2022

Annual Report, 2022

University of Arkansas, Fayetteville. Dale Bumpers College of Agricultural, Food and Life Sciences. Dept. of Biological and Agricultural Engineering

Department of Biological and Agricultural Engineering

2022 Annual Report

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

UNIVERSITY OF ARKANSAS
College of Engineering
Biological & Agricultural Engineering

2022 Annual Report
Department of Biological and Agricultural Engineering

Lalit R. Verma
Department Head

University of Arkansas System
Division of Agriculture
Deacue Fields
Vice President for Agriculture

Arkansas Agricultural Experiment Station
Jean-Francois Meullenet
Senior Associate Vice President for Agriculture Research

Cooperative Extension Service

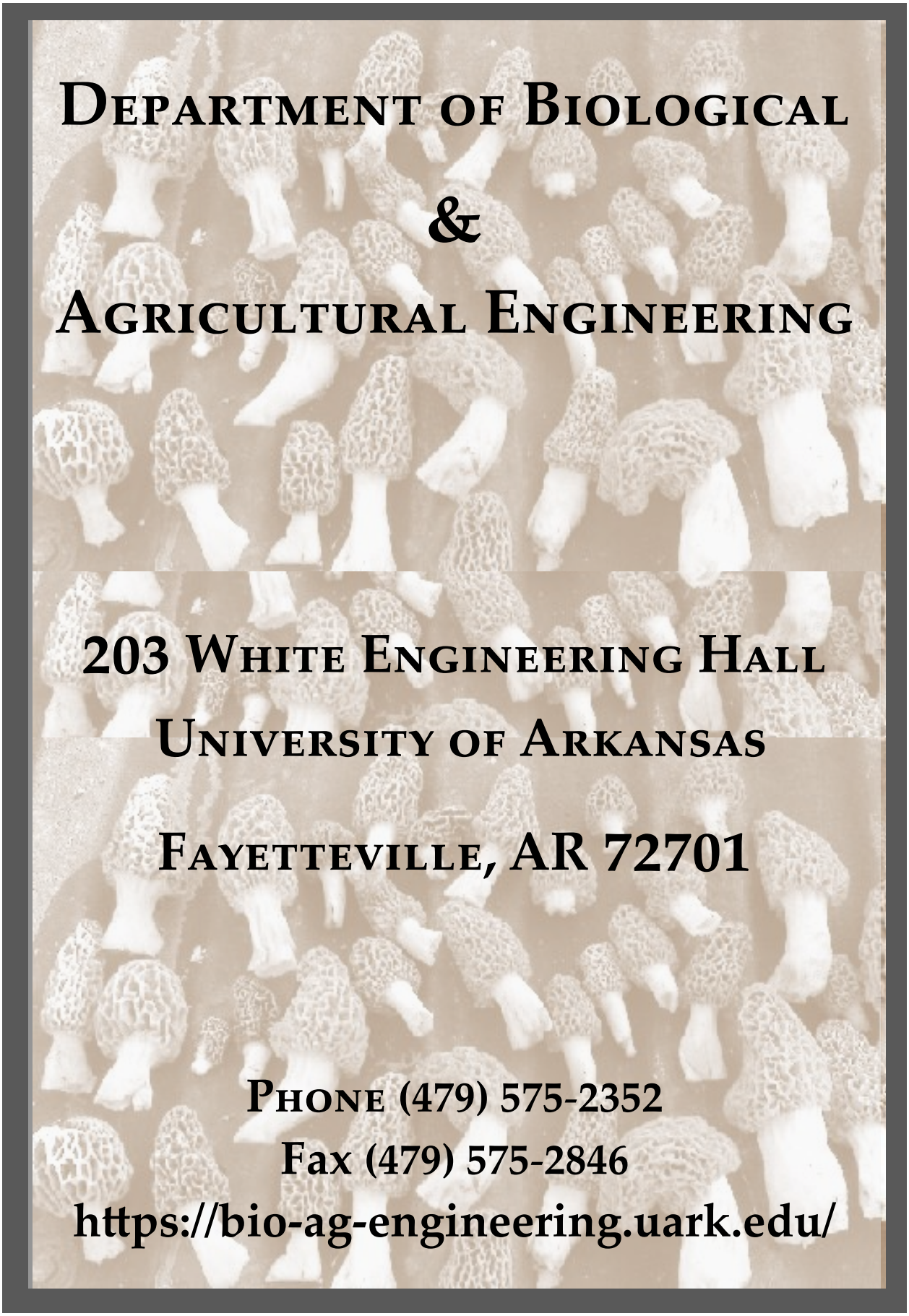
Bob Scott
Senior Associate Vice President - Agriculture Extension

College of Engineering

Kim LaScola Needy
Dean

University of Arkansas
Charles Robinson
Chancellor

Terry Martin
Provost and Executive Vice Chancellor for Academic and Student Affairs



Department of Biological & Agricultural Engineering

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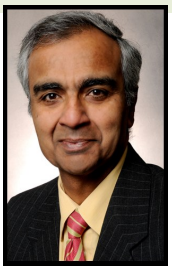
FOREWORD

FROM THE DEPARTMENT HEAD



I am pleased to share highlights of our departmental programs and personnel in 2022, the second year of the lingering pandemic. Our faculty and staff continued to contribute to the departmental mission through education, research and extension programs in 2022.The mission of our department is "to develop and disseminate engineering knowledge to address problems dealing with sustainable food, water and energy systems." This mission is well aligned with the land-grant mission delivering our programs to the students and clientele we exist to serve.

