation easements represent a natural carbon sink, storing tens of millions of kilograms of carbon and continuing to absorb more each year. Their ecological and cultural value makes them highly important for long-term conservation, climate resilience, and tribal heritage. While protecting the forested areas within its easements, GRDA helps maintain ecological health and preserves cutural heritage.

Management Implications: This study emphasizes that GRDA's conservation easements hold high ecological and cultural value and can guide future forest management, afforestation, and restoration projects across the region.

A 10x10 sampling plot at SparrowHawk

Habitat Characteristics of Terrestrial Burrowing Crayfish in Oklahoma

Cale Ingle, Cheyanne Olson, & D. Christopher Rogers
Northeastern State University
College of Science and Health Professions

Terrestrial burrowing crayfish are a unique group of decapod crustaceans that live most of their lives in deep burrows, sometimes far away from open water. In northeastern Oklahoma, two primary species are recognized: the Prairie Crayfish (*Procambarus gracilis*) and the Osage Burrowing Crayfish (*Procambarus liberorum*). These crayfish are classified as primary burrowers, meaning they spend nearly their entire lives underground, unlike species that rely more heavily on open water. Primary burrowers construct complex tunnels with multiple chambers, sometimes extending down more than six feet, often with surface chimneys above ground. Both crayfish species often emerge during rainy periods or on warm, humid nights, with peak activity observed at night from late spring to early summer.

Burrowing crayfish play important roles in ecosystems. Their digging aerates soil, improves water infiltration, and cycles nutrients, which benefits plants, fungi, and microbes. They also act as scavengers and omnivores, processing organic matter into forms usable by other organisms. Their burrows provide shelter not only for the crayfish during droughts, but also for amphibians, reptiles, insects, and small mammals. Despite their ecological importance, burrowing crayfish remain understudied due to the difficulty of locating and excavating their deep burrows, as well as variability in occupancy related to soil and hydrology.

We are investigating the environmental factors that influence burrowing crayfish occupancy in northeastern Oklahoma. During summer 2025, a total of nine sites were surveyed around Tahlequah, Oklahoma and measured weekly for water content, temperature, pH, and crayfish activity. Male form I specimens were collected and identified as *Procambarus liberorum* Fitzpatrick, 1978.

This project is ongoing, with site surveying and future collection planned for Spring 2026. By combining soil data with hydrology and biological observations, we aim to fill gaps in our understanding of burrowing crayfish ecology.

A typical surface burrow from *Procambarus liborорum*.

Management Implications: This project aims to fill gaps in our understanding of burrowing crayfish ecology, with an emphasis on habitat requirements. The results will help resource managers make informed decisions about conservation, habitat protection, and land-use planning.

Unveiling the Role of Sulfur in Harmful Algal Blooms: Implications for Microcystin Management in Grand Lake

Ankur Biswas & Puni Jeyasingh
Oklahoma State University
Department of Integrative Biology

Harmful algal blooms (HABs) present significant global ecological and public health challenges due to their production of harmful toxins such as microcystin. These cyclic heptapeptides disrupt essential cellular processes, posing risks to aquatic ecosystems and human health. Predicting the occurrence and potency of microcystin remains a pressing challenge. Sulfur (S) is critical for the synthesis and toxicity of microcystin. However, the role of S in microcystin production in natural systems has received little attention compared to nitrogen (N) and phosphorus (P). This is particularly notable given the documented spatiotemporal variability in S availability across and within aquatic ecosystems.

Here, we examine the relationship between sulfur availability and microcystin production in Microcystis aeruginosa, a prominent toxin-producing cyanobacterium. Using a gradient of S supply (2–300 µM sulfate), we found that S availability positively influences cyanobacterial growth, with higher cell abundance observed under increased S concentrations. Correspondingly, microcystin quotas were highest under conditions of high S availability, suggesting a direct relationship between S supply and toxin production. This finding points to a regulatory mechanism governing microcystin synthesis that remains poorly understood and warrants further investigation.

Our findings underscore the potential of ionomic data, specifically S bioavailability, as a valuable tool for forecasting microcystin production in freshwater ecosystems. Traditional monitoring and management strategies have predominantly focused on the roles of N and P in promoting bloom formation and toxin production. However, our results highlight the need to expand this perspective to include S. Given the substantial heterogeneity in S availability across freshwater systems, incorporating S dynamics into predictive models could enhance our ability to anticipate and mitigate the risks associated with HABs.

Management Implications: The findings of this study inform strategies for monitoring and managing harmful algal blooms in Grand Lake, Oklahoma. The spatiotemporal variability of S in Grand Lake, driven by differences in geology across the reservoir's arms, presents an opportunity to apply this research in real-world scenarios. By assessing S bioavailability alongside traditional metrics such as N and P, the GRDA could enhance its capacity to forecast microcystin production and develop more targeted mitigation strategies.

Ankur loads his sampling gear into GRDA's research vessel

Chemical Interactions between Magnesium and Phosphorus determine the growth of Algae and Daphnia

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The growth of an organism is influenced by the availability and interactions of about 25 elements that are required to support the structures and functions inside any living cell (the unit of life). The element carbon (C) forms the backbone of biomolecules and is abundant in cells. Nitrogen (N) and phosphorus (P) are next two abundant elements in biomass. Much of the cellular N is in the form of amino acids, while the majority of cellular P encompasses nucleotides (e.g., RNA, DNA, ATP). Other elements of lower abundance also play key roles in biochemistry, such as magnesium (Mg), an indispensable associate of P in DNA, RNA, and ATP, balancing the negative charge of phosphate so that these key molecules maintain structural integrity to perform biochemistry.

While the role of P in algal growth and eutrophication has been investigated at different levels of organization (i.e., cells to ecosystems), forecasting productivity has remained elusive. We contend that attention to Mg could advance prediction of eutrophication and algal blooms in models based solely on P. Given the chemical requirement of Mg on the biochemical functioning of P, and the heterogeneity of Mg across lakes nationally (range: 100 to 8000 µg/L), we have designed experiments to study the interconnectedness of Mg and P supplies on the growth of the freshwater primary-producer green algae (*Scenedesmus obliquus*) and the growth of a primary consumer zooplankton (*Daphnia pulex*). Under laboratory conditions, we found altering Mg supply significantly changed algal growth rate and phosphorus use efficiency (PUE) at the same P supply levels. Further, Daphnia that were fed with algae grown under different Mg:P supply conditions also showed significant differences in growth rate and PUE.

