New method to gauge nutrient flow across buffer zone between land and streams

Walter Dodds and Gretchen Wichman, Kansas State University

Riparian rain simulators

REU student and volunteer sampling the stream during the rain simulation.

Researchers at Kansas State University have developed a new method to measure transport of nutrients to streams when rain falls on nearby land.

This work is important because Riparian vegetation (vegetation bordering streams) forms a vital filter that protects water quality by intercepting materials that would wash from higher areas into streams during storms. However, we know little about the way materials move through the riparian zones during storms. Researchers developed a method to simulate rain on the riparian zone and characterize movement of dissolved and particulate materials into streams.

Aquatic and terrestrial researchers often work separately on the relationship between movement of pollutants and the storms that move them. Both fields have developed methods that can be applied to study storms and transport of pollutants. We combined a method to simulate precipitation from terrestrial researchers with a tracer release approach commonly used in stream studies to assess movement of nitrogen (a biologically active nutrient) and an inert material (assessing water movement). We found that ammonium removal was highly efficient in the riparian zone of a tallgrass prairie stream, and ammonium uptake in the stream channel was also significant. This allowed us to assess the influence of atmospheric nitrogen loading at the stream/ land interface.

This project was accomplished using NSF EPSCoR funding and was the centerpiece of an REU project. It involved researchers from two EPSCoR states (Kansas and Nebraska). The results were published in a top ecological methods journal (Dodds et al. 2022) and have been presented in several professional meetings.

Reference:

Dodds, W. K., G. Wichman, J. P. Guinnip, J. R. Corman, and J. M. Blair. 2022. Assessing transport and retention of nitrate and other materials through the riparian zone and stream channel with simulated precipitation. *Methods in Ecology and Evolution* 13:757-766.

Kansas researchers study nutrient pollutants in Guam waters and launch new collaboration

Walter Dodds, Sonny Lee, and Molly Fisher, Kansas State University

Molly Fisher collects samples from corals in Guam.

Molly Fisher tests coral reef samples.

A new collaboration launched this year between EPSCoR jurisdictions in Kansas and Guam explored the effects of nutrient pollution on Guam reefs. The research is important because fertilizer, stormwater runoff, and discharge from sewage treatment pollute waterways and harm aquatic life.

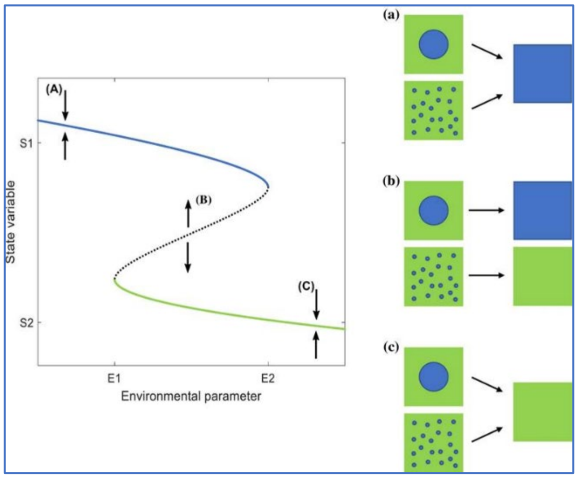
During the spring semester, a graduate student and her co-mentors traded their landlocked labs in the heartland for the sunny island shores of Guam to study coral reefs. While much is known about how warming waters, diseases, and sedimentation harm corals, less is known about how these critical ecosystems respond to nutrient pollutants like fertilizer runoff and sewage treatment discharge.

Molly Fisher, Kansas State University Master's student, spent a month in spring 2022 collecting and analyzing coral samples from two nearshore reefs in Guam. They were collaborating with Dr. Sarah Lemer, Assistant Professor of Marine Invertebrate Genomics and the University of Guam Marine Station, and co-investigator in the Guam Ecosystems Collaboratorium for Corals and Oceans (GECCO) NSF EPSCoR. Ms. Fisher's Kansas MAPS EPSCoR mentors, K-State Distinguished Professor Walter Dodds and Assistant Professor Sonny Lee, also made the 7,000-mile trek, bringing their decades of experience investigating water quality, nutrient cycling, and microbiome analysis to help launch the first academic collaboration between Kansas NSF EPSCoR and Guam NSF EPSCoR.

