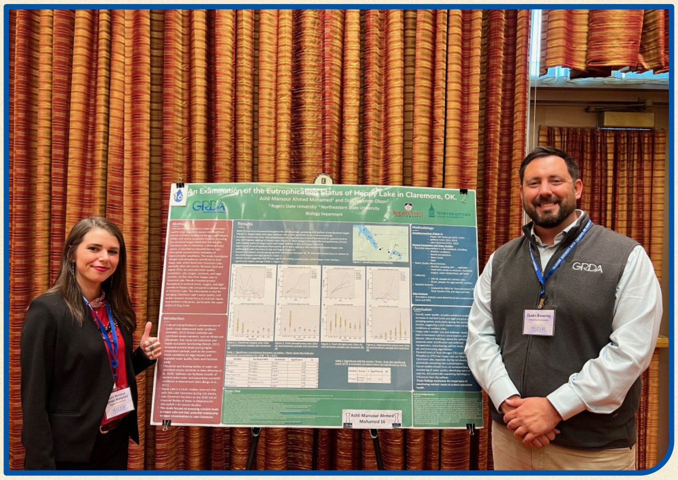
Grand River Dam Authority

2024 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.

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.

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

Ecosystems Explorations - 2024 Annual Review

Table of Contents

The following is a compilation of programs, projects, and research performed and supported by the Ecosystems and Watershed Management Department of the Grand River Dam Authority. The work that is displayed in the following pages of this years annual review represent the continued commitment that GRDA has made to be good stewards of the natural resources under our control.

Grand River Dam Authority **2-16**
- Ecosystems Department Information 4
- Program and Project Awards 5
- GRDA Watersheds 6-7
- Water Quality & Fisheries 8-9
- T&E Species & Bioassesment Programs 10-11
- Guard the Grand 12
- Education Program 13
- Conservation Easements 14
- Neosho Bottoms 15

University Projects **17-41**
- Northeastern State University 18-21
- Oklahoma State University 22-27
- Rogers State University 28-29
- University of Oklahoma 30-41

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

The Ecosystems team at the 2024 Oklahoma Governors Water Conference. (Jeri, Steve, Christopher, Dustin, & Ed)

Darrell T.

Ecosystems and Watershed Management

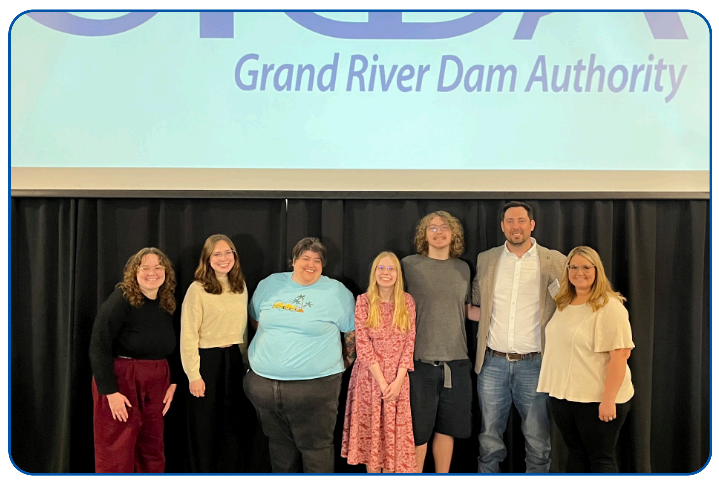
When the Grand River Dam Authority established its Office of Ecosystems Management in 2004, it did so knowing there was much work ahead. After all, the Grand Lake watershed spans four states including Kansas, Missouri, Arkansas and Oklahoma and culminates into one of the most popular recreation destinations in the region: Grand Lake.

Because Oklahoma only encompasses approximately nine percent of the watershed and the majority of Grand Lake's water supply originates from neighboring states, GRDA realized it could not face the natural resource challenges alone. Thus, the underlying theme for the department has been to build cooperative relationships to facilitate communication and efficient utilization of resources necessary to accomplish GRDA's conservation and restoration goals.

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 water quality team for the summer of 2024



GRDA Staff and NSU partners at OCLWA 2024 Conference

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 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 along the way, some of which can be seen on the next page.

Northeastern Oklahoma A&M: 18 students supported through various functions of the partnership.
Northeastern State University: 21 students supported, 21 BS.
Oklahoma State University: 14 students supported, 7 MS, 7 Ph.D.
Rogers State University: 12 students supported through senior level research projects.
University of Oklahoma: 25 students supported, 12 MS, 13 Ph.D.

Ecosystems - Recent Awards and Extent of Research

Recent Awards

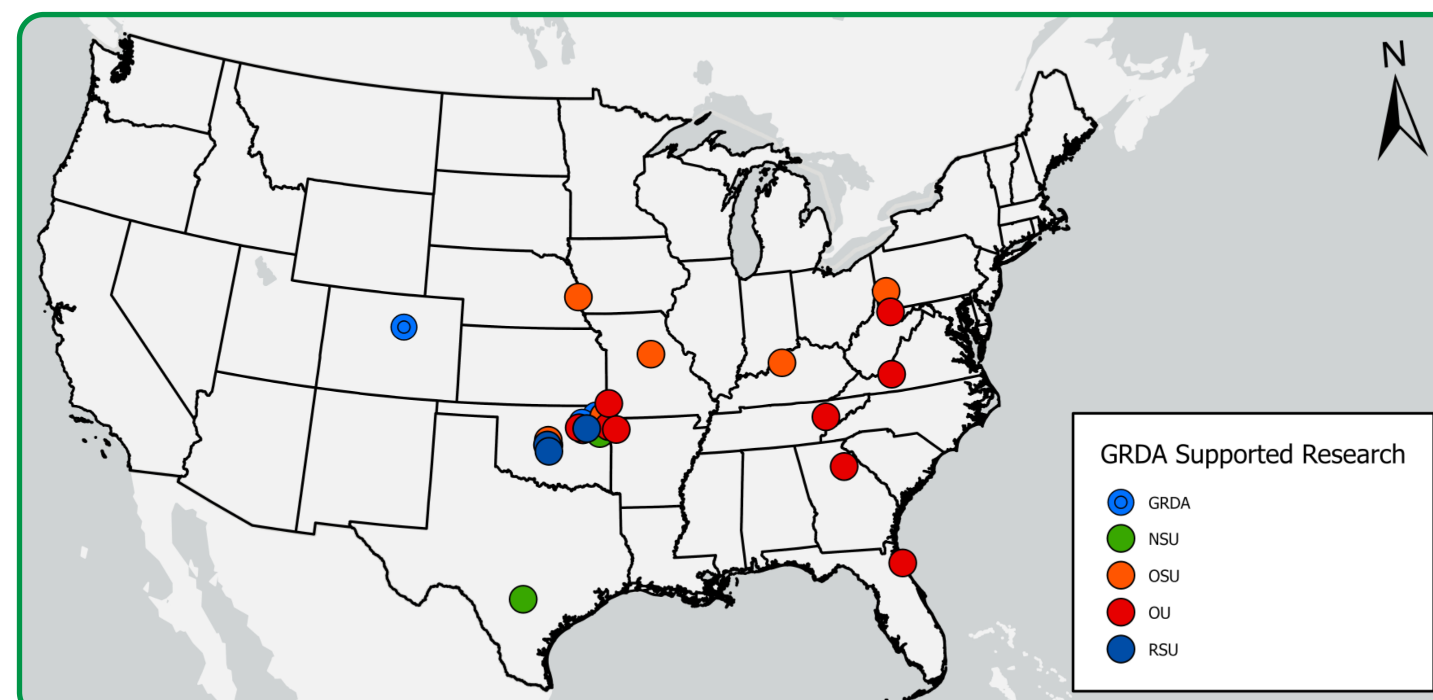
2024:
Shoreline Cleanup w/ FFA Chapters (GRDA Shoreline Team): ***Best Government Program***: Keep Oklahoma Beautiful. November 22.
Bald Eagle Monitoring (Dustin Browning/Brian Lambert): ***GEO for GOOD***: Google. May 2.

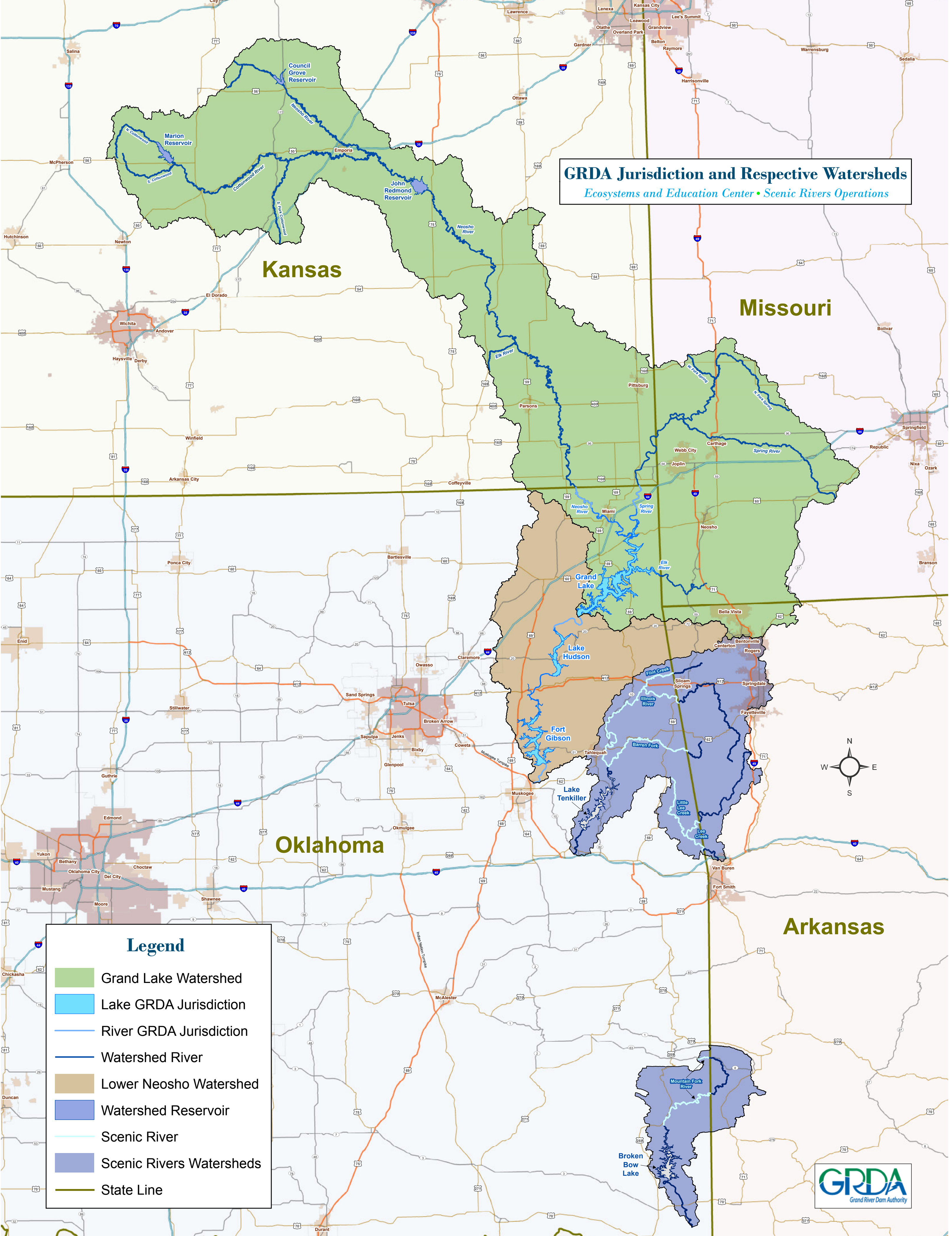
2023:
Community Education Program (Jeri Fleming): ***Outstanding Stewards of Americas Waters***: National Hydropower Association. October 12.
Source Tracking Program (Dustin Browning/Bill Mausbach): ***Frank Condon Environmental Excellence Award***: Environmental Federation of Oklahoma. October 10.