We are addressing the challenges facing our society – from climate change to global food insecurity. Our academic programs in Biological Engineering prepare engineers to solve problems in sustainable water, food and energy systems. Our graduates go on to engage in designing sustainable engineering solutions for in light of complex challenges including societal issues and are prepared to pursue successful careers supporting "Green Engineering." These programs contribute to the goals of both UA System's Division of Agriculture's agricultural research and extension programs, and the UA College of Engineering. Our offices are in White Engineering College and lab space is at the Milo J. Shult Agricultural Research and Extension Center off the main campus. Our departmental support budget is provided by the Arkansas Agricultural Experiment Station and the Cooperative Extension Service, while our academic programs are funded by the College of Engineering. Some of our faculty are located off-campus in the state office of the UA System Division of Agriculture's Cooperative Extension Service in Little Rock and at the Rice Research and Education Center in Stuttgart. Our team is engaged in providing engineering expertise for critically relevant and emerging challenges in Agriculture for our state and nation.

The Accreditation Board for Engineering and Technology provided their official report confirming regular 6-year accreditation without any concerns or weakness. Thirty-six undergraduates completed their degrees with all those seeking employment being successful. Dr. Dongyi Wang joined us in the Food Engineering program jointly with the Department of Food Science and Dr. Ahmed Mahmoud came on board as a Teaching Assistant professor. Ms. Haley Ellis was honored as a College of Engineering Outstanding Senior Finalist and the Biological Engineering Outstanding Senior. Ms. Alexis Barber, one of our undergrads was selected as a 2022 Udall Scholar. Dr. Brian Haggard was awarded the College of Engineering Dean's Award of Excellence for Outstanding Public Service. Drs. Ben Runkle, Jun Zhu and Scott Osborn were the recipients of department's outstanding teaching, research and "service to students" awards, respectively and Ms. Leslie Reinhart was named the outstanding staff. Dr. Chris Henry was recognized as the "Outstanding Engineer" at the ASABE Arkansas State section virtual meeting in October. Dr. Ben Runkle was honored with the UA Alumni Association's "Rising Teaching Faculty Award" and was also honored with the "Distinguished faculty teaching and research award" from the UA Honors College. Dr. Marty Matlock is serving as Senior Advisor for Food Systems Resiliency with Marketing and Regulatory Programs in the USDA. Dr. Ebenezer Kwofie was named a Distinguished Ag. Alumnus at McGill University. The Induction Banquet of Arkansas Academy of Biological and Agricultural Engineering (AABAE) was postponed.

We look forward to a healthier and safe 2022 with continued growth and progress in all our programs.

Lalit R. Verma, Ph.D., P.E.
Professor and Department Head
www.bio-ag-engineering.uark.edu

Departmental Resources

Faculty

Thomas A. Costello, Ph.D., P.E.
Associate Professor
B.S. Ag.E. (1980) University of Missouri
M.S. Ag.E. (1982) University of Missouri
Ph.D. (1986) Louisiana State University
Research Areas: Ecological engineering, agricultural engineering, bio-energy, alternate energy, energy conservation, development and evaluation of economical BMP's for improved water quality, air quality and sustainability of agricultural production.

Brian E. Haggard, Ph.D.
Professor
Director, Arkansas Water Resources Center
B.S. Life Sciences (1994) University of Missouri
M.S. Environmental Soil & Water Science (1997) University of Arkansas Ph.D. Biosystems Eng. (2000) Oklahoma State University
Research Areas: Ecological engineering, environmental soil and water sciences, water quality chemistry, algal nutrient limitation, and pollutant transport in aquatic systems, water quality monitoring and modeling.

Christopher Henry, Ph.D., P.E.
Associate Professor, Extension
B.S. (1996) Kansas State University
M.S. (1998) Kansas State University
Ph.D. (2009) University of Nebraska
Research Areas: Development and implementation of statewide integrated research and extension programs in irrigation water management and water quality; improve irrigation efficiency practices, novel irrigation system design, and improved energy efficiency and alternative energy sources for irrigation; develop alternative irrigation systems for rice; water policy research; solar power; pumping plant telematics; improve irrigation systems using embedded systems and mobile apps; develop curricula and training materials for educational programs in irrigation water management for cropping systems, performance and energetics, irrigation systems, and water quality impacts; investigate and develop solutions for reduction of pollutant loads with respect to gulf hypoxia; work with other UA personnel to develop and demonstrate irrigation and farming practices that address environmental, production, and economic considerations; develop and maintain positive working relationships with other government agencies and industries.

Jin-Woo Kim, Ph.D.
Professor
B.S. Ch.E. (1986) Seoul National University, Korea
B.S. Microbiology (1991) University of Iowa
M.S. Biology (1994) University of Wisconsin
Ph.D. Ag.E. (1998) Texas A&M University

Research Areas: Biotechnology engineering, biomedical engineering, bionanotechnology, and bio-abio interfacing technology.

Ebenezer Kwofie, Ph.D.
Assistant Professor
B.Sc. Chemical Engineering (20006) Kwame Nkrumah University of Science and Technology
M.Sc. Industrial Engineering (2010) University of Boras, Sweden
Ph.D. Bioresouce Engineering (2016) McGill University, Canada
Research Areas: Industrial eco-friendly analysis (food and bio-products, Nutrition-sensitive agriculture programming and food value chain analysis, food quality and nutrition dynamics for sustainability

Yanbin Li, Ph.D., P.E.
Distinguished Professor, Tyson Endowed Chair in Biosensing Engineering
B.S. Ag.E. (1978) Shenyang Agricultural University, China
M.S. Ag.E. (1985) University of Nebraska, Lincoln
Ph.D. Ag.E. (1989) Pennsylvania State University
Research Areas: Biosensor and bioinstrumentation, microbial predictive engineering, quantitative risk assessment, and food safety engineering.