In Grand Lake, a reservoir of great socioeconomic importance for the State of Oklahoma – Mg varies spatially among different parts of the reservoir due to geological factors (e.g., underlying bedrock composition) and land-use practices (e.g., agricultural run-off). Moreover, Mg supply can also vary seasonally due to stratification/mixing of the water column as well as sediment geochemistry. Little is known about the relevance of such variation on growth physiology as well as lake ecology. In the future, we plan to apply and expand our laboratory findings to field sites in Grand Lake and test our hypothesis of Mg supply relative to P on organismal growth and ecosystem productivity.

Management Implications: This study will help forecast eutrophication illuminating novel management and regulatory strategies.

Parna Ghosh working on samples in the growth chamber

Evolutionary Ionomics: Illuminating the Systemic Context of Metal Tolerance in Sunfish Inhabiting the Tar Creek Superfund Site

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Why do fish populations differ in metal tolerance? This study investigated the adaptive responses of fish populations to heavy metal pollution at the Tar Creek Superfund site within the Tri-State Mining District, historically contaminated by metals. Despite environmental remediation efforts, persistent contamination by metals, notably lead (Pb), cadmium (Cd), and zinc (Zn), continue to impact the aquatic ecosystem. Remarkably, we discovered populations of Bluegill (Lepomis macrochirus) inhabiting this polluted ecosystem. To understand how these conditions affect Bluegill populations, we hypothesized that fish in the most contaminated sites would differ in their elemental compositions. Our investigation examined Bluegill from 2 polluted – 1 highly polluted, 1 moderately polluted - and 2 reference sites. We measured concentrations of metals in fish tissues, including gill, liver, intestine, skin, white muscle, excrement, and water samples using inductively coupled plasma optical emissions spectrometry and mass spectrometry (ICP-OES and ICP-MS, respectively) methodologies. The concentrations of 15 elements were measured, including lead, cadmium, zinc, arsenic, bromine, calcium, copper, iron, magnesium, manganese, potassium, phosphorus, sodium, sulfur, and selenium. Metal concentrations measured in the water from the most polluted site were 12.49 µg/L, 12.17 µg/L, and 7445.39 µg/L for Cd, Pb, and Zn, respectively; and were below the limit of detection in the reference site farthest away from the sources of contamination. Preliminary analyses revealed significantly elevated metal concentrations in fish tissues collected from highly contaminated sites compared to reference sites. There was a strong positive correlation between the concentration of metals measured in the fish tissues and those measured in the water. Moreover, the patterns were tissue-specific, with skin and gill ionomes exhibiting the greatest responses to dissolved metal concentration. Our findings indicate that changes in the ionomes might be associated with evolutionary adaptation of sunfish inhabiting Tar Creek waters.

Management Implications: Deciphering the biochemical mechanisms underlying observed ionomic patterns can provide key insights for future research. As such, our study not only illuminates on possible physiological mechanisms of metal bioaccumulation but is also relevant to inform policies addressing ongoing contamination from legacy mining operations.

OSU utilizing GRDA's mobile command center

Aryanna fishing to collect fish samples from Sycamore Creek

Resurrection Ecology and Paleolimnology: tracing invasion history and cyanobacterial tolerance of *D. lumholtzi* in an Oklahoma reservoir

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Grand Lake O' the Cherokees, one of Oklahoma's most economically and culturally important reservoirs, has been experiencing growing pressure from two major ecological sources: the presence of aquatic invasive species and increasing cyanobacterial blooms. My research explores how these forces interact by studying *Daphnia lumholtzi*, a tropical freshwater zooplankter that first appeared in the southern U.S. in the 1980s. Since, it has spread rapidly across warm waterbodies. Using paleolimnology (the study of lake history through sediment analysis), I aim to uncover how *D. lumholtzi* arrived, established, and potentially adapted to Grand Lake's changing environmental conditions. Grand Lake's sediments function like a natural archive. As material settles year after year, layers stack up, preserving microscopic clues about the past conditions of the reservoir. One of these clues comes from ephippia, the durable resting eggs produced by Daphnia in response to stressful conditions. Ephippia can survive for decades or even centuries in cold, dark sediments, providing a timeline of how zooplankton communities have changed.

Using sediment cores collected from two contrasting sites, Horse Creek (a location with frequent cyanobacterial blooms) and Duck Creek (a site with minimal bloom history), I am isolating, counting, and identifying ephippia to reconstruct the ecological narrative of the reservoir. Cyanobacteria, sometimes called "blue-green algae", thrive in warm, nutrient rich, and stratified waters. They can produce toxins harmful to humans, wildlife, and pets, and they often outcompete other algae by changing their buoyancy and blocking sunlight from competitors. While native Daphnia species struggle under these conditions due to poor food quality or toxicity, *D. lumholtzi* appears more tolerant. This tolerance may stem from its tropical origin, where cyanobacterial blooms are more common, potentially selecting species with greater resistance.

Initial analyses of cores from other Grand Lake sites show interesting spatial variation: some locations have dense ephippia layers indicating long-term, stable Daphnia populations, while others show low abundances that suggest more recent or fluctuating communities. These patterns may suggest that Grand Lake's zooplankton dynamics are shaped by local water quality. Completion of analyses will help us understand how bloom-prone environments may either help or hinder the long-term success of *D. lumholtzi*. This information will help clarify whether *D. lumholtzi* is simply a symptom of broader reservoir change or an active contributor to ecosystem shifts.

Management Implications: This project provides a historical baseline for how warming, nutrient enrichment, and invasive species collectively shape Grand Lake. Understanding how *D. lumholtzi* respond to blooms helps forecast ecological shifts and identify areas at greatest risk, supporting effective watershed planning, HAB mitigation, and long-term conservation of native communities.