2022:
Septic Tank Remediation Program (Jeri Fleming): ***Environmental Excellence Award***: Keep Oklahoma Beautiful. November 18.
Conservation Easements (Ed Fite/Darrell Townsend): ***Outstanding Stewards of Americas Waters***: National Hydropower Association. October 20.
Jesse Rader (RSU Student)/Dustin Browning (GRDA Mentor): ***Best Biology Research Project***: Rogers State University. May 5.

The Geographic Extent of GRDA's Research Efforts

GRDA's research and conservation efforts have far reaching impacts not only within the State of Oklahoma, but outside its borders as well. In 2024, GRDA supported research reached 14 states and 2 countries.





GRDA's Watersheds


Joel B.

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.

GRDA's Commitment to Water Quality

Steve N.

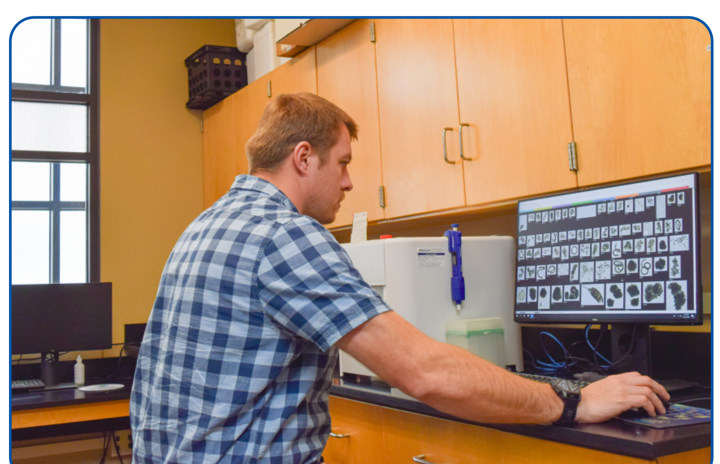
Bill M.

Water is an essential resource for human prosperity. We rely on water for drinking, bathing, domestic tasks, agriculture, recreation, waste removal, wildlife habitat, hydropower, and aesthetic enjoyment. Because water serves so many diverse purposes, it is important that GRDA's jurisdictional waters are safe for humans and wildlife and of high quality for domestic, municipal, and industrial use. The GRDA Ecosystems and Watershed Management Department operates two water quality laboratories that are dedicated to monitoring and studying GRDA's three reservoirs (Grand Lake, Lake Hudson, and W.R. Holway Reservoir) and Oklahoma's Scenic Rivers (Barren Fork Creek, Flint Creek, Lee Creek, Little Lee Creek, Illinois River, and Mountain Fork River).

The Water Quality Research Laboratory (WQRL) at the Ecosystems and Education Center in Langley, Oklahoma focuses on water quality issues involving GRDA's reservoirs and their watersheds. This facility is located on the shore of Grand Lake, allowing for quick response times to water quality issues and concerns such as fish kills, toxic algae blooms, and waterborne illnesses. The WQRL is one of the best equipped laboratories in the region for monitoring and studying toxic algae blooms, boasting an automated algae toxin analyzer, inverted microscope for algae identification, a FlowCam Cyano for rapid identification and enumeration of toxic cyanobacteria, and real-time water quality monitoring buoys that are positioned in areas at high risk of toxic algae blooms. At the WQRL, you will also find a dedicated microbiology laboratory where we use bacteria cultures and genetic tools to measure fecal pollution in our waterbodies. Currently, we can determine if a water sample is contaminated with poultry, cow, pig, horse, dog, sheep, and human feces, as well as, the presence of infectious protozoans.

At the Scenic Rivers Watershed Research Laboratory (SRWRL) at Northeastern State University in Tahlequah, Oklahoma, we focus on water quality issues involving the Oklahoma Scenic Rivers and their watersheds. We work closely with NSU faculty to monitor and study the scenic rivers as well as provide research opportunities for college students. The SRWRL is uniquely equipped for processing aquatic and terrestrial invertebrate samples and maintains a reference collection for Northeast Oklahoma invertebrates.

Water resource management is complex and requires numerous stakeholders to be successful. Generating reliable, comprehensive water quality datasets to share with our partners is the first step in addressing water quality issues in Northeast Oklahoma. Thus, both of our laboratories work closely with our sister resource agencies and researchers throughout the Great Plains and Ozark regions, and local stakeholders. We are continually expanding our knowledge of these dynamic aquatic systems, and we do so by striving to stay current on the science and occasionally paving the way forward for others to follow.



Bill Mausbach using GRDA's FlowCAM to sort algae

Fisheries Enhancement

Cale C.

GRDA's Rush for Brush Program

In the spring of 2007, the Grand River Dam Authority's Rush for Brush program made its debut on Lake Hudson, with a small workshop attended by a few volunteers. With an end goal of enhancing the lake's fishery, GRDA staff and several volunteers spent the day building artificial fish habitat structures out of materials supplied by GRDA. Simulating natural brush piles, these structures provide protection to fry and fingerlings while staying in place and lasting longer than natural brush piles. This fisheries enhancement helps GRDA to meet its mission as a good steward for the natural resources under its control.

Nearly 16 years later, hundreds of volunteers, and dozens of workshops later, the program's end goal has not changed, even though its popularity and impact across the GRDA lakes region has grown exponentially. In fact, Rush for Brush was recognized with the "State Government Program" award from Keep Oklahoma Beautiful in 2017, and in 2018 it won the "Outstanding Stewards of America's Waters" award from the National Hydropower Association. To date, roughly 19,000 structures have been placed in GRDA lake waters. That is large enough to cover over 11 acres of lakebed with artificial habitats that continue to benefit countless numbers of fish.

At a workshop in the spring of 2024, over 40 volunteers built 750 structures, destined for GRDA lake waters.

But the program is not limited to Grand and Hudson lakes. In October 2021, GRDA and the Oklahoma Department of Wildlife Conservation (ODWC) teamed up with students from Stilwell, Okla, to place 300 artificial fish habitat structures into GRDA's W.R. Holway Reservoir, part of the Salina Pumped Storage Project, near Locust Grove. Those structures were deployed in 28 clumps to resemble large piles of hardwood trees. That took place while GRDA had lowered the reservoir for a scheduled inspection.

Other Fisheries Efforts

GRDA has also worked 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. As part of our efforts to maintain world class fisheries, GRDA also stocks Lake Hudson with hybrid striped bass yearly.

New habitat being installed at a GRDA courtesy dock

Katrina Sherrick assisting with fish stocking efforts

Dustin B.

Threatened and Endangered Species

Bald Eagle Monitoring

The Ecosystems and Watershed Management team conducts aerial bald eagle surveys from a helicopter every year in January and April. Surveys are typically conducted by a GRDA pilot and at least one observer. These surveys take place 400-500 feet above the tree line at airspeeds ranging between 50-60 MPH. In the January surveys, adults, juveniles, paired eagles, and active nests are counted. Nesting locations from previous years are also inspected for new activity. New nesting locations are always noted and marked.

During the spring survey, observers look for new eagle nests and also check eagle nesting sites from previous surveys for activity and for the numbers of juveniles and adult eagles present at the time of the survey. New nesting locations are marked with a GPS and the coordinates are examined to determine if these nests are located within the project boundary. The information that is collected on these surveys is then shared with the George Miksch Sutton Avian Research Center in Bartlesville, Okla, to help update their bald eagle nesting database as GRDA is an active member of their Bald Eagle Survey Team (BEST).

In 2024, Grand Lake has 10 active nests inside of the project boundary, while Lake Hudson has 11. GRDA also recieved the Geo for Good award from Google in 2024 for our bald eagle survey program.

Bat Species Monitoring

With the help of The Nature Conservancy and the United States Fish and Wildlife Service, GRDA manages three bat caves around the Grand Lake area. Two of these caves are found inland, and one is found directly on the shores of Grand Lake. These caves hold maternity colonies of the endangered cave obligate Gray Bat (*Myotis grisescens*). The shores of Grand Lake are also home to the threatened tree dwelling Northern Long-Eared Bat (*Myotis septentrionalis)*.

Management activities are conducted by GRDA with the help of agency and university partnerships. These management techniques include population estimates, nighttime counts, acoustic monitoring, and White Nose Syndrome monitoring. GRDA has also written protective measures into its shoreline management plans to prevent any harm or habitat loss to these unique guests of GRDA lakes.

GRDA's 2024 Interns heading to a bat cave

Dustin delivering the statewide bat update at 2024 EFO

GRDA's Macroinvertebrate Bioassesment Program

Christopher R.

GRDA is implementing a new biological assessment program using macroinvertebrates (insects, snails, clams, crayfish, worms, *et cetera*). 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.

GRDA's bioassessment effort is part of a long term monitoring program to determine the ecological functionality and 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. Macroinvertebrate communities are sampled because they are typically less motile (*i.e.*, they stay in a particular area), produce numerous generations within a single season, and have the highest biodiversity in the smallest sampling area. Thus, macroinvertebrate community structure is often the most measurably responsive to environmental circumstances.

Additional reasons for using macroinvertebrates are: 1) they have the greatest biodiversity of any macro-organismal group by orders of magnitude; 2) they are easy to sample using traps; 3) they are small in size, such that large numbers are easily transportable and samples take very little storage space; 4) most species are specialists regarding habitat type or food; 5) some are important pests either for crops or as disease vectors, and; 6) they are ecologically important as food for most birds and fish, or are pollinators, as herbivores, or as predators on other invertebrates, including crop pests and disease vectors. Thus, macroinvertebrate bioassessment reflects the ecological integrity of the sites under study.

A Hercules beetle (*Dynastes tityus*)

Insects being collected at night using a blacklight

GRDA's Guard the Grand and Community Involvement Programs

Jeri F.

GRDA has expanded its education and outreach program beyond just Guarding the Grand, we are working to protect and improve watersheds in the Illinois River watershed and the waters around our customer cities. We also began partnering with the Oklahoma Association of Conservation Districts on their Yard by Yard program, branding it in the Grand Lake area as Guarding the Grand Yard by Yard.

We held workshops and/or youth events in Collinsville, Pawnee, Stillwater, Pryor, Siloam Springs, Claremore and Tahlequah. We also held workshops and hosted a two-day youth camp in the Grand Lake area.

GRDA Ecosystem staff attended several community events and hosted numerous school groups at the Ecosystem and Education Center. In total, we reached over 3,800 students in 2024.

This year, we hosted ten teachers at our educator workshop in Tahlequah. We discussed drinking water and waste water treatment, the Illinois River Watershed Partnership brought benthic macroinvertebrates, and the teachers participated in several hands-on activities that were sponsored by Blue Thumb, Oklahoma Ag in the Classroom, and OSU Extension Services.

Working with the Oklahoma Turnpike Authority and Lake O' the Cherokees Subwatershed Association, we installed signs at 4 stream/river crossing on the Will Rogers Turnpike, informing drivers that these waterbodies flow into Grand Lake.

We continue to offer rain barrel workshops in the Grand Lake and Illinois River watershed and in our customer communities. We gave away approximately 100 barrels that residents can use to collect rainwater for use during our often dry summers. We began a new partnership with PepsiCo in Tulsa to source our barrels. This keeps them out of the landfill and gives them a second use all at no cost to us or community members. We were recognized as finalists at the Keep Oklahoma Beautiful Annual Environmental Awards celebration for this work and for our partnership with the city of Collinsville.

Thanks to our dedicated staff, we have provided watershed protection information to over 4,000 people in 2024 alone. Education continues to be an important part of protecting the water resources we care about.

GRDA's stream trailer setup at an Earth Day event

GRDA Staff and Campers next to GRDA's education trailer

GRDA's Education Programs

Jacklyn S.

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.

One option GRDA offers for educational outreach for schools, is that the school can contact GRDA to request a guest speaker to come to their classroom to discuss water quality, water management, conservation, stream health, and much more. The speaker will bring hands-on resources to the classroom and will use them to connect the lesson to Oklahoma's Academic Standards for Science.