Yi Liang, Ph.D.
Associate Professor, Extension
B.S. Ag. E. (1990) China Agricultural University, China
M.S. Ag. E. (1995) China Agricultural University, China
Ph.D. (2000). University of Alberta, Canada
Research Areas: Air quality and energy efficiency with confined animal feeding operations, quantification of emission and transportation of air pollutants, development and evaluation of emission prevention and control technologies.

Marty D. Matlock, Ph.D., P.E., B.C.E.E.
Professor
Area Director, Center for Agricultural and Rural Sustainability
B.S. Soil Chemistry (1984) Oklahoma State University
M.S. Plant Physiology (1989) Oklahoma State University
Ph.D. Biosystems Engineering (1996) Oklahoma State University
Research Areas: Ecological engineering, ecological watershed modeling, biological assessment and monitoring, ecosystem design and management.

Ahmed Mahmoud, Ph.D.
Assistant Professor
B.S. Biology (2007) Ain Shams University, Cairo, Egypt
M.S. Environmental Engineering (2014) Texas A&M University
Ph.D. Environmental Engineering (2018) Texas A&M University
Research Areas: Urban Pollutant Fate and Transport, Green Infrastructure, Low Impact Development, Stormwater Runoff Effects on Human and Ecological Health

Departmental Resources

Faculty

Thomas Matthew McVey
Instructor
B.S. Biological Engineering (2015) University of Arkansas
M.S. Agricultural and Biological Engineering (2017) The Pennsylvania State University
Research Areas: Bioi-energy conversion, technoeconomic analysis, biofuel upgrading, biological modeling, anaerobic digestion, pyrolysis

Scott Osborn, Ph.D., P.E.
Associate Professor
B.S. Ag.E. (1984) University of Kentucky
M.S. Ag.E. (1987) University of Kentucky
Ph.D. Bio & Ag.E. (1994) North Carolina State University
Research Areas: Grain and Food Processing, dissolved oxygen and ozone technologies for water and wastewater treatment.

Sammy Sadaka, Ph.D., P.E., P.Eng.
Associate Professor, Extension
B.S. (1982) Alexandria University, Egypt
M.S. (1988) Alexandria University, Egypt
Ph.D. (1995) Dalhousie University, Nova Scotia, Canada and Alexandria University, Egypt
Research Areas: Bioenergy and energy conservation, grain drying and storage; gasification, pyrolysis, biodrying, energy con-servation.

Benjamin Runkle, Ph.D.
Assistant Professor
B.S.E.. Princeton University
M.S., University of California, Berkeley
Ph.D., University of California, Berkeley
Research Areas: Wetland ecohydrology and agro ecosystems, surface water nutrient fluxes and source partitioning. Land-atmosphere exchange of carbon dioxide, methane, and water vapor.

Karl VanDevender, Ph.D., P.E.
Professor, Extension Engineer
B.S. Ag.E. (1985) Mississippi State University
M.S. Ag.E. (1987) Mississippi State University
Ph.D. Engineering (1992) University of Arkansas
Research Areas: Development and implementation of statewide extension programs in livestock and poultry waste management, liquid and dry; develop curricula and training materials for educational programs in collection, storage, and land application of waste to prevent contamination of surface and groundwater; work with other UA personnel to develop and demonstrate manure storage, treatment, and utilization practices that address environmental, production, and economic considerations; develop and maintain positive working relationships with other government agencies and industries.

Lalit R. Verma, Ph.D., P.E.
Professor
Department Head
B.Tech Ag.E. (1972) Agricultural University, India
M.S. Ag.E. (1973) Montana State University
Ph.D. Engineering (1976) University of Nebraska
Administration of the Department of Biological and Agricultural Engineering.

Jun Zhu, Ph.D.
Professor
B.S. Civil Eng. (1982) Zhejiang University, China
M.S. Civil Eng. (1985) Zhejiang University, China
Ph.D. in Ag. E. (1995) University of Illinois
Research Areas: Air and water quality related to animal agriculture and value added products production from agricultural renewable resources (bio-energy and chemicals).

Julian Abram
Program Technician

Jake Anderson
Fiscal Manager

Randy Andress
Program Associate

Brad Austin
Research Scientist

Erin Gantz
Program Associate

Beatriz Moreno Garcia
Post-Doctoral Fellow

Fei Jia
Research Scientist

Sydney Jones
Administrative Specialist III; Extension

Evan Jurick
Program Technician

Sandhya Karki
Post-Doctoral Associate

Lisa Cooney Kelso
Program Associate II

Bonan Li
Post-Doctoral Fellow

Linda Pate
Department Administrative Manager

Leslie Reinhart
Administrative Specialist III

Lee Schrader
Program Technician

Eric Simon
Program Associate

Elahe Tajfar
Post-Doctoral Associate

BAEG Advisory Board
2022 Members

Mark Christie
Manufacturing Services
Tyson Foods

Alan Fortenberry
Chief Executive Officer
Beaver Water District

Tyler Gipson
Hydraulic Engineer
Southwestern Power Administration

Kevin J. Igli
SVP and Chief EHS Officer
Tyson Foods

Kyle Kruger
Garver Engineering

Jeff Madden
Director of Engineering
Riceland Foods, Inc.