Bee and Bill collecting sediment cores from Grand Lake

Assessing Macroinvertebrate Communities throughout Grand Lake and its associated tributaries.

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Freshwater ecosystems are home to a wide diversity of insects, worms, mollusks, and other small creatures without backbones. These animals are commonly referred to as macroinvertebrates. Although they are often overlooked, macroinvertebrates play vital roles in aquatic ecosystems. They help break down leaves and organic matter, cycle nutrients, and serve as an essential food source for fish, amphibians, and waterfowl. Macroinvertebrates vary substantially in their tolerance to environmental conditions, their ability to move between habitats, and in their interactions with other organisms. These differences help explain why certain species thrive in one location but not another. By studying what drives macroinvertebrate community patterns, we can better understand, protect, and restore the ecosystem services that freshwater environments provide.

One current project investigates how macroinvertebrate communities vary across Grand Lake. This work focuses on the zones where smaller streams (i.e. tributaries) enter the lake. These "confluence areas" (i.e. the "branches" of Grand Lake) are notably different than the "mainstem" habitats. Sampling in 2023 and 2024 has revealed that each confluence hosts a distinct community, influenced by the unique characteristics of its tributary. These findings emphasize that maintaining connectivity among tributaries and the lake is critical for sustaining regional biodiversity.

A second project examines the elemental makeup of macroinvertebrates in the Neosho River, particularly trace elements that accumulate in tissues. Different species feed on different resources and occupy different habitats. For example, worms deep within sediments have a very different role in the ecosystem than beetles near the surface. Our results indicate that each taxonomic group is composed of a unique assortment of elements. These patterns may provide valuable insight into how different elements, both biologically necessary and potentially toxic, can move through the food web and eventually reach fish and other wildlife.

Another project focuses on nearshore invertebrates in Duck Creek, where we use different forms of carbon and nitrogen (i.e. stable isotopes) to understand diet differences and relative food-web positions. These positions are often known as their "trophic niches," and they can be used to understand which species compete for resources, and which species are specialized in their diet. The results show that generalist feeders consume a wider range of food sources than specialist species, although certain species (like freshwater shrimp) have a more specialized diet than previously thought. Additional ongoing work includes examining how invertebrates disperse upstream against flowing water and studying freshwater sponges throughout the state.

Management Implications: Because macroinvertebrates link energy and nutrients from algae and decaying material to larger animals like sportfish and waterfowl, changes in their communities can have substantial effects. By understanding how species differ in their movement, feeding, and environmental tolerance, we can better manage freshwater habitats, identify areas most in need of restoration, and protect the wildlife and human communities that depend on them.

Early detection of Zebra Mussels through Environmental DNA (eDNA)

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Early detection of invasive species increases the likelihood of successful eradication. An emerging technique for early detection of invasive species is environmental DNA (eDNA), which is intracellular and extracellular DNA that has been shed into the environment by the organisms present in an area. eDNA sampling is a highly sensitive method that can be used to detect invasive species at relatively low quantities or in low visibility habitats compared to traditional detection methods. Even if eradication is not possible, eDNA sampling techniques could be incorporated into Early Detection Rapid Response (EDRR) plans, which are detailed action plans to help minimize the impacts and costs of invasive species.

Studies have shown that eDNA sampling is an effective method for detecting zebra mussels (ZM), which are a prolific invasive species. Our recent samples suggests that ZM are currently in abundances in Grand Lake. Traditionally, eDNA sampling for detecting ZMs has been collected using grab, kick, and veliger tow-net samples of varying volumes. However, the traditional grab sampling method may not provide enough eDNA in newly invaded or low-abundance systems. A recent study showed that large volume tow-net samples (>1000L) collect more ZM eDNA than traditional grab samples (~1L). A tow-net (63µm mesh) was pulled through the water for 100m which funneled all the biological material into a small cup while filtering ~1000L of water. This filtration method allowed researchers to analyze larger volumes of water per sample and then determine if the large volume filtered sample was more sensitive to detecting low levels of eDNA and as a result a more effective option for early detection. These researchers compared these two approaches in several lakes in Minnesota and found that the large volume tow-net samples had more copies of eDNA than the grab samples. While the results of this study support the idea that large volume samples can be used as a tool for early detection of eDNA, comparisons of eDNA detection from tow-nets vs. traditional grab samples have been limited to a few lakes in Minnesota. Additional research is needed to extend this research into human-made reservoirs like Grand Lake, which are different than natural lakes in many ways including connectivity, turbidity, disturbance, and maximum temperature. These differences could influence ZM eDNA detection.

A plate sampler deployed at Grand Lake

This study will determine if the large volume tow-net sampling method is viable for detection of zebra mussel eDNA in reservoirs. I am collecting monthly paired tow-net and grab samples for comparisons of eDNA detection. GRDA is conducting eDNA analyses.

Management Implications: The use of eDNA for detecting ZM in northern lakes suggests that it is a viable tool for use in early detection. This study will evaluate their use in warm, turbid reservoirs. This comparison of eDNA methods will help managers make informed monitoring decisions.

Assessment of Remote Sensing of Culturally Important Vegetation, *Arundinaria gigantea* (Giant Rivercane), in Eastern Oklahoma, USA