The second option is for local schools to have a field trip to the Ecosystems and Education Center for a day of hands-on learning and to see our state-of-the-art Water Quality and Research Lab and Oklahoma's first hydroelectric facility – the Pensacola Dam. There are educational resources on-site and space to accommodate a large group of students. The center serves as a space where students and adults can learn about ecosystems management, hydroelectric power, water safety, the history of the Grand River region, and much more. While visiting the ECO Center, students can check out our rain garden, see a life-size turbine wheel, or take in the views of Grand Lake and the Pensacola Dam up close.

GRDA also hosts a youth camp in the summer at the ECO Center. At this camp, GRDA partners with other agencies to have a day full 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 2024, it is estimated that our team reached over 4,000 people through these outreach programs!

Roy Heginbotham teaching students about rain gardens

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.

Conservation Easements

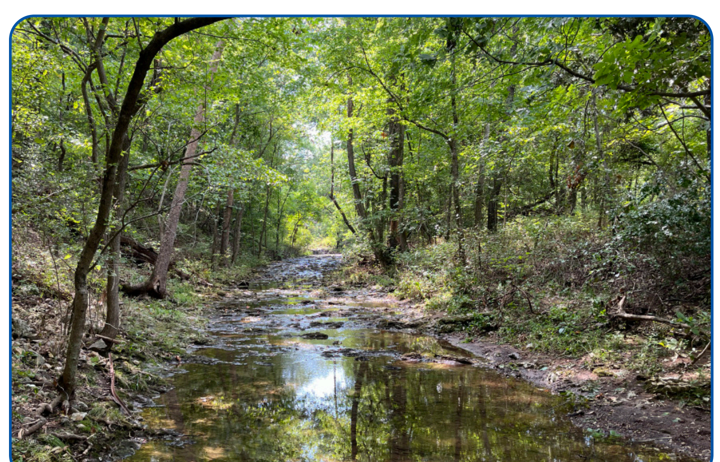
Ed F.

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 ecological quality of landscapes within the easements. The goal of this program is to keep the land surrounding our precious water bodies as close to its natural state as possible. By doing this, the water quality in these areas will be better off and 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 livestock out, 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 2024, 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 are in development.

A photo of the riparian area of a GRDA Easement



A stream running through a GRDA Conservation Easment

NEO A&M Partnership

Aaron R.

In the summer of 2016, GRDA and NEO A&M formally announced a partnership agreement for pecan orchards and livestock grazing. The original plan was for GRDA to lease 1,600 acres in Ottawa County to NEO A&M for $1 per year. Since then, the original 1,600 acres has turned into around 3,000 acres available for the school's use. GRDA plays an active role in helping manage these lands by performing controlled burns and applying various best management practices.

The partnership allows NEO A&M to sublease the pecan orchards to local pecan producers and allows it to become a revenue stream for the school. These types of private-public partnerships help universities deal with massive reductions to public education budgets.

GRDA staff also work with the university to provide drone classes and other guest speaking opportunities as well as research support.

Controlled Hunts

Jared G.

Wyatt S.

In addition to the NEO A&M partnership, GRDA has opened around 2,000 acres of this area along the Neosho River for controlled hunts, managed by GRDA. The public can register for these hunts online. Winners are selected at random with special consideration being given to those who are residents of municipal customers or public power communities.

The different types of hunts include deer, waterfowl and turkey. There are also hunting areas that have been designated for use by the Mid-America Chapter of the Paralyzed Veterans of America (PVA). In fact, around 1,000 acres has been designated for PVA hunts since 2014. This partnership with PVA has given hunting opportunities to people with impaired mobility, who would otherwise have very limited access to public hunting lands.

Extracting lymph nodes from a harvested deer

During the 2024 hunting season, GRDA hosted around 20 PVA hunters along with another 80 conventional draw-in hunters.

Additionaly, GRDA's Neosho Bottoms team is working with the Quapaw Tribe to do Chronic Wasting Disease (CWD) testing on deer harvested during GRDA's controlled hunts.

A look back at 2024

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.

Bald Eagle nesting signage with a nest in the background


GRDA Staff and Thunderbird Cadets after a clean up event

Aaron and Joel at ECO's 2024 Christmas Party

Steve presenting at the 2024 Hydrovision Conference


GRDA's Shoreline Team with a Keep Oklahoma Beautiful award

UNIVERSITY PROJECTS

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

Kaitlin Branson and 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 serve as the one of the greatest and most valuable forms of terrestrial carbon sinks. Individual trees within forests extract carbon dioxide from the atmosphere and utilize it for maintenance and growth. 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 project sought to quantify the amount of carbon being sequestered by plots of forested land in Grand River Dam Authority (GRDA) conservation easements. During the summer of 2024, 166 trees were inventoried throughout 18, 10x10 meter plots at the conservation easements outside of Sparrowhawk Village. The tree heights and diameters were measured. Additionally, the trees were identified and recorded according to species.
All of this information was input into the U.S. Forest Service's I-Tree Software in order to determine how much carbon was being sequestered by the trees that were inventoried. Using this software, it was determined that the projected carbon sequestration for 2 years would be 4,076 kilograms of carbon. The software was then used to project carbon sequestration for 50 years. This would yield 513,676 kilograms of carbon.

This project is still ongoing. Currently, work is being done to determine how much carbon is being sequestered in all other GRDA conservation easements.

Kaitlin presenting her research in San Antonio, TX

A 10x10 sampling plot at SparrowHawk

Timing of Aquatic Insect Emergence Between Two Different Habitats

Rachael Croley and Elizabeth Burba
Northeastern State University
College of Science and Health Professions

Temperature is a known contributor to insect metamorphosis and the timing at which aquatic larval insects emerge as terrestrial adults. Emergence timing is evolutionarily linked to the reproductive season of insectivorous bats that depend on availability of this ephemeral food resource during pregnancy and lactation. Climate change is predicted to cause earlier emergence timing of aquatic insects, potentially causing asynchrony between emergence timing and their availability during pup development. This project compares two different habitat types at Thomas Bamberger Wildlife Management Area: Barren Fork Creek and an old Oxbow Wetland. Barren Fork has a constant flow and an open riparian corridor, whereas the wetland has little to no flow and a nearly closed canopy coverage.

Arial SLAM traps were suspended over Barren Fork Creek and the wetland to capture insects as they emerged from the water from April to August 2024. Traps were checked every 2-3 days to remove insects and replace capture vials. This study aims to evaluate water quality parameters, environmental conditions, and habitat characteristics that are correlated with insect emergence timing. Insects were identified to family during summer and fall 2024. Data analysis is ongoing and will compare emergence timing between the two habitat types and correlate environmental factors with aquatic insect emergence. Water quality data is taken from USGS monitoring station on Barren Fork Creek approximately 5 mi downstream of study site.

The data will serve as a baseline for which similar future studies can compare emergence timing between years. Additionally, the data will be used by other studies to evaluate how bat foraging patterns change in response to insect emergence timing. Acoustic detectors were deployed near the insect nets throughout the duration of the study; thus, bat foraging patterns can be studied in regard to insect availability. Bats were also live captured to collect fecal pellets so DNA extraction and sequencing can be conducted to determine prey selection based on insect availability. The study provides insights into factors that affect local emergence timing of aquatic insects and how the timing may affect terrestrial insectivores in response.

A slam trap set up over Barren Fork Creek

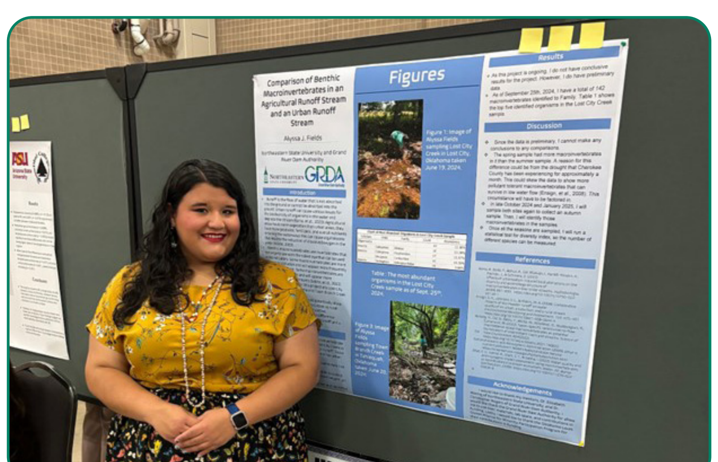
Rachel and AJ collecting insects on a night mission

Comparison of Benthic Macroinvertebrates in an Agricultural Runoff Stream and an Urban Runoff Stream

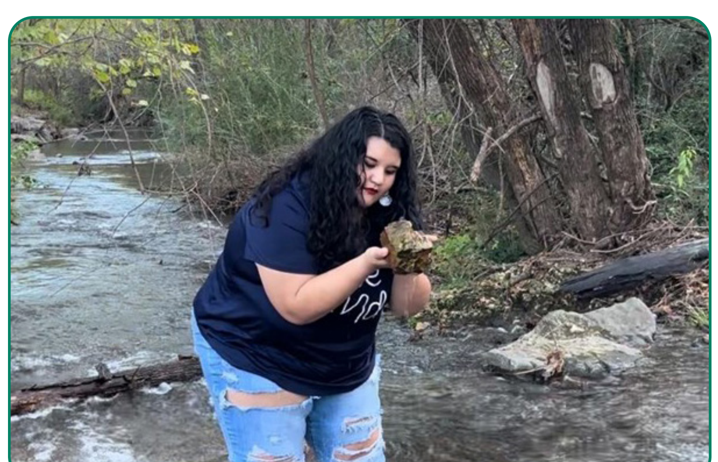
AJ Fields and Lizz Waring
Northeastern State University
College of Science and Health Professions

Macroinvertebrates are an important group of organisms for evaluating stream health. The amount of pollution in the stream will impact what macroinvertebrate species can live in that area of the stream. To understand the impacts of seasonal changes on macroinvertebrate communities, we conducted a study of benthic macroinvertebrates at two sites in Cherokee County, Oklahoma throughout the course of a year. The first site was a creek called Lost City Creek in Lost City, OK that receives agricultural runoff with a dominance in bovine feces. The second site was a creek called Town Branch Creek in Tahlequah, OK that received urban runoff. We hypothesized that there is a difference in macroinvertebrate diversity between a creek that receives urban runoff and a creek that receives agricultural runoff. Our null hypothesis is there is no difference between a creek that receives urban runoff and a creek that receives agricultural runoff. We sampled from three upstream and three downstream riffles at each site using a rectangular kick net. We collected dissolved oxygen, temperature, and pH with a YSI Exo 2 Sonde. We planned to use this data to corroborate our macroinvertebrate diversity findings.

The hypothetical outcomes are that the creek with urban runoff has worse macroinvertebrate biodiversity than the creek with agricultural runoff, the creek with agricultural runoff has worse macroinvertebrate biodiversity than the creek with urban runoff, and both creeks have poor macroinvertebrate biodiversity. The results of this study could potentially show how different stream pollutants (urban vs rural) impact macroinvertebrate communities.



AJ presenting her research at AISES Conference



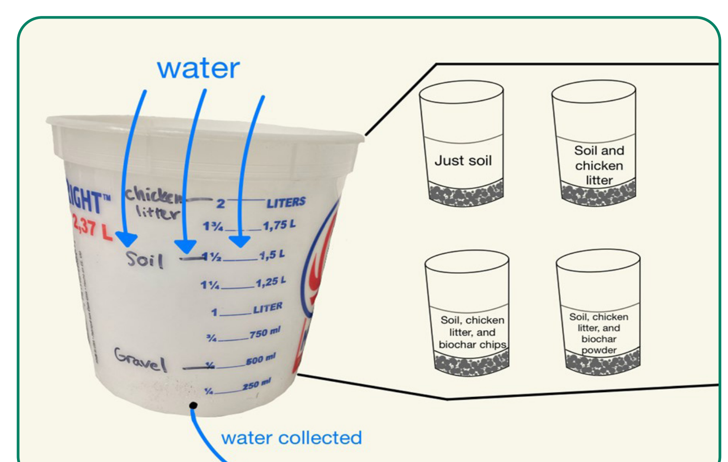
AJ sampling in Town Branch Creek

Nitrogen and Phosphorus levels Introduced to Streams by Chicken Litter Runoff

Annika Kerns and Lizz Waring
Northeastern State University
College of Science and Health Professions

Nutrient pollution in water bodies poses significant health and ecological risks. This can lead to algal blooms and the eventual eutrophication of aquatic ecosystems. Chicken litter, rich in nitrogen (N) and phosphorus (P), is commonly used as a soil fertilizer. However, its application can lead to the release of N and P into streams during precipitation events. This study examines the potential of biochar, a soil conditioner, to mitigate nutrient leaching from chicken litter. Experiments subjected chicken litter with and without biochar to simulated rain events. Two sizes of biochar were used to compare effective surface areas. Nutrient levels were measured using Hach TNTplus™ kits. While both groups exposed to biochar experienced nutrient reduction, the powder biochar seemed to be more effective. The biochar showed to be effective in reducing Nitrogen concentrations; however, the Phosphorus concentrations were initially reduced but then rose over time.