Toni Peacock McCrory
Director-Water Compliance
Wal-Mart

Robert Morgan
Manager of Environmental Quality
Beaver Water District

Chris Pixley
VP of Operations
Pacific Vet Group-USA

Randy Young
Executive Director
Arkansas Natural Resources Commission

Academic Advisory Committee
2022 Members

Bill HagenBurger
Beaver Water District

Jeff Madden
Riceland

Don Mosley
Entegrity

Katherine Yarberry
Wal-Mart

Thomas Costello
BAEG Faculty

Scott Osborn
BAEG Faculty

Lydia Huck
Undergraduate student

Katharine Campbell
Undergraduate Student

Academy Members

David Anderson
B.S. ('70)

Stanley B. Andrews
B.S. ('90), M.S. ('93)
COE Young Alumni 2007

Howard B. Austin
B.S. ('56)

Ray Avery
B.S. ('03) M.S. ('07)

Greg Baltz
B.S. ('80)

Pat Bass
B.S. ('76)

David Beasley
B.S. ('71), M.S. ('73), Ph.D. ('77)

Nupra Bhise
B.S. ('07), Ph.D. ('13)

John L. Bocksnick
B.S. ('76), M.S. ('78)

John Chris Brock
B.S. ('85) M.S. ('00)

Shawn Brewer
B.S. ('94), M.S. ('98)

Dennis K. Carman
B.S. ('73)

Dylan Carpenter
B.S. ('05) M.S. ('07)

Indrajeet Chaubey
M.S. ('94)

Robert Chatman
B.S. ('71)

Randy Childress
B. S. ('85)

Mark Christie Childress
B. S. ('85), Ph.D. (18)

John J. Classen
B.S. ('87), M.S. ('90), Ph.D. ('95)

William L. Cooksey
B.S. ('79)

David "Gail" Cowart
B.S. ('60)

Zach Dalmut
B.S. ('06)

Steven D. Danforth
B.S. ('80)

Glenn Davis
B.S. ('67)

Anthony Doss
B.S. ('94)

Catherine Erickson
B.S. ('07)

Joe D. Faddis
B.S. ('67)

Alan D. Fortenberry
B.S. ('72), M.S. ('77)
COE Distinguished Alumni 2007

Michael W. Freer
B.S. ('85), M.S. ('88)

Dennis R. Gardisser
B.S. ('79), M.S. ('81), Ph.D. ('92)

Thomas Garrison
B.S. ('05), M.S. ('07), Ph.D. ('13)

Floyd R. Gunsaulis
B.S. (88), M.S. (90)
COE Young Alumni 2006

Kevin Henry
B.S. ('99)
COE Young Alumni 2008

Darrell Holmes
B.S. ('81)

John P. Hoskyn
B.S. ('60), M.S. ('64)

Michael D. Jones
B.S. ('67), M.S. ('68)

Adam Jokerst
B.S. ('02), M.S. ('06)

AJ Kaufman
B.S. ('07)

Jeff Keeter
B.S. ('84)

Dayna King-Cook
B.S. ('85), M.S. ('88)

Kyle Kruger
B.S. ('86)

John L. Langston
B.S. ('71), M.S. ('73)

Otto J. Loewer
B.S. ('68), M.S. ('70), Ph.D. ('73)

Jeffery D. Madden
B.S. ('88)

Ralph A. Mashburn
B.S. ('58)

Leslie Massey
B.S. ('06), M.S. ('08)

Stanley A. Mathis
B.S. ('84)

James McCarty
B.S. ('06), M.S. ('15), Ph.D. ('20)

Katherine McCoy
B.S. ('09), M.S. ('12)

Toni McCrory
B.S. ('07)

Drake McGruder
B.S. ('06)

James McNeal
B.S. ('86)

Kate Merriman-Hoehne B.S. ('02)

Amber Meisner
B.S. ('02)

Katie Migliaccio, Ph.D.
Ph.D. ('05)

Rebecca Muenich
B.S. ('09), M.S. ('11), Ph.D. ('15)

Bruce Netherton
B.S. ('60)

Richard Penn
B.S. ('82), M.S. ('92)

Carl Peters
B.S. ('58), M.S. ('61)

Chris Pixley
B.S. ('02) Ph.D. ('13)

Jonathan W. Pote
B.S. ('75), M.S. ('75), PhD ('79)

Bill R. Ridgway
B.S. ('88)

David Wesley Ritter
B.S. ('79), M.S. ('81)

Richard M. Rorex
B.S. ('78), M.S. ('81)
COE Distinguished Alumni 2011

Corey Scott
B.S. (2005)

Michael D. Shook
B.S. ('82)

William Hix Smith, JR
B.S. ('67)

Eugene H. Snawder
B.S. ('69)

Billy Staton
B.S. ('91), M.S. ('95)

Phil Tacker
B.S. ('79), M.S. ('82)

Rusty Tate
B.S. (2008)

Jessica Temple
B.S. (2007)

Shelly Thomas
B.S. ('05)

Marcus Tilly
B.S. ('00)

Karl VanDevender
B.S. ('87), M.S. ('87), PhD ('92)

Earl Vories
B.S. ('81), M.S. ('83), Ph.D. ('87)

Paul N. Walker
B.S. ('70), M.S. ('71), Ph.D. ('74)

William K. Warnock
B.S. ('72), M.S. ('75), Ph.D. ('77)