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Current remote sensing capabilities allow to potentially locate and access culturally important vegetation, such as Arundinaria gigantea (giant rivercane), more quickly and easily than traditional methods (i.e., ground-truthing). As the abundance of rivercane continues to diminish from the landscape, Indigenous peoples with ties to this keystone species are losing a significant resource for cultural uses. A small unoccupied aerial system (sUAS), equipped with an optical sensor, collected high-resolution (0.7-meter), leaf-off, multispectral aerial imagery data of known rivercane ecosystems, or canebrakes, within bottomland forest canopies. Red, blue, green, red-edge, and near infrared (NIR) wavelengths were analyzed to create index maps (i.e., Normalized Difference Vegetation Index or NDVI) for detecting canebrakes. The study site, historically known as Lake Frances, focused on one-kilometer tract of early successional bottomland forest along the Illinois River, designated as a State Scenic River, near the town of Watts in Adair County, Oklahoma, and within the boundaries of the Cherokee Nation. Canebrakes were detected at the known locations using NIR; however, the imagery in dense vegetation areas did not allow for distinguishing rivercane from other riparian vegetation (Figure 1). Furthermore, the presence of facultative wetland (FACW) and wetland obligate (OBL) plant species indicated that the underlying soil, hydrologic regime, and atmospheric vapor likely produced wetland vegetation canopies, which can complicate or decrease the NIR values due to the occurrence of water and wet soil. NDVI results were used to assess vegetation density and the potential health of canebrakes (Figure 2). The north study area displayed the greatest NDVI values outside the canebrake areas, which supported the conclusion that other evergreen or cold-tolerant vegetation were present along the riparian areas. The NDVI analysis of the south study area agricultural field were greatest within the field area, which further suggested a winter cover crop had been planted. Therefore, a unique spectral signature for canebrakes compared to other vegetation present could not be identified. It was concluded that ground truthing remained the most reliable tool for identifying rivercane, while an approach for classifying canebrakes from other vegetation species using remote sensing could be improved upon in the future. The utilization of only remote sensing techniques for finding canebrakes is not yet practical for local stakeholders and tribal members due to the lack of accessibility to high-resolution imagery. Future combinations of readily accessible optical sensors, with hyperspectral wavelengths and light detection and ranging (LiDAR) capabilities may allow for more precise and accurate remote sensing of canebrakes. The combination of more robust wavelengths or wavelength ratios and transformations, including short wave infrared or SWIR, and height data could distinguish rivercane from other vegetation (evergreen or deciduous).

Management Implications: As accessibility to innovative remote sensing technologies and tools increases, the ability for tribes and stakeholders to use similar methods to detect and identify canebrakes for cultural use will serve as a guide.

A drone image taken during a rivercane search flight

Modelling the Effects of Natural Infrastructure in a Bottomland Hardwood Forest

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Land use change and climate variability have contributed to the fragmentation and degradation of culturally significant, self-sustaining ecosystems such as canebrakes and wetlands in the bottomland hardwood forests of the southeast United States. Canebrakes are dense culms of Arundinaria gigantea (rivercane), a native bamboo, that once dominated natural levees and floodplains and served as a cultural resource for Indigenous peoples. Both ecosystems are cost effective natural infrastructure and promote ecosystem services. In this study, rivercane restoration and wetland creation scenarios were studied using a calibrated hydrologic model, Gridded Surface/Subsurface Hydrologic Analysis (GSSHA), to determine rivercane and wetlands placement and extent and associated effects on water quality and quantity near Lake Frances in the Illinois River watershed. GSSHA model was set up by 1) delineating the watershed area (53 km2) (Figure 1); 2) creating a grid of the watershed area (50-meter resolution); 3) establishing infiltration values, surface roughness values, soil moisture values, and channel flow parameters; and 4) completing calibration and validation. Three scenarios of rivercane restoration were simulated. The first scenario simulated restoration of rivercane at the current stand locations (0.05 km2). The second scenario expanded the restoration of canebrakes in the northern portion (0.38 km2). The third scenario included areas from the first and second scenario as well as potential rivercane expansion at suitable locations (0.81 km2). Similarly, three phases of wetland implementation were simulated. Phase one included the Lake Frances property immediately south of the confluence of the Illinois River and Ballard Creek (0.19 km2). Phase two included the phase one changes and the expanded Lake Frances property (0.54 km2). The potential locations for wetlands in phase three included the sites modeled in phase one and two as well as nearby stakeholder properties (0.77 km2). The rivercane restoration scenarios showed the potential for minimizing sediment loading to the channels, maximizing infiltration, and decreasing overland flow as restoration extent increased (Table 1). The wetland creation scenarios predicted decreased peak flow as wetland area increased, with nearly 19 percent less overland flow and 44 percent retained in Phase Three (Table 2). However, elevated levels of sediment were transported as wetland area increased due to generalized hydrologic parameters and/or extent constraints. Based on these findings, it was estimated that the logarithmic increase of rivercane or wetland resulted in decrease of peak flows. Rivercane restoration and wetland creation also showed that sediment and nutrient loading into channels could be decreased. Rivercane restoration and wetland creation provide a multi-faceted approach to decreasing overland and channel flows, while arresting sedimentation and nutrients from reaching stream channels.

Management Implications: GSSHA modeling allows for the design of natural infrastructure and demonstrates how the use of best management practices impacts water quality and quantity. Besides the estimated benefits to water quality and habitat from adding natural infrastructure, restoration of rivercane and associated vegetation species provides opportunities for tribal use.

Hailey Blackwell working at Lake Frances

Simulating Extreme Climate Events on Restoration of a Cultural Keystone Species to Evaluate Plant Resiliency as Natural Infrastructure

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A culturally significant resource of southeastern United States Indigenous tribes, Arundinaria gigantea, or rivercane, has been demonstrated to support biodiversity, act as a vegetative buffer, and decrease surface runoff and sediment deposition. Anthropogenic changes to the landscape and the increasing number and intensity of climate change-induced disasters, or extreme climate events (ECEs), have adverse effects on riparian ecosystems where rivercane is located, thus increasing the need for restoration efforts. To better understand how rivercane productivity and resiliency are being affected by a changing climate, a study was conducted in a wind tunnel-porous media test facility operated by the United States Army Corps of Engineers (USACE). The Synthetic Environment for Near-Surface Sensing and Experimentation (SENSE) wind tunnel at the USACE Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi, USA, allowed for micro-climatological scenarios of sudden below-freezing temperatures, or "cold snaps", and extreme hot and dry conditions, or "flash droughts" to be simulated on rivercane plants prepared in a soil-test bed interfaced with the wind tunnel. Using environmental sensors, rivercane was monitored throughout the duration of each simulation. Chlorophyll/carotenoid index (CCI), used to monitor plant stress, and stomatal conductance (gs), enlisted to gage photosynthetic or transpiration activity, data showed significant differences between the rivercane plants exposed in the two experiments and in situ values. Soil moisture and vapor pressure deficit (VPD) were compared to CCI and gs to further explore the effects of transplanting and ECEs on rivercane. As hypothesized, the results showed the cold snap experiment had adverse effects on the capabilities of the rivercane leaves to photosynthesize and transpire ($p < 0.001$) and significantly impacted plant stress during in situ ($p < 0.001$) and pre-experiment conditions ($p < 0.05$).