These findings suggest that biochar application holds promise for reducing nutrient pollution into the environment in regions where chicken litter is utilized as fertilizer. Further research is needed to understand underlying mechanisms and optimize biochar application for water quality preservation.



Annika's experimental setup

Annika working in the greenhouse at NSU

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

Ankur Biswas and 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 for both fundamental and applied limnology. A comprehensive review of the literature on microcystin highlights the critical role of sulfur (S) in the synthesis and toxicity of these compounds. Despite this, the role of sulfur in freshwater ecosystems has received comparatively little attention compared to nutrients like nitrogen (N) and phosphorus (P). This is particularly notable given the documented spatiotemporal variability in S availability across and within aquatic ecosystems.

In this study, we examine the relationship between sulfur availability and microcystin production in *Microcystis aeruginosa*, a prominent toxin-producing cyanobacterium, through laboratory batch culture experiments. Using a gradient of sulfur supply, 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 sulfur availability, suggesting a direct relationship between S supply and toxin production. This unexpected finding points to a potentially complex regulatory mechanism governing microcystin synthesis, the details of which remain poorly understood and warrant further investigation.

Our findings underscore the potential of ionomic data, specifically sulfur bioavailability, as a valuable tool for forecasting microcystin production in freshwater ecosystems. Traditional monitoring and management strategies for HABs 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 sulfur, an element that may play a pivotal role in regulating toxin synthesis. Given the substantial heterogeneity in S availability across freshwater systems, incorporating sulfur dynamics into predictive models could enhance our ability to anticipate and mitigate the risks associated with HABs.

In addition to advancing scientific understanding, this research holds significant practical implications for freshwater ecosystem management. For example, the findings of this study can directly inform strategies for monitoring and managing harmful algal blooms by incorporating sulfur monitoring into nutrient management programs. The spatiotemporal variability of sulfur 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 sulfur bioavailability alongside traditional metrics, GRDA could enhance its capacity to forecast microcystin production and develop targeted mitigation strategies. Furthermore, including sulfur-based ionomic monitoring systems inform health advisories and ensure water quality safety.

In conclusion, this study provides novel insights into the interplay between sulfur availability and microcystin production in *M. aeruginosa*. It advocates for a broader ionomic perspective in HAB research and management, emphasizing the need to consider sulfur as a key driver of cyanotoxin production. By extending this research to practical applications in ecosystems such as Grand Lake, it becomes possible to bridge the gap between laboratory findings and real-world solutions, contributing to both the scientific understanding and effective management of harmful algal blooms.

Magnesium Supply alters Phosphorus use efficiency, Algal Growth, and Algae-grazer Interactions

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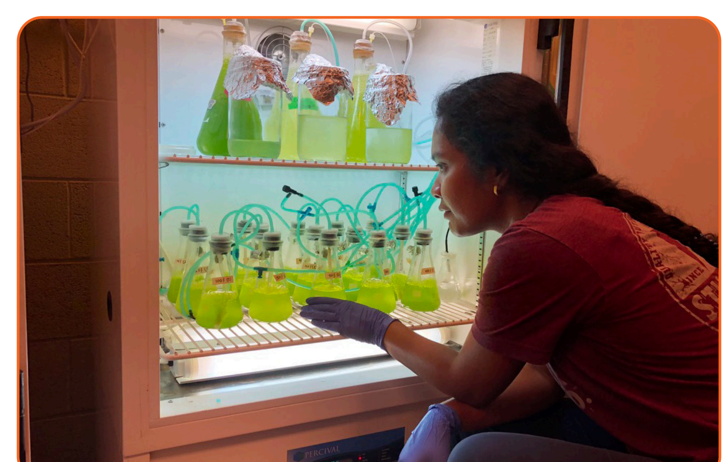
Department of Integrative Biology

The growth of an organism is affected by the availability and interactions of about 25 elements that are required for life. Carbon (C) is the most abundant building element in a cell that accounts for ~50% of the body mass. Nitrogen (N) and phosphorus (P) are other abundant building elements and are irreplaceable in macromolecules such as (i) nucleic acid, (ii) in protein synthesizing apparatus (with nearly 50% of cellular P is present in rRNA that catalyze protein synthesis), and (iii) in cellular energy reserve molecules - adenosine triphosphate (ATP). The negative charge of P in RNA and ATP molecules is balanced by the positive charge of a balancing element, magnesium (Mg).

Although the role of P in algal growth has been studied globally for decades now, we still cannot accurately forecast and manage algal blooms. Nationally Mg varies greatly across lakes ranging from 100 to 8000 µg/L. Given this heterogeneity of Mg, its importance in P biochemistry, and the current lack of reliable prediction of algal blooms based on P abundance, we are exploring the interactive effects of Mg and P on the growth of (i) primary producers– *Scenedesmus obliquus* (a green algae) and (ii) their primary consumers, Daphnia (zooplankton). We hypothesized that changing the Mg:P supply will alter phosphorus use efficiency (PUE) and organismal growth of these primary producers and consumers. We found that changing the Mg:P supply, significantly changes the growth rate, and PUE of Scenedesmus, and altered the elemental quotas of all elements in the algae. A change in Mg:P supply also altered Daphnia growth rate along a Mg:P gradient.

Different parts of Grand Lake, show seasonal and temporal variations in elements largely due to variations in land-use and geographical factors around this reservoir. These variations alter the availability of building (phosphorus) and balancing (magnesium) elements and affect the organismal growth and community structure due to altered Mg:P supply. We will expand our laboratory findings to field studies in Grand Lake and test our hypothesis on Mg:P supply and organismal growth. These studies will help in improving the forecasting of algal blooms and improved management practices of reservoirs.



Parna working on samples in the growth chamber

Microscope view of Scenedesmus (left) and Daphnia (Right)

Evaluating the Toxicity of Metal Mixtures Found in the Tar Creek Superfund Site Using RTgill-W1 Cells

Stacey Herriage, Jason Belden, and Matteo Minghetti
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Department of Integrative Biology

Aquatic ecosystems are exposed to mixtures of various metals due to natural geological processes, industrial discharges, construction, and mining. For example, historic mining activity in the Tri-State Mining District (Oklahoma, Kansas, Missouri). Metals like lead and zinc continue to pollute the area, affecting water quality and aquatic life. Cleanup efforts are ongoing, but understanding metal mixtures and their effects on ecosystem recovery is crucial. The study of metal mixtures in aquatic ecotoxicology is complex due to the interactions between different metals and environmental variables. While significant progress has been made in understanding the toxicity of individual metals, knowledge gaps regarding metal mixtures remain. Addressing these gaps requires integrative approaches: combining field studies, advanced modeling techniques, and mechanistic research to better predict and manage the ecological risks associated with metal mixtures in aquatic environments. This investigation aims to incorporate such multiple approaches to characterize the effects of metal pollution in Tar Creek. One such approach involves an in vitro experiment to evaluate specific metal mixtures using RTgill-W1 cells in the laboratory.

The RTgill-W1 cell line, derived from gill cells of rainbow trout (*Oncorhynchus mykiss*), has been determined an appropriate model for measurement of fish acute toxicity based on the premise that impairment of gill tissue after acute toxicant exposure is linked with fish death. These cells provide a relevant and specific model for studying the effects of contaminants. We hypothesize that RTgill-W1 cells can detect the toxicity of water samples from Tar creek superfund site. To test this hypothesis, gill cells are cultured in flasks until they reach approximately 80-90% confluence. The cells are then washed, counted, and seeded in a 24-well plate. After being allowed to incubate for 48 hours, the cells are then exposed to a synthetic culture medium containing various concentrations of bi-metal mixtures of zinc (Zn), cadmium (Cd), copper (Cu), and manganese (Mn). Following 24 hours in the exposure medium, the viability of the cells is measured using a plate reader and analyzed as percentage viability compared to the control using 3 endpoints to assess cytotoxicity: metabolic activity, membrane integrity, and lysosomal integrity. The results are then used to determine if mixture effects are additive, synergistic, or antagonistic.

This research contributes to a more nuanced understanding of metal mixture toxicity, particularly in regulatory contexts where predicting the environmental impact of metal discharges into aquatic systems is critical. Additionally, adding to the overall knowledge of metal-metal interactions, and metal interactions at the site of uptake, such as the gill, can assist in the development of models capable of predicting toxicity in more environmentally relevant terms. The insight gained can also be helpful for environmental risk assessment, providing useful information instrumental in shaping regulatory policies to manage environmental health.

Matteo Minghetti processing collected fish tissue

Predicting the Bioavailability of Heavy Metals in Tar Creek Using the Biotic Ligand Model

Stacey Herriage and Matteo Minghetti
Oklahoma State University
Department of Integrative Biology

Bioavailability is an important concept in aquatic toxicology because it refers to the portion of a substance, such as a metal or other pollutant, that is available for uptake and utilization by living organisms in a given environment. Understanding the bioavailability of metals and other contaminants in aquatic ecosystems is important for numerous reasons including accurate risk assessment, biological uptake, environmental fate and transport, and species sensitivity. Assessing the toxicity of a substance based solely on its total concentration in water may not accurately reflect its potential harm to aquatic organisms. The bioavailability of substances is influenced by environmental factors such as pH, temperature, and the presence of complexing agents. Understanding these factors helps predict the fate and transport of pollutants in aquatic ecosystems because bioavailability of a substance determines the extent to which organisms can take it up from their surrounding environment. In this study, we aimed to predict the toxicity of metals, based on such bioavailability factors, in water samples collected from Tar Creek using the Biotic Ligand Model.

The Biotic Ligand Model (BLM) is a mathematical model used to predict the toxicity of metals to aquatic organisms. It takes into account the complex interactions between metal ions, water chemistry, and the biological characteristics of the organism. Water samples were collected from several sites in Tar Creek and from waterways in the surrounding area. Metal concentrations were measured using inductively coupled plasma optical emissions spectrometry (ICP-OES). Additional parameters were measured including temperature, pH, nitrate, sulfate, and organic carbon. Visual MINTEQ v3.1, a chemical equilibrium model, was then used to study the metal speciation of metals, especially zinc, in all waters. The BLM module within Visual MINTEQ was used for the estimation of zinc toxicity based on the amount measured at each site. The results predicted that the concentration of zinc would result in high mortality of fish in the most contaminated sites. In fact, the most contaminated site was predicted to contain an amount of zinc sufficient enough to be 3 times higher than the concentration needed to be 100% lethal. However, we have observed that fish still live in those waters, leading us to consider that the model might overestimate the predicted toxicity.

Aryanna fishing to collect fish samples from Sycamore Creek

Regulatory standards and guidelines for water quality are increasingly incorporating bioavailability considerations, making related research important for improvement of current models that predict metal toxicity. Despite the results predicted by the BLM, we have found a variety of fish species and other aquatic organisms in the most contaminated waters, which suggests that these organisms have evolved specific mechanisms to tolerate metal toxicity. Future research will include investigations into the possible acclimation and adaptation mechanisms.