Bruce E. Westerman
B.S. ('90)
COE Young Alumni 2005
COE Distinguished Alumni 2012

John Westerman
B.S. ('94)

Dawn Wheeler-Redfearn
B.S. ('99), M.B.A. ('00)
COE Distinguished Alumni 2008

Robert W. White
B.S. ('72), M.S. ('76)

J. Randy Young
B.S. ('71), M.S. ('75)
COE Distinguished Alumni 2006

HONORARY ACADEMY MEMBERS

BILLY BRYAN
B.S. ('50) M.S. ('54) Posthumously

Wesley Busheled

FRED G. FOWLKES
B.S. ('68), M.S. ('77)

CARL L. GRIFFIS
B.S. ('63), M.S. ('65), Ph.D. ('68)

ALBERT H. MILLER
Posthumously

ROBERT W. NEWELL
B.S. ('54)

STANLEY E. REED
B.S. ('73) Posthumously

HAROLD S. STANTON
B.S. ('50) M.S. ('53)

FREDDIE C. STRINGER
B.S. ('70)

ALBERT E. "GENE" SULLIVAN
B.S. ('59)

H. FRANKLIN WATERS
B.S. ('55) Posthumously

2022 Academy Inductees

Nupura Bhise

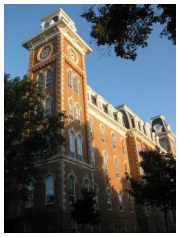
Catherine Erickson

James McCarty

UNIVERSITY OF ARKANSAS

The University of Arkansas was founded in 1871 under the Morrill Land-Grant Colleges Act of 1862. Originally named Arkansas Industrial University, classes began in February of 1872.

Old Main was completed in 1875, and was the primary instructional and administrative building. The first class to graduate etched their names in the sidewalk in front of Old Main, starting Senior Walk and a tradition that is still going today.



The University of Arkansas became the first major Southern public university to admit African-American student without litigation when Silas Hunt of Texarkana, an African-American veteran of World War II, was admitted to the university's School of Law in 1948. Vitamin E was co-discovered by UA Agricultural Chemistry Professor Barnett Sure (1920-51). Sure, along with fellow professor Marinus C. Kik (1927-67), made major advances in nutrition science during their tenures at the university. Along with this discovery, Sure extended knowledge of how vitamin E, amino acids, and B-vitamins function on reproduction and lactation. Kik developed the process for parboiling rice to increase retention of vitamins and shorten cooking time. Kik also documented benefits of adding fish and chicken to rice and grain diets to provide adequate protein for a growing world population.

The university has many great traditions like Senior Walk. The *UA Alma Mater* was written in 1909 by Brodie Payne and was recognized in 1931 as one of the twenty-five best college songs by the University College Song Association in New York, and at the end of the song, students and alumni always point toward Old Main. The *Arkansas Fight Song* was written in the late 1920's and is still sung at every football game. The university received the Razorback mascot in 1909 during a speech by the current football coach, Hugo Bezdek, when he referred to the team as "a wild band of Razorback hogs," and in 1910, the student body voted to change the mascot from the Cardinals to the Razorbacks. The "calling of the Hogs" began in the 1920's, when several local farmers attending a football game decided to try to help a lagging team and yelled "Woo, Pig Sooie!" The school colors are cardinal red

The Carnegie Foundation recognized the University of Arkansas as one of 108 elite research universities in the nation for 2011, one of only seven schools in the Southeastern Conference to receive this distinction.

Northwest Arkansas and the University of Arkansas were featured in the July 2013 issue of *U.S. Airways Magazine*. The 11-page section on NWA detailed the many positive impacts provided by the $1 billion Campaign for the 21st Century, one of the largest fund-raising efforts by a U.S. public university, while focusing on the university's future goals.

DEPARTMENT OF BIOLOGICAL & AGRICULTURAL ENGINEERING

In 1921, the University of Arkansas activated the Department of Agricultural Engineering to teach service courses and conduct applied research. The department was housed in Gray Hall, located where Mullins Library now stands. The department moved to the old campus infirmary, nicknamed "the old agriculture building" and now called the Agriculture Annex, in 1966, and finally to its current location in Engineering Hall in 1990 after a renovation of the building originally built in the early 1900's.

The first Bachelor of Science in Agricultural Engineering was conferred in 1950, with the first Master of Science in Agricultural Engineering following in 1952. The first Ph.D. degree was conferred in 1984.

To reflect the change in the engineering field of study, the department's name was changed to Biological and Agricultural Engineering in 1988. In 1990, the B.S. and M.S. degrees were renamed to reflect the change in the curriculum and the new name of the department, and in 2002, were renamed again to Biological Engineering.

In 2003, the department received approval from the Arkansas Department of Higher Education to begin the M.S. in Biomedical Engineering program. This showed the department's continued goal of keeping up with the changes in the biological engineering research fields. The first M.S. in Biomedical Engineering was conferred in 2006.

DEPARTMENT OF BIOLOGICAL & AGRICULTURAL ENGINEERING

In 2012, the Biomedical Engineering program was separated and the revised curriculum in Biological Engineering of *"Healthy Planet Healthy People"* was designed to address the challenges in sustainable food, water and energy systems.

The Biological and Agricultural Engineering Department is housed on the second floor of the John A. White Jr. Engineering Hall. The main department office and all the faculty offices are located on the second floor. The department has use of two classrooms, two conference rooms, one computer lab, one student lab, and a study lounge.