The unchanged post-experiment CCI values suggested cold-temperature tolerance or that the foliage was not physiologically damaged despite the frost-impacted appearance of the leaves. The VPD was not a contributing factor for pre-cold snap experiment stomatal closure. During the flash drought experiment, the 40-day acclimation period allowed for plant recovery based on soil moisture being retained and CCI values remaining unchanged. The post-experiment stomatal closure was unchanged due to drought tolerance, similarity to in situ conditions, or foliage thermal damage. The VPD gradient assisted with determining when and why stomatal closure was occurring due to the differing VPD and gs values based on location, which demonstrated the microclimate of a rivercane ecosystem. Overall, the two ECE scenarios demonstrated how rivercane restoration via transplanting could be affected unless management for suitable acclimation occurs.

Management Implications: These studies provided insight on the importance of matching rivercane plant stock to their receiving climate for successful and resilient restoration and reintroduction projects.

Hailey Blackwell working in the SENSE lab at USACE's ERDC

Utilizing Geospatial Data for Rivercane Restoration in the Illinois River Watershed of Oklahoma and Arkansas, USA

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Arundinaria gigantea (rivercane) is a native bamboo to the riparian and bottomland areas of the southeast United States and carries significance to Indigenous peoples. Dense clumps of rivercane, or canebrakes, offer wildlife habitat and the elaborate network of rhizomes provide streambank stabilization and nutrient and sediment retention to support water quality. However, this culturally and ecologically important natural resource has declined to less than two percent of its former abundance. Although the evergreen foliage of rivercane allows greater visibility during leaf-off, the challenging terrain and dense vegetation of eastern Oklahoma and northwest Arkansas can make proper plant identification a timely and arduous process. In this study, physical parameters collected at 44 known locations of rivercane were collected to inform a suitability model in geographic information system (GIS) software to identify where rivercane may potentially be found in the Illinois River watershed (HUC 11110103).

The Illinois River watershed covers 4,144 square kilometers within Benton, Crawford, and Washington Counties in Arkansas (46 percent) and Adair, Cherokee, Delaware, and Sequoyah Counties in Oklahoma (54 percent) and within the treaty boundaries of the Cherokee Nation in Oklahoma. The Illinois River, a designated State Scenic River and culturally significant resource to the Cherokee Nation, flows 252 km east to west-southwest to Lake Tenkiller (Tenkiller Ferry Reservoir) and into the Arkansas River near Gore, Oklahoma. Land use, soil, elevation, and wetland datasets were reclassified according to the distribution of the known canebrake characteristics, which favored classes with greater rates of rivercane occurrence, and the sum of the four criteria established a likelihood scale for rivercane occurrence within the watershed. The land use/land cover (LULC) dataset showed 36.4, 31.8, and 27.3 percent of the canebrakes were located within emergent herbaceous wetlands, deciduous forests, and hay/pasture land use types, respectively, and the remaining 4.6 percent was evenly distributed among mixed forests and open water. The 44 known canebrakes overlapped with nine different soil types, which derived from five soil series (Elsah, Razort, Healing, Waben, and Britwater). The National Wetlands Inventory (NWI) dataset overlapped with 16 known canebrakes, which were distributed among forested/shrub wetlands and riverine areas with 15 and 1 canebrakes, respectively. Most canebrakes (28, or 63.6 percent), were not located within any wetland type. The known canebrakes occurring at specific points were extracted from the slope dataset. The slope percent ranged from 0 to 575 (0 to 80 degrees). Of the known canebrakes, 61 percent were located on a slope with less than 19 percent (11 degrees). Of the remaining canebrakes, slopes at 13 sites ranged from 27 to 66 percent (15 degrees to 33 degrees) and four canebrakes were distributed between 288 and 575 percent (71 to 80 degrees). Potential canebrake areas were estimated to occupy 395 km2 of habitat, or 9.54 percent of the watershed (Figure 2). Potential rivercane locations overlapped with 80 percent of the known canebrake locations, and remotely sensed rivercane locations from aerial imagery intercepted 82 percent of known canebrake locations.

Management Implications: By promoting rivercane along these riparian areas, resilient ecosystems may be conserved which will protect other crucial natural resources and ecosystems from more frequent and intense weather events. Furthermore, rivercane restoration efforts focused at locations identified from the GIS model can serve as a guide for Indigenous tribes to gather rivercane for cultural use.

Evaluating Impacts of Legacy Mine Wastes and Current Nature-Based Interventions on a Watershed Scale

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Comprehensive environmental assessment and monitoring are vital in the efficient planning and evaluation of remediation and restoration efforts. Detailed assessment and monitoring are especially important at large, complex legacy mining sites such as the former Tri-State Lead-Zinc Mining District, where contaminant sources such as mine drainage and waste rock have been allowed to interact with and degrade the quality of surrounding water, soil, and habitat. This study examined the effects of point sources, such as mine drainage seeps, and nonpoint sources, such as stormwater runoff interacting with surface-stockpiled mine waste, on water quality in Tar Creek, a mining-impacted tributary of the Neosho River. The first section of this study compared point and nonpoint source loading in Tar Creek and identified areas where nonpoint source loading was more likely to occur. Nearly 30 months of monthly monitoring indicated that most of the cadmium, iron, and lead loads in Tar Creek come from mine drainage, but most of the zinc loads come from nonpoint sources like the interaction between surface water and mine waste. Areas where vegetation has grown on the mine waste in and around the creek.