Spatiotemporal Variation in Dissolved, Bioavailable, and Particulate Elements and the Abundance of Harmful Algae in Grand Lake

Yetkin Ipek and Puni Jeyasingh
Oklahoma State University
Department of Integrative Biology

Harmful algal blooms (HABs) are a recurring environmental problem with detrimental effects on both human health and ecosystem services. Under favorable conditions, the overgrowth of toxin-producing cyanobacteria results in an increase in cyanotoxin concentration in drinking water, including neurotoxins, hepatotoxins, cytotoxins, and endotoxins. Through such direct but also indirect effects (i.e., resource depletion), HABs also result in damage to ecosystem services; severely impacting local economies relying on aquatic systems. The Environmental Protection Agency (EPA)'s 2015 report has estimated management costs associated with HABs to be up to $2 billion annually.

While several environmental parameters have previously been associated with phytoplankton blooms, the increased loading of limiting nutrients remains to be the most common variable resulting in HAB overgrowth. Hypotheses to forecast blooms have previously been focused on two limiting elements: nitrogen (N) and phosphorus (P). This fundamental approach is based on the growth rate hypothesis; as cellular N is required as building blocks of proteins, while P is utilized to produce rRNA to facilitate the synthesis of proteins. However, despite prior observations of N and P on phytoplankton growth, the prediction and mitigation of HABs still cannot accurately be made based on these two elements.

As elements that act as building blocks of cells (i.e., C, H, O, N, P, S) are required for cellular growth, other nutrients are also essential to ensure the functionality of proteins. Such elements can either act through balancing ionic charges (i.e., Na, K, Mg), or form the catalytic centers of proteins to facilitate cellular reactions. Trace metals, that make up the catalytic centers of proteins are one of the most important groups of elements on the periodic table. Furthermore, there is significant heterogeneity in the natural supplies of trace metals which are further altered by anthropogenic activities. Among trace metals, prior studies have underlined the significant heterogeneity of iron (Fe) concentrations between Oklahoma reservoirs, as well as the growth-promoting effects of Fe on bloom-forming phytoplankton. However, it is important to remember that such heterogeneity of elemental supplies not only occur between aquatic bodies over large spatial scales, but possibly also among different locations of the same water body, subject to the size and the differential inputs of elements at different sites.

Our results indicated significant differences between cyanobacterial abundance across sites and seasons, with highest recorded counts during the late summer season (Oct) in Horse Creek compared to the three other sites. We also measured significantly higher concentrations of Fe in both total dissolved and bioavailable forms in Horse Creek during October sampling. Furthermore, we found a higher demand for cellular Fe in cyanobacteria compared to other phytoplankton taxa. Finally, the bioassays we conducted indicated that samples with chelator-bound Fe had significantly less growth compared to the control and added Fe treatments. This study is currently published as an article on ES&T Water. As growing evidence suggests that multiple elements can promote phytoplankton growth, incorporating and understanding the association between the processing of multiple nutrients and their growth-promoting effects may be the key to better predict HABs. As such, integrating an atom-first approach to account for the shifts in elemental processing may be vital in forecasting HABs under different scenarios

Heavy Metal Accumulation in Macroinvertebrates downstream from a Historic Mining District

Sam Miess and Andy Dzialowski
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Department of Integrative Biology

The Tar Creek superfund site in northeast Oklahoma remains one of the largest and most challenging superfund sites in the United States. The large piles of chat, or mining waste, present at the superfund site contain high quantities of heavy metals (e.g. zinc, copper, lead), which leech into the eponymous Tar Creek. These toxic metals can then flow downstream into the Neosho River, and eventually to Grand Lake, impacting the various organisms living in these waterbodies. Although some work has assessed heavy metal concentrations in fish and larger animals, little work has examined the heavy metal concentrations of insects and other invertebrates, especially those living in deep-water sediments. These deep-water sediment invertebrates are of particular interest. These invertebrates serve as prey for various fish species. Insect larvae living in deep-water sediments emerge from the water as winged adults, potentially transporting any heavy metals present in the deep-water sediment to the water's surface and beyond.

Our research examined various invertebrates that live in the deep-water sediments of the Neosho River to see how much heavy metal was present in these organisms. Focusing primarily on burrowing mayfly larvae (Ephemeroptera; Ephemeridae), midge larvae (Diptera; Chironomidae), and sludge worms (Tubificida; Naididae), we collected specimens from the confluence (i.e. where the two rivers meet) of Tar Creek and the Neosho River (Upper Neosho site) and further downstream on the Neosho River (Lower Neosho site). We then determined the concentrations of seventeen elements within these specimens through inductively coupled plasma optical emission spectroscopy. Overall, invertebrates collected at Upper Neosho had higher copper, nickel, and zinc concentrations than those collected at Lower Neosho. Additionally, we found that both burrowing mayflies and sludge worms had significantly higher zinc concentrations at the Upper Neosho site versus the Lower Neosho site. Sludge worms also had significantly higher concentrations of copper at the Upper Neosho site versus the Lower Neosho site. The difference in sludge worm copper concentrations between the Upper and Neosho sites (i.e. enrichment) was significantly greater than the copper enrichment of the water and sediment collected. When compared to mayflies collected in Grand Lake, Upper Neosho mayflies had significantly higher concentrations of both nickel and zinc.

Sam sampling macroinvertebrate communities in Grand Lake

Our findings suggest that organisms in deep-water sediment possess higher concentrations of heavy metals within the Neosho River, specifically zinc, copper, and nickel. This is particularly concerning for the insect larvae collected (midges and mayflies) as they reach high densities (100s-1000s individuals/m2), and they can transport the metals to terrestrial systems as adults. Additionally, sludge worms appear to be taking up larger loads of copper, although the reason remains unclear.

Current work continues examining the elemental profile (i.e. ionome) of the deep-water sediment invertebrates mentioned here, as well as others.

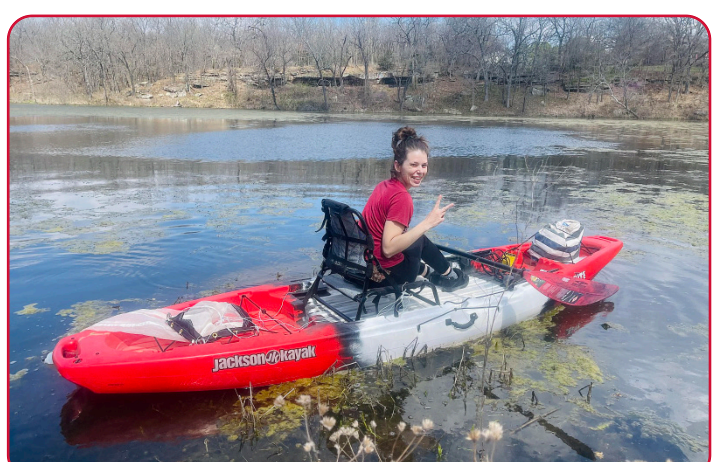
An Examination of the Eutrophication Status of Happy Lake in Claremore, Okla.

Ashli Mansour Ahmed Mohamed and Cheyanne Olson
Rogers State University
Department of Biology

Freshwater access is a growing concern among the majority of populations with only 0.001% of the world's freshwater available for human use, much of it being contaminated. One major problem is cultural eutrophication, which happens when excess nutrients from farming and other human activities pollute lakes and rivers. Oversaturation of nutrients in waterways can lead to harmful algal blooms (HABs), which release toxins dangerous to both humans and animals. Scientists can measure these algae by testing for chlorophyll-a, a pigment found in them. This pollution is a serious threat to our water systems, natural ecosystems, and health, and calls for urgent attention.

Lake Claremore is an artificial reservoir that was created in 1932 by building a dam on Dog Creek. Lake Claremore is not only used as the community's primary drinking source, but it also serves recreational purposes such as fishing, boating, and kayaking. However, Lake Claremore is listed on the Oklahoma 303(d) list of impaired bodies of water for high chlorophyll-a levels with an unknown source of contamination. Previous attempts to find the source of contamination have failed in the past and the conditions of Lake Claremore persist today. In this study, we began investigating the water quality of Lake Claremore, from April to August 2024, focusing on chlorophyll-a levels. Research began with Happy Lake, separated from the main lake in the 1950s by a rock and concrete spillway designed for flood control. Since then, the spillway has been left untouched, and Happy Lake's water quality goes unmonitored. Additionally, key data on Happy Lake's size, depth, and volume are largely unknown, as there are no data entries found on the system.

Over the sampling period, the group monitored 7 different sample sites along the gradient from Happy Lake, over the spillway, into Lake Claremore, once a month, and analyzed samples for common water quality parameters such as water temperature, pH, dissolved oxygen levels, algal particles, and nutrients such as total nitrates (TN) and total phosphates (TP). Each parameter examined plays an important part in the eutrophication process. Higher water temperatures in addition to elevated levels of nutrients, and algal counts accumulating with lower dissolved oxygen levels indicate a lean towards a more eutrophicated system that could be at risk for HABs.



Ashli sampling Happy Lake from a kayak

Statistical analysis of the data collected revealed that more pronounced fluctuations in nutrient and oxygen levels in addition to algal particles were found in Happy Lake than that compared to the data on deeper sections of Lake Claremore. These findings suggest that excess nutrient levels from Happy Lake can spill over into Lake Claremore, especially during rain events, potentially worsening lake eutrophication and the contribution of elevated levels of chlorophyll-a found in Lake Claremore.

Population Dynamics of Bats in Rural and Urban Forest Habitats in Rogers County, Okla.

Katrina Sherrick and Keith Martin
Rogers State University
Department of Biology

Bats are a cryptic species, meaning they're harder to observe than other wildlife species like deer. Every county in Oklahoma has at least one native species of bat, and most have multiple. Methods to observe bats fall into two main categories: physical capture and passive monitoring. Physical capture typically uses a net system to catch the bats during flight or when they exit their caves, while passive monitoring systems include infrared light cameras and acoustic detectors. Acoustic detectors have become comparable in accuracy to physical capture methods in terms of species presence and absence surveys. Given bats are a highly specialized group of mammals, they fill specific niches in a wider ecosystem; losses can shift food web dynamics and potentially impact other species as well. However, bats are also extremely susceptible to disturbance, which occurs via changes to the landscape or the introduction of a fungal illness called White Nose Syndrome to cave roosts. Changes in the landscape are primarily associated with green energy development, especially wind farms due to the large turbine blades; and urban development increasing habitat fragmentation, usually with the construction of roads and structures.

Multiple maternity caves for federally protected gray bats are found in Mayes and Delaware counties and are monitored by multiple agencies, including GRDA. The RSU Field Research Station and Outdoor Education Preserve are two locations closer to the RSU Claremore campus with potential habitat for NE Oklahoma bat species. The Evening bat, Eastern Red bat, Silver-haired bat, and Big Brown bat are commonly seen bats in the Rogers County area, with Eastern Red bats reportedly caught via netting in the RSU Reserve before by the Rogers County Conservation Service. The RSU Research Station has been a conservation area to foster habitat for the American Burying Beetle and Northern Long-eared bat.

Given that historical data reports bats being present on the RSU Claremore campus, a study was developed to compare the species presence on campus at RSU with those found at the Research Station. Sites were chosen based on vegetation density and water proximity and monitored using ultrasonic acoustic detectors. The species expected for Rogers County described earlier are insectivores. The Mexican free-tailed bat is also an insectivore, but is primarily a desert-dwelling species that roosts in the caves and crevices of rocky areas. The Mexican free-tail bat has increasingly been moving east, which could lead to changes in which species are predominately found in Northeastern Oklahoma.

The findings in this project can potentially provide a more detailed record of local species and possibly help identify areas of conservation concern, especially if new species are moving in, native species are moving out, or if competition between multiple different species could develop, leading to the local extinction of one or more species.