Dr. Lee, Dr. Dodds, and Ms. Fisher have ties to Kansas NSF EPSCoR-funded research. Dr. Dodds is co-principal investigator for the microbiomes of aquatic, plant, and soil systems (MAPS) project. Dr. Lee was hired as a microbiome informatics researcher by the project and is an active intellectual participant. Before she joined K-State as a graduate student, Ms. Fisher received training from Dr. Dodds as part of the 2019 MAPS Research Experiences for Undergraduates program, which included research on streams in Mongolia and at Konza Prairie Biological Station in Kansas.

Kansas scientists organize symposium for national meeting focused on new ecological recovery framework

Theo Michaels and James Bever, University of Kansas



Nucleation experiment

Theo Michaels tests predictions of nucleation dynamics in post agricultural/tallgrass prairie landscapes at Anderson County Prairie Preserve.

A Kansas-organized symposium for the 2021 Ecological Society of America meeting explored a new theory on spatial dynamics driven by plant-soil feedbacks. This symposium illustrated the utility of nucleation as a conceptual and practical approach to meeting the challenges of ecosystem recovery. This research is important because ecological restoration is critical for slowing the loss of biodiversity, improving the quality of air, land and waterways, and supporting human livelihoods.

A “nucleation” framework shows promise in restoring ecosystems. In this process, patches of healthy soil (i.e., soil monoliths) are transplanted to areas needing restoration. Living organisms in the transplanted patch grow outward. When this growth reaches a critical radius, it catalyzes rapid growth through local positive feedback dynamics, thereby connecting local-scale interactions and landscape-scale transitions between alternate stable states.

By providing a platform for scientists to discuss the merits of nucleation, this symposium set the stage for future research on nucleation to restore areas disturbed by human activities. After discussing the underpinnings of nucleation, participants explored three detailed examples of forest, grassland and salt marsh systems that demonstrate how the framework can be leveraged to promote ecosystem recovery.

Kansas NSF EPSCoR doctoral student Theo Michaels organized the symposium with Dr. James Bever, who served as moderator. The symposium featured talks by Ms. Michaels and scientists from Switzerland, California, and Florida. A summary of this symposium was published in the *Bulletin of the Ecological Society of America* (Michaels et al. 2022).

“Roots and microbes call the shots that shape soil structure, steer flow of water and nutrients, and sway climate”

Sharon Billings, professor of ecology and evolutionary biology at the University of Kansas with KU graduate students Micah Unruh, Annalise Guthrie, and Ligia Souza, as well as Jesse Nippert, professor of biology at Kansas State University, along with Oregon State University collaborators, Pamela Sullivan (formerly KU Geography) and Xi Zhang.

Plant roots from deep in a soil profile demonstrate the great depths to which biota can extend their influence in soils.

A team of scientists has shown that roots and microbes combine forces to govern soil structure in ways that influence how water and nutrients are released from and flow through soils, and thus govern climate.

By integrating concepts from disciplines old and new, this work outlines four fundamental questions that must be investigated to more accurately model soil structural parameters that reflect the rapidly changing conditions in Earth’s critical zone—from groundwater to vegetation canopy.

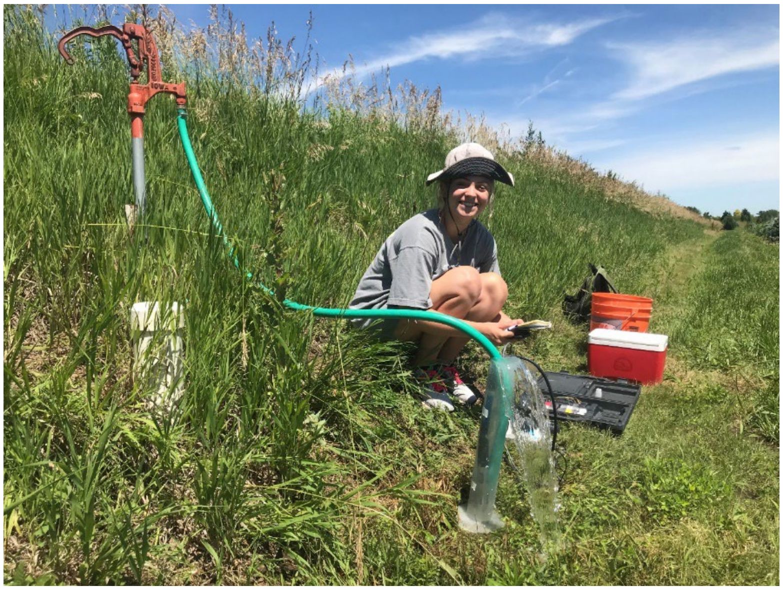
One third of the soils on Earth are degraded now, and the problem is expected to worsen to 90% by 2050. Because soils govern fluxes in terrestrial water, carbon, and nutrients, it is vital to understand the rates at which soil structure respond to changes in the current geological age with timescales of decades to centuries. Without this, we will not be able to accurately project ecosystem functioning nor management strategies for the future.