The second section of this study focused on nature-based interventions to decrease diffuse metals loading. Two interventions were examined: partial remediation of a mine waste pile, which included construction of a vegetated detention pond in the flood plain that was recently buried under mine waste, and the use of manure-based biochar as a sorbent for metals introduced to surface water by interaction with mine waste. The area where mine waste was partially removed was noted as a stream reach where nonpoint source loading occurred, although a lack of measurements before removal began does not make attributing the loading to the activity involved in mine waste removal possible. The vegetated detention pond constructed in the area uncovered by the partial removal of mine waste did not decrease metals concentrations in the runoff of the site. The functions of this detention pond in the first year after construction were limited by the lack of metals in the particulate fraction that could be removed via settling and a lack of wetland functions to decrease metals in the dissolved fraction. Continued monitoring may show improved performance of the detention pond in the future. The use of manure-based biochar also did not increase retention of trace metals from surface water and generated substantial concentrations of other pollutants (elevated nutrients and salts and diminished dissolved oxygen).

Management Implications: This study found that mine waste, secondarily contaminated soils and sediment, and unabated mine drainage discharges all negatively impact water quality in the watershed, and all should be addressed to effectively improve water quality in Tar Creek.

Justine McCann measuring turbidity in the field

Legacy Sediment Riparian Ecosystems: Understanding Phosphorus Dynamics in a Legacy Sediment Floodplain

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Legacy sediments are deposits of anthropogenically-derived historic sediments that accumulate in the landscape over time. These accumulations contain not only sediment but often pollutants like trace metals and excess nutrients. Historically, environmental legacy sediment research has focused on fluvial morphology and ecological changes following dam removal, stream bank sediment erosion and pollutant concentrations, and determining if legacy sediments within streams and lakes contribute to ongoing water quality degradation. As stream and lake sediments become increasingly exposed due to climatic changes, research is needed to determine if legacy sediment, when allowed to remain in place, continues to be a source of pollution decades after dam removal.

The Lake Frances dam, impounding the Illinois River in eastern Oklahoma, was damaged and the reservoir partially drained in 1990. Legacy sediments were allowed to remain in place and after 35 years the former lakebed is now a riparian floodplain with a young successional bottomland hardwood forest. An ongoing research project is being conducted at Lake Frances to better understand if and how the legacy sediment floodplain (LSF) is a source or sink of one type of pollutant: phosphorus (P). The research focuses on the hydrologic mechanisms behind P storage and release from the surficial soils of a LSF. The research goals are to 1) analyze LSF soils to better understand their composition and physical characteristics, 2) determine where P is stored throughout the floodplain, and 3) evaluate whether LSF soils may serve as either sinks or sources of P to adjacent water bodies.

The project includes three interrelated studies. The first study involves site-wide characterization of soil physical and hydrologic properties, including particle size distribution, soil moisture content, porosity, and infiltration capacity. The second study provides an estimate of soil total P and plant-available P while also determining the potential of the soils to release P to standing or flowing water. The third study evaluates LSF soil P sorption capacities and compares those capacities to a single-point P sorption index. To date 175 shallow soil samples have been collected and analyzed. The soils characterization and phosphorus studies are nearly complete.

An incised creek in the old Lake Frances lake bed

Management Implications: This research aims to evaluate whether legacy sediments and their associated pollutants continue to impact riverine ecosystems and downstream water quality decades after dam removal, ultimately supporting the development of best management practices for legacy sediments.

Microbial Adaptations in Sulfate-Reducing Bioreactors for Treating Mine Drainage

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Trace metals polluting surface waters can be immobilized by naturally occurring sulfate-reducing bacteria (SRB) that "inhale" sulfate and "exhale" sulfide, instead of oxygen and carbon dioxide as in aerobic respiration. The sulfide they produce binds with dissolved metals, precipitating them into solid forms, decreasing their bioavailability and toxicity. These organisms mitigate metal contamination and are utilized as a nature-based solution in the Tar Creek Superfund Site of northeast Oklahoma, where metal-rich mine drainage is a considerable source of pollution. The Mayer Ranch Passive Treatment System in Commerce, OK has been remediating mine drainage for more than 17 years, and contains a series of treatment units, including compost-based bioreactors that are designed to promote the activity of SRB and prevent metals like lead, zinc, iron and cadmium from reaching downstream water bodies. These sulfate-reducing bioreactors amplify metal sulfide precipitation by having a carbon rich substrate to feed the SRB, and a vertical flow design that creates the anaerobic environment that SRB require.

This research assesses the identities and adaptations of microorganisms in this system by cultivating wild SRB from the Mayer Ranch bioreactors, and analyzing their microbial communities with DNA sequencing methods. Novel strains of wild SRB were isolated and tested for metal tolerance adaptations by growing them with large amounts of zinc but they did not outperform the reference organisms from non-contaminated sites, suggesting a lack of strain level metal tolerance adaptations. DNA extraction and sequencing of the bioreactor substrate showed that a variety of SRB were present, as well as a diverse array of microorganisms capable of breaking down complex carbon sources, like those in the compost bioreactor substrate. These types of microbes are important in sulfate-reducing bioreactors because SRB tend to use simple forms of carbon and need other organisms to break down complex carbons for them. These preliminary results suggest that the individual SRB in mine drainage treatment bioreactors were not necessarily adapted to tolerate greater amounts of metals, but having a diverse community of SRB and supporting microbes is important in the efficacy of these systems. These findings reflect the importance of an ecosystem level approach, instead of focusing on individual organisms for nature-based bioremediation.

Management Implications: Designing systems that promote naturally occurring microbial processes are an effective method for treating surface water contamination, and creating an optimal environment for the desired organisms is key to the success of the mine drainage treatment bioreactors. Adaptation at the community level, leads to a diversity of organisms capable of the key functions, and is more important than the adaptations of individuals. Bioaugmentation, the addition of foreign organisms to improve remediation outcomes, is likely unnecessary in the studied system if the proper environment is created.