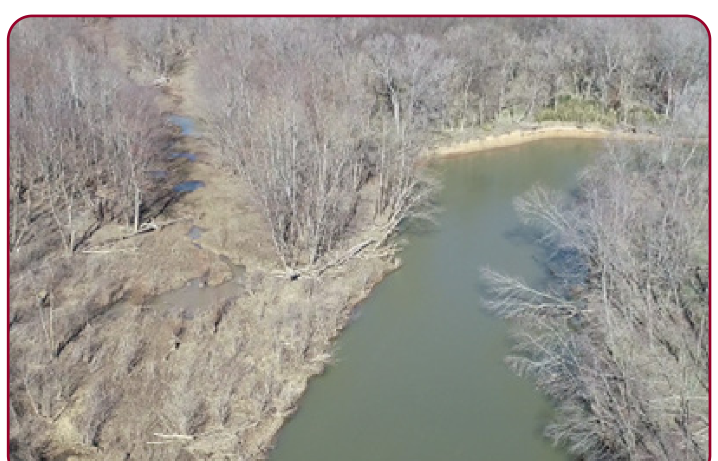
An ultrasonic bat detector deployed along a wetland area

Utilizing Geospatial Technology Techniques to assess *Arundinaria gigantea* (Giant Rivercane) for Restoration Management

Hailey N. Blackwell and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Arundinaria gigantea, or rivercane, have been regarded as a great priority for conservation and restoration due to both the ecosystem (e.g., maintaining and enhancing biodiversity) and cultural importance of the vegetation to indigenous tribes of the southeast and southcentral United States. Recommendations for protecting rivercane have encouraged stand monitoring and rivercane management plans, including exclusion fencing, suitable fire regimes (i.e., winter or summer burns), eliminating feral swine, overstory and understory disturbance, and canebrake faunal surveys. With research being conducted and traditional ecological knowledge (TEK) being passed down, more information is available today to help identify rivercane and predict potential restoration sites using geospatial technologies, like remote sensing, geographic information systems (GIS), and Light Detection and Ranging (LiDAR). Remotely sensed data allows for detecting, identifying, classifying, evaluating, and measuring various land cover types and changes, using qualitative and quantitative methods, over large areas consistently and repeatedly. Advancements in remote sensing technology have made it possible to estimate biomass, biophysical and biochemical properties, and water content of vegetation. The digital data derived from remote sensing allows for integration into software like GIS for further analysis.

In this study, geospatial technologies are being used to estimate the location, size, and overall health of rivercane stands at the Lake Frances site along the Illinois River on the Oklahoma-Arkansas border and promote the growth and restoration of rivercane ecosystems. Nearly 4 acres of rivercane stands were identified at the 253-acre site using small unoccupied aerial system (sUAS) flights and verified through ground-truthing trips to measure size and physical characteristics of the stand location. Using ArcGIS Pro software, future areas suitable for rivercane restoration at the Lake Frances site will be identified using data collected at known rivercane location characteristics, such as soil, elevation, canopy cover, water availability, and plant health. The objective of the study is to better understand why or why not rivercane is growing within the study site and determine what rivercane stand characteristics can be universally applied to identify future potential restoration sites.



A drone image taken during a rivercane search flight

Hailey prepping the drone for a flight mission

Simulating the Effects of Climate Variability on a Culturally Important Native Vegetation, *Arundinaria gigantea* (Giant Rivercane), for Resilient Restoration Management

Hailey N. Blackwell and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Both Traditional Ecological Knowledge (TEK) (the observations, knowledge, practices, and beliefs which support sustainability of the environment and stewardship of natural resources and ecosystems) passed down from southeast and southcentral United States indigenous tribes and scientific research have shown that Arundinaria gigantea, or rivercane, supports biodiversity, works effectively as a vegetative buffer in agricultural areas, and decreases surface runoff and sediment deposition. Anthropogenic changes to the landscape, such as damming, deforestation, agriculture, and urbanization, in addition to the increasing amount and intensity of climate change-induced disasters, have adverse effects on riparian ecosystems where rivercane is located. To better understand how rivercane productivity is being affected by the changing climate, a study is being conducted within a wind tunnel-porous media test facility operated by the United States Army Corps of Engineers (USACE). The facility is known as the Synthetic Environment for Near-surface Sensing and Experimentation (SENSE) at the USACE Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi. The SENSE facility allows for the creation of micro-climatological scenarios on objects of interest and background environments prepared in a soil-test bed and interfaced with the wind tunnel. The rivercane was tested in the SENSE wind tunnel through the simulations of sudden below-freezing temperatures, or "cold snaps", and extreme hot and dry conditions following increased intensity and frequency precipitation events, or "flash droughts." Using instrumentation techniques to monitor plant performance, the overall productivity and resiliency of the rivercane was analyzed and compared to results of the climate change-induced weather extreme scenarios and current conditions. The cold snap showed minimal to no change in rivercane foliage chlorophyll content index (CCI), which indicated the possibility of cold temperature tolerance due to the lack of plant stress, while the leaf stomatal conductance, or the plant's ability to conduct photosynthesis or transpiration, remained either low or nearly the same. The flash drought scenario showed indications of plant stress increasing and photosynthesis and transpiration decreasing throughout the experiment as well as visible signs of stress through dried up foliage on the rivercane. The remaining data from the experiments are being analyzed. Results from the studies will be used to develop an ecological design technical report for resilient rivercane restoration management in the changing climate of the South Central United States.

Hailey doing fieldwork at a reasearch site

Hailey working in the USACE SENSE tunnel

Modelling *Arundinaria gigantea* (Giant Rivercane) as a Culturally Important Nature-Based Solution for Ecosystem Restoration

Hailey N. Blackwell and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Arundinaria gigantea, or rivercane (a native grass), is considered a culturally important species to Native American communities who use it for sacred ceremonies, tool making, and hunting and gathering purposes. Native vegetation, like rivercane, on river and stream banks and associated riparian zones is beneficial for erosion and pollution control and habitat provision. Established rivercane stands can grow into a dense configuration called a canebrake, an important riparian ecosystem in the southeast and southcentral United States, which has an interlocking rhizomic root structure with excellent soil stabilization potential. Less than 2% of original rivercane ecosystems still exist in the U.S. Taking into consideration known cultural and ecological uses, rivercane restoration may serve as a nature-based solution (NBS) for several environmental challenges associated with urbanization and climate variability.

The 1,069,530 acres of the Illinois River watershed, located on the Oklahoma-Arkansas border, faces water quality concerns and an estimated fifty percent increase in population (over 1 million people) by 2045. The old Lake Frances area, now a 30-year-old bottomland hardwood forest along the Illinois River, near Watts, Oklahoma and Siloam Springs, Arkansas provides the opportunity for modeling rivercane and other potential NBS for the concerns of the watershed. An evaluation of rivercane as an NBS is being conducted with the watershed-based model, Gridded Surface/Subsurface Hydrologic Analysis (GSSHA). GSSHA is a multi-dimensional physics-based hydrologic simulation of physical processes, impacts of restoration alternatives, and methods for decreasing or preventing pollution to surface water, developed by the United States Army Corps of Engineers (USACE). The GSSHA model is being used to analyze how rivercane restoration and other NBS, like wetland creation, can influence water quality and quantity in riparian settings on the Illinois River watershed. The objectives for the GSSHA model are to create a calibrated and validated hydrologic model representative of the study site and to evaluate rivercane as a riparian area NBS by analyzing how the location and size of rivercane stands influence water quality and quantity. The goal of this study is to promote the implementation of rivercane as a NBS for water quality and quantity issues throughout the Illinois River watershed and other applicable areas.

Giant Rivercane (*Arundinaria gigantea*)

Hailey during a field trip to the Illinois River area

Sustainable Reuse of Mine Drainage Residuals for Phosphorus Management in Support of a Circular Economy

Dayton M'Kenzie Dorman and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Eutrophication of waterways is a major problem affecting watersheds in today's world. Eutrophication is often caused by excessive phosphorus (P) from runoff that can cause harmful algal blooms and degrade water quality. Phosphorus-sorbing materials have been investigated to decrease external P loadings into streams and reservoirs and are often iron (Fe) and/or aluminum (Al) oxides. However, commercial Fe and Al salts can be cost-prohibitive for wide-scale watershed applications. However, natural sources of iron oxides are mine drainage residuals (MDRs), which are formed when dissolved Fe in the mine water is exposed to oxygen and precipitates as an ochreous floc either in raw, untreated discharges or in a designed treatment system aiming to remove these ecotoxic metals. The primary units in mine drainage passive treatment systems are oxidation ponds, which accumulate iron oxide solids over time and the disposal of which can be financially burdensome and environmentally unsustainable. Previous studies alongside this research have found that MDRs have a high P sorption capacity and can be a more economical alternative to traditional Fe/Al salts. A considerable data gap exists on the effect mine drainage chemical composition has on the resulting physicochemical and mineralogical characteristics of formed iron oxide precipitates and their overall P sorption performance. In this study, water quality samples and iron oxide precipitates were collected and analyzed from six different and varied locations. Two of the locations were oxidation ponds in passive treatment systems located in the Tar Creek Superfund Site within the Tri-State Lead-Zinc Mining District and the Grand Lake o' the Cherokees watershed, where the mine drainage is net-alkaline and contains elevated Fe, Pb, Zn, and Cd concentrations. Two of the locations were net-acidic coal mine discharges, and two were oxidation ponds in net-alkaline coal mine passive treatment systems (where anoxic limestone drains generated alkalinity in net-acidic waters) in the Arkoma Basin, USA, with a wide range of metal concentrations. Water quality sampling, iron oxide collection and characterization, P sorption studies, and a cost analysis of reusing MDRs for P sorbents were performed.

The research showed that the MDRs formed in circum-neutral waters have more available surface sorption sites and more favorable surface charge for the sorption of P than MDRs formed in untreated net-acidic discharges. However, the release of metals was found to occur at higher dosing of MDRs and in more acidic conditions and thus should be monitored in larger-scale applications. This research also found that the MDRs continue to crystallize over time, which can decrease their specific surface area and overall P sorption capacity. Despite the change in crystallinity of the MDRs between water chemistries and as they age, all MDRs had a large P sorption capacity. There was no statistical difference between the P sorption performance of the MDRs and a commercially available Fe-based sorbent, Bayoxide ® E33. Cost analyses showed that recovering the MDRs from oxidation ponds and leaving them on-site for future use is less costly than hauling the MDRs to a landfill for disposal. Selling the MDRs at 1-5% of the cost of Bayoxide® E33 can provide enough revenue to offset recovery costs and provide money for the next 15 years of maintenance for the passive treatment systems. Beneficially reusing MDRs from mine drainage passive treatment systems can improve watersheds such as the Grand Lake of the Cherokees two-fold. The MDRs can be used as a P sorbent to decrease P runoff into waterways, decreasing eutrophication and the potential for harmful algal blooms. Similarly, the recovery and potential sale of these MDRs ensure the continued performance of the passive treatment systems treating mine drainage that would otherwise pollute the local streams and waterways within the larger watershed.

Ecological Effects of Prescribed Fire on *Fraxinus pennsylvanica* (green ash) Mortality, Species Diversity, and Soil Quality within the Neosho Bottoms

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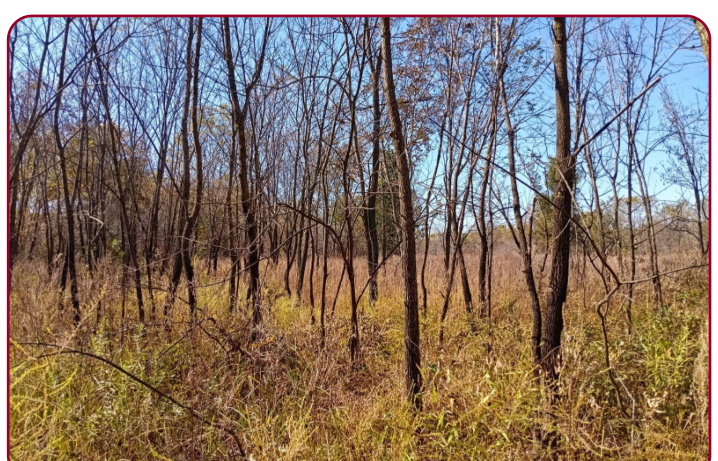
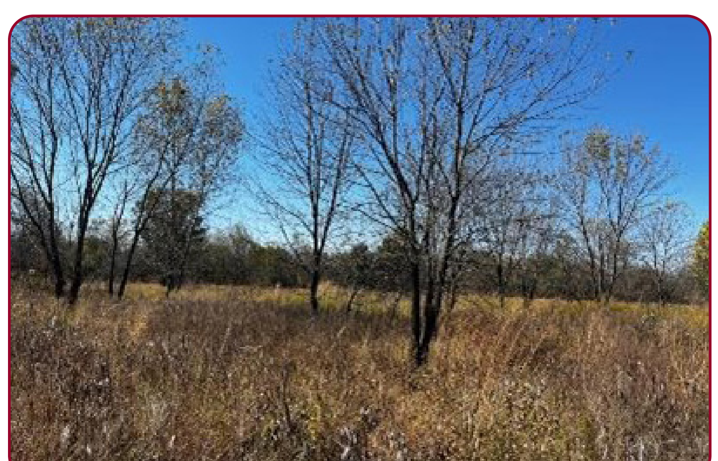
Prescribed fire is a nature-based solution (NBS) and widely used management tool in bottomland hardwood ecosystems, yet its specific impacts on green ash dynamics and associated ecological parameters remain underexplored. This research aims to assess the implications of fire-based management practices in the Neosho Bottoms, which is a native oak-hickory-ash hardwood forest degraded by human activity, namely clear-cutting and attempts to convert the land to agriculture.