Working collaboratively, 29 researchers, including 2 faculty and 3 graduate students from the Kansas reviewed the nature of soil structure. Their work hypothesizes that the rapid responses of vegetation and microbes to changes in climate and land use alter soil structure at increasing rates in today’s geological age, and therefore govern the future of global water and carbon cycles. They also embrace the dynamic nature of soil structure, a systematic shift from static to dynamic thinking that illuminates the role of microbes, roots, and other life in the Earth’s critical zone.

Reference:
Sullivan, P.L., et. al. Embracing the dynamic nature of soil structure: A paradigm illuminating the role of life in critical zones of the Anthropocene, *Earth Science Reviews* 225 (2022) 103873.

Variation in runoff and baseflow in watersheds located across a regional precipitation gradient

Breanna Rivera Waterman, Gonzalo Alcantar, Samantha Thomas, Matthew Kirk, Kansas State University



Student collects groundwater sample.

Researchers at Kansas State University identified spatial and temporal variation in streamflow components across the Kansas precipitation gradient. Their findings show that the contribution of baseflow to streamflow decreases with increasing precipitation across the study region. Moreover, during the past sixty years, the proportion of baseflow has increased in areas that are more arid.

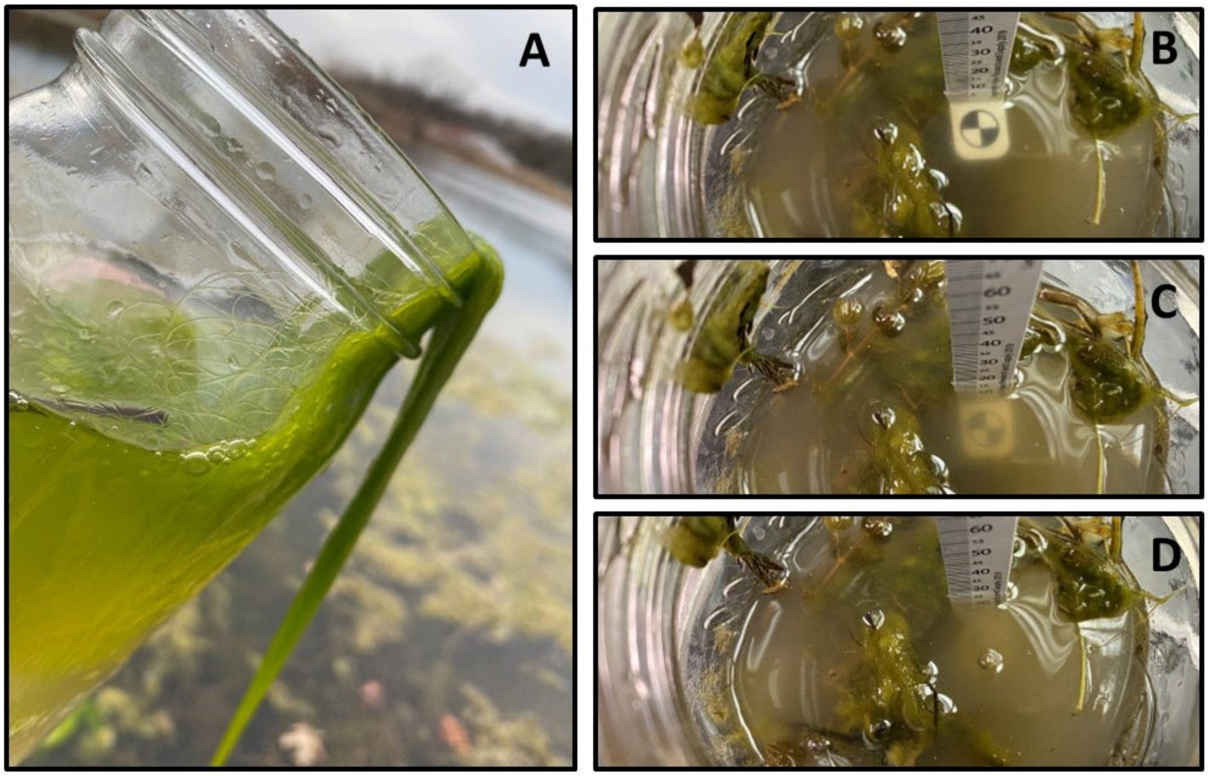
By better understanding sources of streamflow, we better understand physical connections between terrestrial and aquatic environments. This knowledge can help us better manage impacts of climate change and land use on the quality and quantity of our water resources.