The department also has offices and labs at the Biological and Agricultural Lab, located on North Garland Avenue, and at the Institute for Nanoscience and Engineering, located at 731 W. Dickson St.

CITY OF FAYETTEVILLE AND NORTHWEST ARKANSAS

Fayetteville is the third-largest city in Arkansas and county seat of Washington County. The city is centrally located within the county and has been home of the University of Arkansas since the institution's founding in 1871. Fayetteville is on the outskirts of the Boston Mountains, deep within the Ozarks. Known as Washington until 1829, the city was named after Fayetteville, Tennessee, from which many of the settlers had come. It was incorporated on November 3, 1836 and was rechartered in 1867. The four-county Northwest Arkansas Metropolitan Statistical Area is ranked 105th in terms of population in the United States with 463,204 in 2010 according to the United States Census Bureau. The city had a population of 73,580 at the 2010 Census.[5] At 1,400 feet of elevation, it is also one of the highest major US cites between the western Great Plains and the Appalachian Mountains.

Fayetteville is home to the University of Arkansas, the state's largest university. When classes are in session, thousands of students on campus dramatically change the city's demographics. Thousands of Arkansas Razorbacks alumni and fans travel to Fayetteville to attend football, basketball, and baseball games. The University's men's track and field program has won 41 national championships to date. Fayetteville was named the third best place to live in the United States in the 2016 U.S. News Best Places To Live Rankings, and one of the best places to retire in the South. Forbes also ranked Fayetteville as the 24th-best city for business and careers in 2016. Lonely Planet named Fayetteville among its top 20 places to visit in the South in 2016. Based in nearby Bentonville, the Walmart corporation has dominated Fayetteville's economy. The city hosts the Wal-Mart Shareholders Meetings each year at the Bud Walton Arena.

According to the 2018 census, Fayetteville has a population of 86,751 and is the third most populous city in Arkansas. It boasts a proud history, with several notable residents including authors Ellen Gilchrist (*In the Land of Dreamy Dreams*, 1981) and Donald Harrington (*The Cherry Pit*, 1965), Arkansas U.S. Senators J. William Fulbright and David Pryor, poet Miller Williams and his Grammy Award-winning songwriter daughter Lucinda, and noted architect E. Fay Jones.

The city of Fayetteville has many highlights, including the town square, where a farmer's market is held from April through November. Dickson Street is a main thoroughfare leading to the University of Arkansas and is lined with shops and restaurants. The Walton Arts Center is a professional performing arts center and hosts many national and international fine art events throughout the year.

Many industry giants consider Northwest Arkansas home. Bentonville based Wal-Mart, is the world's largest public corporation by revenue, according to the 2008 Fortune Global 500. Founded by Sam M. Walton in 1962, it is the largest private employer in the world and the fourth largest utility or commercial employer. Lowell is the home for J.B. Hunt Transport Services, Inc., one of the largest truckload transportation companies in the United States, with annual revenues of over $2 billion. Tyson Foods, Inc. is based out of Springdale and is the world's largest processor and marketer of chicken, beef, and pork.

SCHOLARSHIP RECIPIENTS FOR 2022

Names listed in Italic are spring 2022 scholarship Recipients the others listed are fall 2022 scholarship recipients.

ARKANSAS ACADEMY OF BIOLOGICAL & AGRICULTURAL ENGINEERING SCHOLARSHIP
William Franke
Ellie Kuhn
Craigon Bradley
Kyson Hardaway

BIOLOGICAL & AGRICULTURAL ENGINEERING DEPARTMENTAL SCHOLARSHIP
Megan Doty
Hailey Roye

MILDRED V. AND BILLY B BRYAN SCHOLARSHIP
Megan Doty
Amanda Bogart
Craigon Bradley
Hope Dwyer
Annette Benbrook
Ava Hatch

Division of Agriculture Scholarship
Annette Benbrook
Lillie Bolton
Christopher Pryor

J.A. RIGGS TRACTOR COMPANY SCHOLARSHIP
Juan Arguijo
Sophia Gomez
Kyson Hardaway
Oscar Morton

XZIN MCNEAL SCHOLARSHIP
Sarah Flannery
Christopher Pryor
Harrison Davis
Hayden Engelbrecht
Katherine Skiles
Hope Dwyer
Ava Hatch
Maloree Morris
Kevin Pineda-Vizcanio

XZIN MCNEAL SCHOLARSHIP CONT.
Hailey Roye
Joaquin Camacho
Gabriel Cox
Kyson Hardaway
Galilea Martinez Cruz
Emma Moore
Oscar Morton
Christopher Pryor
Andrew Ritter
Masen Wade
Atticus Warren

Joel Steel & Hardy Croxton Beaver Water District
Jacqueline Steinauer

JOHN W & TRANNYE ODOM WHITE SCHOLARSHIP
Samantha Wheat
Hailey Roye
Spencer Warrick

Carl L. Griffis Endowed Memorial Award
Fernanda Novoa
Samantha Wheat

Alfred B. Rhode Scholarship
Emily Tappana
Holland Oscar Morton
Katherine Skiles
Hunter Dowell
Clarissa Fuller
Tarah Inena
Olivia Torres
Lindsey Bush
Maloree Morris
Jacqueline Steinauer