This study evaluates the ecological effects of prescribed fire by collecting and analyzing pre-burn and post-burn data at selected sites. Specific objectives include: 1) Assessing green ash mortality rates in response to prescribed fire and thinning treatments; 2) Measuring changes in basal diameter and resprouting dynamics of green ash trees; 3) Quantifying changes in species diversity following prescribed fire events and 4) Evaluating alterations in soil properties, including nutrient content and organic matter, due to prescribed fire. An initial site visit was conducted in October 2024, and included discussions with GRDA personnel, a tour of several sites within Neosho Bottoms with recent prescribed fire and forest thinning activities conducted for the management of green ash trees, and identification of three additional locations as potential study sites. These sites were assessed based on their suitability for data collection and their representation of varied management histories. The use of advanced research technologies will play a crucial role in the research. Geographic Information System (GIS) mapping will be employed in the final selection of study sites. In addition, small Unoccupied Aerial System, or sUAS, technology, equipped with a spectral sensor to assess vegetation health, at the Neosho Bottoms research site, will be utilized.

Data collection is set to begin in spring 2025.



Managed area with prescribed fire *without* forest thinning



Managed area with prescribed fire *with* forest thinning

Evaluating Impacts of Legacy Mine Wastes on a Watershed Scale

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University of Oklahoma
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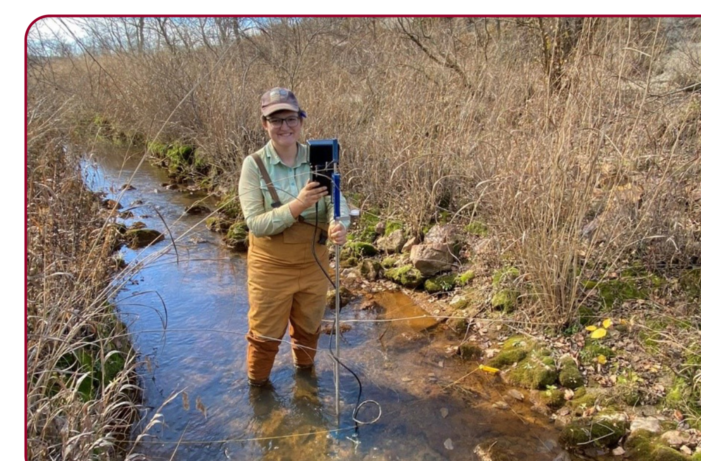
Thousands of stream miles worldwide have been impacted by complex sources of ecotoxic metal contamination from mining. The Tri-State Lead-Zinc Mining District (TSMD) in the Grand River watershed is one such source of mining impacts. Although remedial efforts within the TSMD are underway, the size of the mining district and the logistical and financial constraints on remediation mean that these efforts will need to be sustained over decades. In the interest of being efficient with the available time and budget, it is important to prioritize work that will provide substantial and maintainable water quality improvements to downstream communities that can be completed quickly and without exceeding budget allocations.

This study examines the interaction of the water in Tar Creek, a tributary of the Neosho River that principally flows through the TSMD, with sediments, soils, and mine wastes on the surrounding landscape. Waste rock from mining was placed on the land surface during the 19th and 20th centuries, sometimes directly adjacent to streams such as Tar Creek. Flooding and erosion have transported some of this mine waste into stream beds, and rainfall supplies fresh water to pore areas within the piles of waste rock, both of which increase chances for the transport of trace metals. This study quantifies the impacts these interactions have on the water quality of Tar Creek and compares their impact to the artesian discharge of water from the underground workings, which contribute water with elevated concentrations of trace metals when the water table is high enough to drive artesian flow. Monthly sampling at several points along Tar Creek and at the inflow points of its tributaries has been conducted since March of 2023. As the measured flow increases, the percentage of the flow contributed by discharges from the mine workings decreases, and diffuse sources of stormwater runoff contribute more water to the stream. Measured stream flow and concentration of trace metals in the water samples are used to determine the load of trace metals passing through Tar Creek for a given period of time. Changes in loading at different points along the stream during the same sampling event can indicate settling of metal-rich particles to the stream bed (if the load downstream is less than the load upstream) or contributions of metals from an unmeasured source (if the load downstream is greater than the load upstream).

Over the course of this study, the measured loads in areas where mine waste is present in and adjacent to the stream have exceeded the expectations of loads based on the sum of upstream and tributary loads. These areas have increased storage of trace metals in the porewater of sediment under the stream, which are in some instances composed of mine waste. However, these sediments do not appear to contribute substantial quantities of water to the stream flow. Evaluation of water quality and quantity within the mine waste below and adjacent to the stream is ongoing to determine what factors have the greatest impact on the quantity of trace metal load contributed to the stream in different areas across the watershed.



Justine collecting flow measurements in Tar Creek

An Applied Evaluation of Ecosystem Services Decision-Support Tools: Lake Frances Pilot Study

Ali Meek and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

This study explored the effectiveness of Ecosystem Services Decision Support Tools (ES-DSTs) in quantifying wetland ecosystem services (ES) and bridging the gap between conservation policies and real-world applications. Two tools, the Ecosystem Services Identification and Inventory (ESII) and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), were used to assess ES at three wetland sites.

Lake Frances, which transitioned from a reservoir to a bottomland hardwood forest (BHF) after a dam failure in 1990, was a focal point for demonstrating how ES-DSTs can evaluate ecological and social value for landscape-scale benefit-cost analyses (BCAs). The Lake Frances BHF provides critical ES such as flood attenuation, stormwater retention, and water quality improvement. Trees within the BHF stabilize riverbanks, decrease erosion, and filter pollutants, helping to address water quality challenges in the Illinois River Watershed (IRW). This region faces ongoing pressures from agricultural runoff, urban stormwater, and municipal discharges, all of which are expected to increase with population growth. The BHF also contributes to climate change mitigation by sequestering carbon and supports biodiversity, providing vital habitat for a variety of wildlife. Beyond ecological benefits, Lake Frances offers recreational and aesthetic value, fostering community well-being through activities like hiking, birdwatching, and nature appreciation. To enhance these assessments, expert feedback and wildlife camera traps were used to evaluate stakeholder priorities and biodiversity. Experts identified nutrient retention and flood mitigation as key services at Lake Frances. However, the ES-DSTs underestimated nutrient retention, emphasizing the need to integrate stakeholder insights with analytical tools to achieve a more comprehensive understanding of ecosystem dynamics. This multifaceted approach highlights the importance of combining qualitative perspectives with quantitative outputs to effectively capture site-specific priorities. Consistent with the ES-DST results, habitat quality emerged as a high-performing service at Lake Frances, supported by wildlife camera data documenting species such as armadillos, river otters, coyotes, and white-tailed deer.

The Lake Frances pilot study underscores the role of BHFs as natural infrastructure and hotspots for ES. Their ability to capture runoff and mitigate pollution demonstrates their value for stormwater management and conservation planning. Additionally, the site's recreational and biodiversity contributions bolster its significance for local communities and regional ecological health. By integrating ES-DST outputs with expert input and observational data, the study provides a compelling case for preserving BHFs like Lake Frances. These findings offer actionable insights for policymakers and conservation practitioners, emphasizing the importance of balancing analytical rigor with stakeholder engagement. The Lake Frances BHF serves as a model for how ES assessments can guide effective conservation strategies and inform sustainable land-use planning.

Lake Frances Bottomland near the Illinois River

An Applied Evaluation of Ecosystem Services Decision-Support Tools: Tar Creek Pilot Study

Ali Meek and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

This study aimed to validate the hypothesis that Ecosystem Services Decision Support Tools (ES-DSTs) effectively quantify site-specific wetland ecosystem services (ES), providing valuable insights into environmental and social variables for more comprehensive ES reporting for use in landscape-scale benefit-cost analyses (BCAs). To deepen understanding of how ES-DSTs bridge the gap between wetland conservation policies and practical implementation, two representative ES-DSTs were applied to three different wetland sites including two treatment wetland systems near Commerce, Oklahoma. The Tar Creek Watershed, part of a USEPA Superfund Site, suffers from contamination caused by mine water discharge and runoff from tailings containing lead, zinc, cadmium, and other pollutants. This damage has led to its classification as "irreversible man-made damage," posing a significant challenge for restoration. The University of Oklahoma's (OU) Center for Restoration of Ecosystems and Watersheds (CREW) operates two passive treatment systems (PTS) designed to address mine drainage: the Southeast Commerce PTS (SECPTS) and the Mayer Ranch PTS (MRPTS). A key objective of this study was to assess whether PTS targeting ecotoxic metals could also provide ancillary ES, such as habitat quality. This approach underscores ES-DSTs' potential for documenting ecological success in legacy pollution restoration projects. To complement these assessments, expert feedback and wildlife camera traps were used to evaluate local perspectives and biodiversity. Two ES-DSTs were applied: the Ecosystem Services Identification and Inventory (ESII) and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST). Both tools identified contaminant buffering and habitat quality as primary ES priorities at the PTS sites. Wildlife camera data supported these findings, revealing diverse food chains with key species such as muskrat, beaver, river otter, bobcat, and red-winged blackbird. Considering InVEST and ESII outputs plus expert feedback, the priority and highest-performing ES at the PTSs included contaminant buffering and habitat quality. While expert partner feedback emphasizes the importance of cultural services, ranking education/research as the third most important ES at the PTSs, neither tool explicitly addresses cultural services beyond recreation and aesthetic quality. Addressing this gap is crucial for ensuring a holistic understanding of ES to inform decisions about conservation and management strategies moving forward. Despite these constraints, the study illustrates how nature-based technologies can restore primary and ancillary ES at heavily damaged Superfund and brownfield sites.

While further refinement of InVEST and ESII is necessary, initial findings confirm their applicability in documenting ES at legacy pollution sites. Careful consideration is crucial when applying ES-DSTs, as their inherent limitations must be recognized to ensure accurate and effective practical use.