Streamflow sources can be divided into two categories: runoff and baseflow. Runoff is water that runs over the land surface and baseflow is water that enters streams from the subsurface and helps sustain flow between precipitation events. The contribution of baseflow is known to be sensitive to catchment and regional characteristics. However, how baseflow varies on large spatial scales is not known for many regions. By examining streamflow sources across Kansas, we were able to consider impacts of a steep precipitation and land use gradient. Therefore, our findings have implications for Kansas as well as other regions where precipitation and land use vary spatially or may change with time.

Kansas NSF EPSCoR MAPS provided funding for team members from two institutions to conduct this research, including the lead author, who used the research as part of her Master’s thesis. The second author listed above was an undergraduate student in the Kansas Louis Stokes Alliance for Minority Participation summer research program. Both students are mentored by Associate Professor Kirk at Kansas State University.

What is a Microbe? A new hands-on lesson enriches learning for elementary-aged students

Jennifer Moody, Terra Lubin, and Peggy Schultz, University of Kansas



To learn about microbiomes, children conduct an experiment with algae (A) growing in the presence of fertilizer or salt. Submerging a Sechi disc under water (B, C, D) detects changes in algal growth based on turbidity of the water.

Giving children opportunities to do hands-on science in the classroom creates memorable learning experiences and builds skills in observation, critical thinking, and problem-solving. It also helps inspire children to become interested in science, helping to build a future workforce.

To educate children about microbiomes in terrestrial and aquatic ecosystems, Drs. Moody, Lubin, and Schultz created a set of learning materials, including a teacher's guide, slide deck, and instructions for two in-class experiments. The lesson emphasizes the roles of producers and decomposers in ecosystems and how they are impacted by environmental pollutants. Children also learn about microbes, which are too small to see with the naked eye.

In the lesson, children conduct two experiments to learn about how salt and fertilizer affect small plants or algae systems. The lesson is taught in two one-hour class periods separated by two weeks. At the second visit, the facilitators helped students evaluate data from the experiment.

The lesson is based on research conducted at the University of Kansas as part of the Kansas NSF EPSCoR Track-1 MAPS project. It has been implemented in four elementary school classrooms to date.

Course-Based Undergraduate Research for General Microbiology

Ari Jumpponen, Sonny Lee, and Tom Platt, Kansas State University

CURE research activity materials.

Students engaged in the CURE activity.

A team of scientists at Kansas State University created, piloted, implemented, and assessed a new Course-based Undergraduate Research Experience (CURE) in general microbiology and biology of fungi courses. CURE engages students in an undergraduate research experience.

This is important because undergraduate research enriches student learning, broadening development of a range of skills and critical thinking. Specifically, students generate hypotheses and test them within the outlined CURE activities.

As part of the 2021 REU program at Kansas State University, Dr. Jumpponen piloted a CURE (Course-based Undergraduate Research Experience) activity in General Microbiology (BIOL455) Biology of Fungi (BIOL604). The CURE activity was designed with help from Drs. Lee, Platt, and Smith-Caldas. After piloting it in the summer with 40 students in BIOL455, they offered a modified version in the fall of 2021 with 15 students enrolled in BIOL604. Dr. Jumpponen plans to further modify the CURE activity again and offer it in Fall 2022.

The CURE theme revolves around visible (and invisible) responses in our surroundings to environmental drivers, and students explored how microbial communities respond to i) plant community changes (woody encroachment); ii) fire and landscape context (riparian forest, encroached woody island, open prairie); iii) fire history (no recent fire vs. recent burn). While the summer CURE was chaotic, the fall 2021 course went much better, with students loving the course material. Enrolled students came from Horticulture, Agronomy, and Microbiology majors, and there were a range of comments. One was "WOW! I did not know what a Vortex is. Less yet, I did not know how to pipet;" another, "I enjoyed the environmental aspect of this experiment." Plans are underway to further enhance the course for the next iteration.