Joel T. Walker Scholarship
Craigon Bradley

GRADUATES FOR 2022

BACHELOR OF SCIENCE IN BIOLOGICAL ENGINEERING

Spring 2022

Alexis Barber
Amanda Bogart
Lillie Bolton
Nathan Bowman
Harrison Davis
Megan Doty
Hunter Dowell
Hayden Engelbrecht
William Franke
Clarissa Fuller
Fernanda Novoa
Russell Gartner
Noah Geels
Sophia Gomez
Lauren Gregory
Janeth Jaen Jaen
Logan Jennings
Daniel Krol
Ellie Kuhn
Devyn Meyer
Jacob Miller
Ian Mills
Flora Noble
Dawson Oakley
William Osment
Aubin Payne
Shawn Pearson
Michala Smith
Olivia Torres
Spencer Warwick
Harper Williams-Dow

Summer 2022

Bao Dao
Katie Loethen
Samuel Nepomuceno

Fall 2022

Michael Janorschke
Juliana Newman
Noah Olson

BIOLOGICAL ENGINEERING STUDENT CLUB 2020-2022 OFFICERS

President: Emily Tappana
VP: Kendele Kramer
Treasurer: Emma Moore
Secretary: Daniel Pruitt
Social Media Chair: Madison Leckbee
Event Coordinators: Kyrie Potter, Sarah Flannery, Sierra Isaacson
Faculty Advisor: Dr. Thomas Costello

The department's mission is: *Healthy Planet, Healthy People*. Biological engineers improve people's lives today and help assure a sustainable quality of life for tomorrow. They create solutions to problems by coupling living systems (human, plant, animal, environmental, food, and microbial) with the tools of engineering and biotechnology. Biological engineers improve human health; ensure a safe, nutritious food supply; and secure a healthy and safe environment. The department focuses on engineering design that promotes sustainable production, processing and management of food water and energy. A Bachelor of Science degree in biological engineering is a job-ready degree with opportunities in many industries, government agencies, and consulting firms. It is also excellent preparation for medical, veterinary, dental or other health science professional school as well as M.S. and Ph.D. studies in engineering in other areas.

Biological Engineering is an ABET accredited program leading to the B.S. degree. The M.S. and Ph.D. degrees are also offered. The curriculum is under the joint supervision of the dean of the College of Engineering and the dean of the Dale Bumpers College of Agricultural, Food and Life Sciences. The B.S. in Biological Engineering is conferred by the College of Engineering and is granted after the successful completion of 128 hours of approved course work.

The educational objective of the Biological Engineering Program at the University of Arkansas is to prepare students to successfully practice engineering involving the design and management of sustainable food, water, and energy systems.

Diverse applications of biological engineering can be pursued through elective coursework such as:

- Integrating ecological principles into the design of sustainable systems to treat, remediate, and prevent pollution to the environment. Applications include stream restoration, watershed management, water and wastewater treatment design, ecological service management, urban greenway design and enclosed ecosystem design.
- Food processing, food safety and security, biosensing and bioinstrumentation, biotechnology at the micro and nanoscale, developing new products from biomaterials, and biotransformation to synthesize industrial and pharmaceutical products.
- Sustainable design and management of finite resources with a broad perspective, local and global and cradle to grave life cycle analysis of resource utilization, and environmental impacts with a view toward long-term prosperity.

The B.S. in Biological Engineering degree can lead to careers in consulting, ecological engineering and design, environmental engineering, sustainable agriculture and food production, low impact development, water quality and watershed management, human health, biotechnology, natural resource engineering, nanotechnology, and biofuels development to name but a few.

BIOLOGICAL ENGINEERING B.S.B.E., EIGHT-SEMESTER DEGREE PROGRAM 2022-2023 COURSE CATALOG

The Bachelor of Science in Biological Engineering program is eligible for students who want to participate in an eight semester degree program. The plan below lists a semester-by-semester sequence of courses to finish the degree in eight semesters. University core courses for engineering are listed at the bottom of this page. Students may submit a maximum of four (4) hours of "D" in BENG courses for their degree. Some courses are not offered every semester, so students who deviate from the