Ali presenting her thesis research

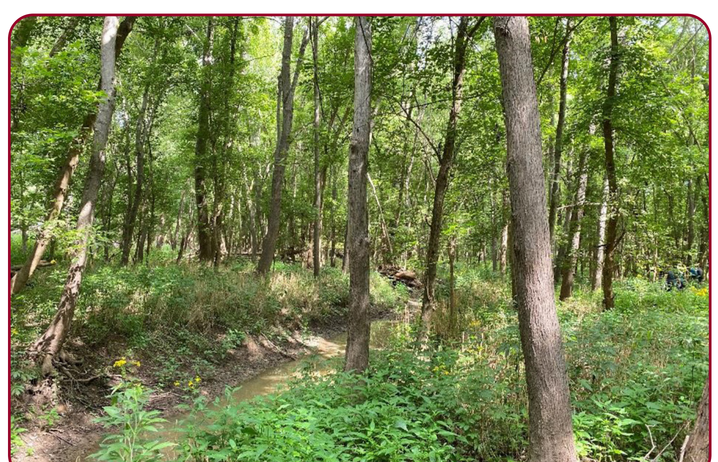
Legacy Sediment Riparian Ecosystems: Understanding Phosphorus Dynamics in a Legacy Sediment Floodplain

Cheyenne M. Morgan and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Legacy sediments are deposits of historic sediment that accumulate along lake beds, river banks, and floodplains. They typically form as a result of people causing soil erosion upstream. In the case of lakes formed by dams, legacy sediments accumulate over long periods of time as the reservoir lakebed. These accumulations contain not only sediment but oftentimes pollutants such as trace metals and excess nutrients. Many studies have been completed that focus on pollutant transport after dams are removed and it has been established that legacy sediment containing elevated concentrations of pollutants may negatively impact adjacent water bodies. However, most studies conducted were within a year of dam removal and mainly along legacy sediment stream banks. It is less clear if legacy sediment, when allowed to remain in place, continues to be a source of pollution decades after the dam has been removed. At Lake Frances, Oklahoma, an ongoing research project is being conducted to better understand if and how one type of pollutant, phosphorus (P), is being released from a legacy sediment floodplain thirty years after the dam was removed. The research focuses on how water can release and/or store P within the legacy sediment floodplain. The research goals are to 1) understand how water moves through legacy sediment floodplain soils, 2) assess where and how much P is stored in the soils, and 3) determine if groundwater is impacted by legacy sediment deposits.

The project is divided into three interrelated studies. The first study involves site-wide characterization of soil physical and hydrologic properties, including particle size distribution, porosity, permeability, and infiltration capacity. The second study provides an estimate of the 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 focuses on P dynamics within alluvial groundwater, shedding light on subsurface nutrient dynamics along flow paths. To date, 130 surficial soil samples have been collected and analyses are underway.

In 2025, temporary monitoring wells will be installed throughout Lake Frances to track groundwater P concentrations over time. Infiltration and leaching tests will assess P mobility during high precipitation, flooding, and drought conditions. 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.



An incised creek in the old Lake Frances lake bed

Metal Tolerance of Sulfate Reducing Bacteria in a Mine Drainage Treatment Bioreactor

Leif H. Olson and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

The Mayer Ranch passive treatment system near Commerce, Oklahoma removes a variety of potentially toxic metals from contaminated mine water in the historic Tri-State Mining District. This nature based environmental remediation system decontaminates metal laden mine water before it enters the Tar Creek watershed, leading to downstream ecological recovery in previously contaminated water bodies. One part of the passive treatment system is called a vertical flow bioreactor, meaning that the water flows vertically downwards through an organic material that provides habitat for bacteria and other life forms that remove metals from the mine water. At Mayer Ranch, the bioreactor substrate is made of a mixture of limestone sand, woodchips, and mushroom compost, and is several feet underwater, creating anaerobic conditions. In the absence of oxygen, microbial processes like sulfate reduction occur, where bacteria use sulfate instead of oxygen to "breathe", and "exhale" sulfide instead of carbon dioxide. Mine water entering the bioreactor is rich in sulfate and the sulfide produced binds with metals, turning them into solid forms and effectively removes them from the water. These sulfate-reducing bacteria (SRB) are a widespread and diverse group of microorganisms. This project aims to identify and characterize some of the SRB in the Mayer Ranch vertical flow bioreactor using bacterial cultivation and environmental DNA surveys. Samples of the bioreactor substrate were collected and brought back to the University of Oklahoma for analysis of metals, microbial communities and SRB growth. Cultivation of SRB was performed using enrichment cultures, where the samples of the bioreactor substrate were injected into test tubes containing a liquid medium designed to mimic the water from the bioreactor. These liquid cultures were then put onto petri dishes to separate bacterial colonies from each other and picked with sterile toothpicks into fresh liquid media where the isolated colonies could be identified and stored for future tests. Additionally, DNA was sequenced from samples of the bioreactor substrate to assess the community of bacteria present. The microbial community in the bioreactor includes a diversity of SRB as well as bacteria associated with breaking down complex forms of carbon, like those contained in the mushroom compost of which the bioreactor is composed. The bacteria that have been isolated appear to belong to the species *Desulfovibrio desulfuricans*, *Solidesulfovibrio alcoholivorans*, and *Cupidesulfovibrio liaohensis*. The former is a common species and one of the most well studied SRB, while the latter two are rare species with limited existing research about them. These bacteria are being assessed for their ability to grow in elevated concentrations of zinc, one of the main metals found in the mine water being treated at Mayer Ranch.

The strains of SRB from Mayer ranch appear to tolerate greater concentrations of zinc than similar strains of SRB not originating from metal contaminated environments. Their genomes have also been sequenced to determine if they possess genetic adaptations that might improve their resistance to metals contamination. These genetic adaptions include metal resistance genes (MRGs), which produce proteins that help bacteria prevent metal toxicity by pumping metals out of their cells, transforming metals into non-toxic forms or safely storing metals inside their cells. Bacteria with a greater tolerance to metal toxicity are thought to have more MRGs, so this genome analysis will complement the experiments testing the Mayer Ranch SRB ability to grow in greater concentrations of metals. Better understanding the microbial adaptations to metal stress from growing in mine water contaminated environments could provide insight into the design or set-up of nature-based metal remediation systems. Additionally, genetic adaptations and metal tolerance capabilities in these bacteria could indicate their potential use in other biotechnological applications.

Using Indicators of Wetland Condition to Predict Trace Metals Changes in Natural and Treatment Wetlands in the Tar Creek Watershed

Samantha N. Taylor and Robert W. Nairn
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Nature-based solutions are ecosystems which employ natural processes to accomplish scientific or engineering goals that benefit both humans and the environment. Nature-based solutions often provide climate resilience and ecosystem services. One common nature-based solution application is treatment wetlands, which provide many anthropogenic and ecological benefits. In fact, wetlands are highly ecologically productive and sometimes known as the "kidneys of the landscape" for their water quality improvement functions. Constructed wetland nature-based solutions are increasingly common due to their relatively low construction and maintenance costs. The Tar Creek watershed has been drastically disturbed by historic lead and zinc mining in the Picher Mining Field in the 20th century. Contaminated water flows from the abandoned mine workings to the surface in artesian discharges, which flow into and contaminate Tar Creek and its tributaries. Wetland units have been included in designed passive systems which successfully treat mine drainage seeps in the Tar Creek watershed. Also, another constructed wetland has been applied as a nature-based solution interim measure during chat removal projects to buffer stormwater runoff. Natural wetlands which have also incidentally formed near the creek and mine drainage seeps may also act as nature-based solutions. Although they have been widely applied, both the ecological evaluations of constructed wetlands and the water quality improvement evaluations of natural wetlands are limited.

Therefore, this project provides a comprehensive evaluation of both constructed and natural wetlands in the Tar Creek watershed for their water treatment efficiency by comparing the wetland indicators of 10 identified sites which have various soil, vegetative, and hydrologic conditions. Monthly water quality analysis determined the change in trace metal concentration of surface water through each wetland. Soils were evaluated for organic matter content, trace metal concentrations, particle size, and bioavailable nutrients. Vegetation was surveyed to determine species richness, relative cover, and vegetative diversity. Hydrology was examined by determining the primary source of water and the frequency of flooding in each wetland. These indicators are used to determine ecological functions as well as understand the chemical and biological processes contributing to water quality changes through the wetland.

The goal of this project is to aid in the development of further wetland nature-based solutions in mining-impacted watersheds. By comparing the relative importance of soil, vegetation, and hydrologic indicators on the success of wetlands in improving water quality, future wetland nature-based solutions can be constructed to maximize both anthropogenic and ecological benefits.

This research is part of a master's thesis which will be completed in May 2025.

A riparian wetland on Tar Creek near a chat pile

Opportunities for Implementing Engineering With Nature Projects in Oklahoma

Robert W. Nairn, Robert C. Knox, and CREW
University of Oklahoma
CREW, School of Civil Engineering and Environmental Science

Engineering With Nature (EWN) has been described as the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration and is based on the idea that sustainable solutions require working with natural ecological, hydrological, and biogeochemical processes. Similarly, Ecological Engineering (EE) is described as designing sustainable ecosystems that integrate human society with its natural environment for the benefit of both. These nature-based solution applications, based on renewable energies and recognizing interdependencies of humanity and nature, hold promise for building a sustainable future for Oklahoma's water resources.

The U.S. Army Corps of Engineers has contracted with the University of Oklahoma's Center for Restoration of Ecosystems and Watersheds (CREW) to develop an inventory of opportunities for implementing EWN projects in the U.S. Central Great Plains. CREW hosted an EWN Opportunities Inventory workshop in early October 2024 at the University of Oklahoma's Tulsa Campus. The workshop solicited input from multiple groups with water resources related interests including Tribal nations, the for profit agricultural and energy sectors of the state's economy, non-profit interest groups and state water-related regulatory authorities. A post-workshop field trip included a visit to the GRDA Ecosystems and Education Center and active nature-based solutions research sites in northeastern Oklahoma.

This abstract and accompanying presentation were presented at the 2024 Oklahoma Governor's Water Conference and Water Research Symposium.

If you are interested in learning more about Engineering With Nature, please visit the website at www.ewn.erdc.dren.mil or scan the QR code with your smartphone camera.

EWN field trip to a research station near Tar Creek

EWN field trip to GRDA's Ecosystems & Education Center

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 environmental programs and 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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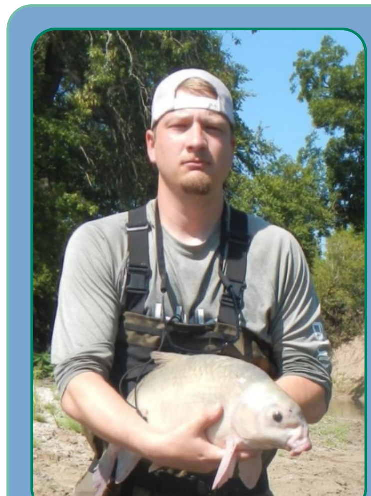
Caden Lyons	Ecosystems Management Intern
Jessie Woodward	Neosho Bottoms Intern



Welcome to the team, Cale Corley!

Cale Corley is a fisheries and water quality biologist at GRDA's Scenic Rivers and Watershed Research Laboratory at Northeastern State University in Tahlequah. He comes to GRDA from a year and a half stint working as an aquatic scientist at another river authority in central Texas. Prior to that Cale worked for Oklahoma State University and the Oklahoma Department of Wildlife Conservation as a fisheries technician. He obtained his Masters degree from Northeastern State University in Natural Science, with an emphasis on lotic stream fishes and their seasonal and longitudinal distributions above and below anthropogenic structures. In his personal life, Cale is an avid outdoorsman, doing a lot of hunting and fishing in Northeast Oklahoma.

Closing Thoughts from the Editor

As you have examined the pages of our 2024 Annual Review, we hope that you found valuable information that we have gained over the last 20 years of research. The information contained within these pages continues to shape and guide GRDA's watershed management programs. The work that current and past employees, as well as our partners, have done over the years has shaped environmental policies, addressed information gaps in scientific literature, and contributed to regulatory license compliance, allowing GRDA to produce clean, low-cost Electricity while keeping our natural resources pristine.

We believe that the work showcased in this publication, as well as our previous publications demonstrate our team's commitment to protecting and enhancing natural resources and shows us leading by example to address the natural resources challenges of the future. The GRDA Employees and University partners that you've met throughout the proceeding pages represent the current and future generation of natural resource professionals and should show that our commitment to Environmental Stewardship remains steady and unwavering. We will continue to prioritize Efficiency, seeking solutions by building partnerships and developing new tools to help secure our natural resources future and ensure that the generations to come are able to enjoy these resources the same way that we are, while also allowing Economic Development to thrive in the communities we serve.

If you have any questions about GRDA's conservation programs or watershed research, visit the GRDA website at www.grda.com, scan the QR Code below, or contact our offices at (918) 981-8473.

Sincerely,

Dustin A. Browning

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: 2024 Annual Review

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2024 Annual Review

ECOSYSTEMS EXPLORATIONS

Grand River Dam Authority