Leif Olson collecting samples at Mayer Ranch

Microbial Communities with Metal Removal Capabilities in Mine Drainage Contaminated Wetlands

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Wetlands are important ecosystems for transforming chemicals in the environment, including potentially toxic metals. In the Tar Creek Superfund Site in Ottawa County, OK many of the numerous mine drainage discharges flow into natural occurring cattail marshes. Wetlands like these cattail marshes can remove metals including lead, zinc, iron and cadmium from surface water through the processes of iron oxidation and sulfate reduction, which transform dissolved metals into solid precipitates that settle out of the water column and are immobilized in the sediments. In addition to these natural wetlands, mine drainage contamination is also mitigated with treatment wetlands, engineered ecosystems designed to amplify naturally occurring water quality remediation processes. The Mayer Ranch Passive Treatment System in Commerce, OK has been remediating mine drainage in the Tar Creek Superfund Site for more than 17 years and contains aerobic treatment wetlands, which are engineered cattail marshes designed to promote iron oxidation. These treatment wetlands are designed to precipitate dissolved iron through the "rusting" process and can immobilize other metals through co-precipitation and sorption. In contrast, the sulfate-reducing bioreactors at Mayer Ranch are designed to promote anaerobic metal sulfide precipitation, another natural wetland process. Microorganisms can perform both processes. Sulfate reduction is almost entirely driven by bacteria, while iron oxidation can also occur spontaneously, without microbial activity. This project compares microbial communities present in the surface water and sediments of a natural cattail marsh receiving mine drainage near Tar Creek with the Mayer Ranch treatment wetlands, as well as a natural cattail marsh downstream of Mayer Ranch, where the metals from the mine drainage have been removed. This approach allows a novel comparison between natural and engineered wetlands to assess if the microbial communities present at each are associated with the expected iron and sulfur cycling processes occurring. Water and sediment samples were collected from the three wetlands of interest. Parts of these samples were processed in GRDA's Microbiology Laboratory in Langley, OK. Sediment samples were centrifuged and water samples were poured through sterile filters to concentrate microbial biomass in preparation for DNA extraction, sequencing, and subsequent microbial community analysis. The remaining sediment and water sample material is being analyzed for chemical content. Preliminary results show that 1) iron-oxidizing bacteria are the dominant organisms in treatment wetland surface water but are relatively scarce in treated water downstream from Mayer Ranch and 2) mine drainage contaminated sediment samples contain a variety of sulfur and iron transforming microbes, but a majority of the sediment microbes are unidentified.

Management Implications: These results indicate that the wetland surface water and sediments are hosting considerable amounts of bacteria associated with mine drainage remediation, but unlike the water, sediment samples are dominated by microbes yet to be identified in microbial databases, suggesting they are reservoirs of novel, unidentified organisms.

Leif Olson filtering samples in GRDA's microbiology lab

Remote Sensing Utilizing sUAS-Mounted LiDAR and Thermal Sensors to Determine Surface Water-Groundwater Interactions and to Map Potential Wetlands

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Streams and wetlands play important roles in the fate, transport and biogeochemical cycling of nutrients, sediments, carbon, and pollutants. Additionally, streams and wetlands act as interfaces between surface waters and groundwater. This research aims to utilize small unoccupied aerial systems (sUAS) to identify areas of metal contaminated groundwater upwellings into streambeds at the Tar Creek Superfund site and to determine microtopographic changes in the former Lake Frances lakebed to find appropriate areas for creation of a mosaic of wetlands. Use of sUAS creates a platform for the generation of rapid and reproducible data without many of the drawbacks of traditional remote sensing methods, such as: atmospheric disturbances, long return times, and low spatial resolution.

For the Tar Creek Superfund Site study, identifying areas of groundwater upwellings is especially important due to mine pool contamination with lead, cadmium, arsenic, zinc, nickel, and iron from legacy mining efforts. The intense and long lasting mining led to massive environmental degradation (unsightly, rusty orange water heavily contaminated with metals) that greatly affects the environment. A Gremsy VIO thermal sensor mounted on the sUAS will be used to identify temperature gradients caused by mine pool upwellings. Identification of upwellings is expected to take place during late winter, when the temperature differences between cold surface waters and relatively constant ground waters will be the greatest. Identifying the spatial extent of the contaminated upwellings and mapping them will provide valuable insight on how to best address contamination.

At Lake Frances, 35 years have passed since partial dam failure, and the former reservoir has regrown into a bottomland hardwood forest. At this site, microtopography and resultant wetland suitability will be determined through the use of a RESEPI HESAI XT-32 LiDAR (Light Detection and Ranging) sensor to generate digital elevation models (DEMs) from the ground point returns with a vertical accuracy of +/- 3 cm.

Management Implications: The elevation products from this study will be utilized to determine areas where water is currently impounded and areas that may be manipulated in order to create/restore a mosaic of wetland types. The created products will also influence the future construction of the planned Lake Frances Wetland Center.

Keegan Stallings presenting his research poster

Assessment of Algae Communities in Constructed Treatment Wetland Mesocosms

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Natural wetland ecosystems are well known to be productive and biodiverse. Treatment wetlands are designed and constructed to improve water quality by mimicking the biogeochemical functions of natural wetlands. Photosynthetic microorganisms such as cyanobacteria, diatoms, and green algae are primary producers that contribute to the foundation of metabolic processes and nutrient transport in wetland ecosystems. Moreover, heterotrophic microfauna such as rotifers and ciliates keep the primary producers 'in-check' through grazing bacterial biomass, small algal cells, and detritus. The roles that photosynthetic taxa and heterotrophs perform are complementary and together these functional groups create a self-balancing microbial food web that improves water quality, stabilizes nutrient cycling, and strengthens overall treatment performance of wetlands.

This research examined algal communities living in treatment wetland mesocosms at the Norman (Oklahoma) Water Reclamation Facility receiving secondarily treated wastewater and urban stormwater. Analyses were completed at the GRDA Ecosystems and Education Center (EEC) in Langley, OK. Three different flow regimes are used in the mesocosm experiment: subsurface flow (SSF), free-water surface flow (FWS), and open-water controls (OWC). In addition, two vegetation planting schemes (planted with *Juncus effusus* and unplanted) were crossed with source waters and flow regimes, creating a robust experimental design (n=50). Water samples were collected from mesocosms for each potential design factor combination and analyzed using the YOKOGAWA FlowCam at the Water Quality Laboratory in the GRDA EEC. The FlowCam detects and photographs particles in a 2-mL sample of water, generating a compilation of all imaged particles present in the sample. Organisms pictured in these images can then be classified using identification guidebooks. There was a substantial difference in the number of particles photographed in the FWS mesocosms than the SSF mesocosms regardless of source water or vegetation presence. However, a considerable proportion of the FWS images were of cyanobacteria. To examine factor(s) which exerted the most influence on these results, a PERMANOVA statistical test was conducted and revealed that hydraulic design (FWS vs SSF) significantly structured microbial community composition, while vegetation and source water had no detectable effect on these samples.

Mesocosm setup from Viktoria's experiment

Management Implications: The study shows how engineering design choices have direct ecological consequences for treatment efficiency and long-term wetland performance. Understanding how wetland design shapes these communities can help water resource managers build resilient and effective wetlands that encourage natural processes beneficial to water treatment.

Effects of Prescribed Fire and Tree Girdling on Over-dominant Tree Mortality and Forest Structure in the Neosho Bottoms

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Bottomland hardwoods (BLH) are floodplain forests found along rivers and streams. They provide important ecological functions, including flood control and storage, improved water quality, wildlife habitat, and timber production. These forests are characterized by a diverse mix of deciduous tree species adapted to seasonally flooded alluvial soils. Historically, the bottomland forests of the United States were vast and widespread, but a significant portion was converted to agricultural lands, resulting in habitat degradation, biodiversity loss, and disruption of ecological balance. However, many of these agricultural lands were frequently flooded, making them marginal for traditional row crop production.

The Neosho River Bottoms, located along the Neosho River, Northeastern Oklahoma, include areas of recolonized forests following agricultural abandonment. These recolonized forests differ from original oak-dominated communities due to the overdominance of pioneer species such as green ash and box elder, resulting in a more homogeneous forest. This project aims to reduce the dominance of these species and enhance vegetation diversity using non-chemical management practices like prescribed fires and mechanical tree girdling. Prescribed fire involves controlled burning to reduce tree density and promote regeneration, while girdling removes a strip of bark around the trunk to induce mortality by disrupting nutrient and water transport. Limited information exists on the short-term effectiveness of these techniques and their combined effects on forest structure and health.

To address this gap, we evaluated the effectiveness of these two treatments on over-dominant tree mortality, vegetation diversity, and soil quality. Four experimental plots were established: 1) burning only, 2) girdling only, 3) burning plus girdling, and 4) untreated control. Burning only and combined plots were placed in previously burned (March 2025) area, and adjacent unburned areas were used for girdling only and controls. Girdling was applied in June 2025, and data were collected six months after burning and three months after girdling. Mortality rates of green ash and box elder trees, vegetation surveys to quantify species richness and diversity, soil nutrient and organic carbon analyses, and Normalized Difference Vegetation Index (NDVI) assessments of canopy health were used to evaluate treatment effects. Data are currently being analyzed, and results will be presented in a thesis and defense in Spring 2026.

Management Implications: The findings from this study will provide an understanding of how prescribed fire, mechanical tree girdling, and their combination will influence forest structure in the short term. These results will aid forest managers in developing more strategic and effective restoration and management plans that promote forest structure using non-chemical methods.

Nethmi collecting data on trees within her study plot

University Partners

Our university partners work hard providing the Ecosystems team insights. Their work saves GRDA ratepayers countless dollars while filling knowledge gaps in scientific literature that have helped shape watershed management programs across the region and contributing to workforce development.

Sam Miess (OSU) samples macroivertebrate communities

Han NBS Lab (OU) members at the 2025 OKGWC

Justine McCann (OU) collects porewater from Tar Creek

Jason Belden (OSU) showcases a largemouth bass

Annika Kerns (NSU) presents her research on chicken litter

Ecosystems and Watershed Management - Employee Directory

The employees of the Ecosystems and Watershed Management Department as well as our partners listed in the pages of our annual reviews are the ones who make these conservation programs and research projects happen. If you have specific questions, please feel free to reach out to us at the contact information listed below.

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Closing Thoughts

2025 was the 21st year of GRDA's ecosystems and watershed management department, demonstrating more than two decades of our commitment to environmental stewardship, ecological monitoring, and scientific research. The fruits of our relationships with our academic, municipal, state, federal, tribal, and NGO partners shines through on every page. The information detailed within this review demonstrates our drive to protect and maintain the natural resources that provide economic, recreational, and cultural benefits to all Oklahoma citizens. Our focus is on finding efficient solutions, tools, and functional partnerships that will allow for sustainable management and use of our watersheds, while promoting the economic development of the community we serve. This same focus supports future generations who will use these resources for power, agriculture, wildlife, boating, floating, and enjoying the outdoors.

This review provides useful information for our water users, both the local populations as well as visitors here for the many recreational opportunities. Many of the studies presented here are from university students who won scholarships and grants from GRDA, or were employed as our interns, working closely with our staff of highly trained scientists. These students represent the future of natural resources management in Oklahoma.

If you have any questions about the programs or studies presented here by our Ecosystems and Watershed Management Team, ongoing or future studies, or are interested in the research and employment opportunities we provide to eligible students, please feel free to call our offices at (918) 981-8472, scan the QR code below, or look us up on the web at: www.grda.com.

- D. Christopher Rogers

GRDA
Grand River Dam Authority

If you are interested in learning more about the Grand River Dam Authority, please visit our website at www.grda.com or scan the QR code with your smartphone camera.

Ecosystems Explorations: 2025 Annual Review

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This publication was produced with input from the entire Ecosystems and Watershed Management team. All maps are property of the GRDA GIS Department. All photos and student summaries have been submitted to GRDA via project updates, and are now authorized for use by GRDA.

This publication printed by Boomerang Printing in Tulsa, Okla, is issued by the Grand River Dam Authority at no cost to taxpayers as authorized by 82 O.S. Sec. 861 et seq. 200 copies have been printed at a cost of $1188.00. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

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