Freshman Year	
First Semester **1** GNEG 1111 Introduction to Engineering I **3** ENGL 1013 Composition I **3** CHEM 1103 University Chemistry I **4** MATH 2554 Calculus I **3** U.S. History or Government Elective - Choose one course from the following: HIST 2003 History of the American People to 1877 or HIST 2013 History of the American People, 1877 to Present or PLSC 2003 American National Government **(14 Semester hours)**	**Second Semester** 1 GNEG 1121 Introduction to Engineering II 3 ENGL 1033 Technical Composition II 4 First-Year Engineering Science Electives: CHEM 1123 University Chemistry II & CHEM 1121L University Chemistry II Laboratory or BIOL 1543 and BIOL 1541L 4 MATH 2564 Calculus II 4 PHYS 2054 University Physics I **(16 Semester hours)**
Sophomore Year	
First Semester 2 BENG 2632 Biological Engr Design Studio 4 MATH 2574 Calculus III (ACTS Equivalency = MATH 2603) 4 Sophomore Science Electives ** 4 PHYS 2074 (ACTS Equivalency = PHYS 2044 Lecture) 3 MEEG 2003 Statics **(17 Semester hours)**	**Second Semester** 2 BENG 2632 Biological Engineering Design Studio 4 MATH 2574 Calculus III 4 Sophomore Science Elective (whichever has not been taken) : CHEM 1123 University Chemistry II & CHEM 1121L University Chemistry II Lab or BIOL 1543 and BIOL 1541L 3 MEEG 2003 Statics PHYS 2074 University Physics II **(17 Semester hours)**
Junior Year	
First Semester 3 BENG 3653 Global Bio-Energy Engineering 3 BENG 3663 Biological Engineering Methods II 3 BENG 3733 Transport Phenomena in Biological Systems 4 **Choose one:** CHEM 3603 Organic Chemistry I & CHEM 3601L Organic Chemistry I Laboratory or CHEM 2613 Organic Physiological Chemistry & CHEM 2611L Organic Physiological Chemistry Laboratory 3 CVEG 3213 Hydraulics (or MEEG 3503 Mechanics of Fluids or CHEG 2133 Fluid Mechanics) **(16 Semester hours)**	**Second Semester** 3 BENG 3723 Unit Operations in Biological Engr 3 BENG 3113 Measurements and Controls for Biological Systems 3 BIOL 3863 General Ecology 3 CVEG 3223 Hydrology 3 Technical Elective **(15 Semester hours)**
Senior Year	
First Semester 2 BENG 4812 Senior Biological Engineering Design I 1 BENG 4831 Biological Engineering Professionalism 3 BENG 4743 Food and Bio-Product Systems Engineering 3 BENG 4933 Sustainable Watershed Engineering 3 Humanities Elective - Choose one course from the list below 3 Social Science Elective-choose any course listed on the State Minimum Core. **(15 Semester hours)**	**Second Semester** 2 BENG 4812 Senior Biological Engineering Design I 1 BENG 4831 Biological Engineering Professionalism 3 BENG 4743 Food and Bio-Product Systems Engineering 3 BENG 4933 Sustainable Watershed Engineering 3 Humanities Elective - Choose one course from the list below 3 Social Science Elective-choose any course listed on the State Minimum Core. **(18 Semester hours)**

This Social Science Elective should be selected from the following courses in order to meet State Minimum Core:
ANTH 1023, COMM 1023, GEOS 2003, GEOS 2003H, HDFS 1403, HDFS 2413, HDFS 2603, HIST 1113, HIST 1113H, HIST 1123, HIST 1123H, HIST 2093, HUMN 1114H, HUMN 2114H, PLSC 2013, or RESM 2853.
The Humanities Elective should be selected from the following courses in order to meet State Minimum Core: CLST 1003, CLST 1013, PHIL 2003, PHIL 2003H, PHIL 2003C, PHIL 2103, or PHIL 2103C.
The Fine Arts Elective should be selected from the following courses in order to meet State Minimum Core: ARHS 1003, COMM 1003, DANC 1003, MLIT 1003, MLIT 1003H, MLIT 1013, MLIT 1013H, MLIT 1333, THTR 1003, or THTR 1013.

BIOLOGICAL ENGINEERING B.S.B.E. ENVIRONMENTAL CONCENTRATION, EIGHT-SEMESTER DEGREE PROGRAM 2022-2023 COURSE CATALOG

Freshman Year	
First Semester **1** GNEG 1111 Introduction to Engineering I**3** ENGL 1013 Composition I (ACTS Equivalency = ENGL 1013) (Satisfies General Education Outcome 1.1) **3** CHEM 1103 University Chemistry I (ACTS Equivalency = CHEM 1414 Lecture) **4** MATH 2554 Calculus I (ACTS Equivalency = MATH 2405) (Satisfies General Education Outcome 2.1) **4** PHYS 2054 University Physics I (ACTS Equivalency = PHYS 2034) **(15 Semester hours)**	**Second Semester** 1 GNEG 1121 Introduction to Engineering II 3 ENGL 1033 Technical Composition II 4 First-Year Engineering Science Electives: CHEM 1123 University Chemistry II & CHEM 1121L University Chemistry II Laboratory or PHYS 2074 University Physics II 4 MATH 2564 Calculus II 3 U.S. History or Government Elective - Choose one course from the following: HIST 2003 History of the American People to 1877 or HIST 2013 History of the American People, 1877 to Present or PLSC 2003 American National Government **(15 Semester hours)**
Sophomore Year	
First Semester **2** BENG 2632 Biological Engineering Design Studio **4** MATH 2574 Calculus III **4** Sophomore Science Elective (whichever has not been taken) : CHEM 1123 University Chemistry II & CHEM 1121L University Chemistry II Lab or PHYS 2074 University Physics II 4 BIOL 1543 Principles of Biology & BIOL 1541L Principles of Biology Laboratory **3** MEEG 2003 Statics **(17 Semester hours)**	**Second Semester** 3 BENG 2643 Biological Engineering Methods I 4 MATH 2584 Elementary Differential Equations 4 BIOL 2013 General Microbiology & BIOL 2011L General Microbiology Laboratory 3 MEEG 2403 Thermodynamics or CHEG 2313 Thermodynamics of Single-Component Systems 3 Social Science Elective - Choose one course from the list below. **(17 Semester hours)**
Junior Year	
First Semester 3 BENG 3653 Global Bio-Energy Engineering 3 BENG 3663 Biological Engineering Methods II 3 BENG 3733 Transport Phenomena in Biological Systems 4 Choose one: CHEM 3603 Organic Chemistry I & CHEM 3601L Organic Chemistry I Laboratory or CHEM 2613 Organic Physiological Chemistry (ACTS Equivalency = CHEM 1224 Lecture) & CHEM 2611L Organic Physiological Chemistry Laboratory 3 CVEG 3213 Hydraulics or MEEG 3503 Mechanics of Fluids or CHEG 2133 Fluid Mechanics **(16 Semester hours)**	**Second Semester** 3 BENG 3723 Unit Operations in Biological Engineering 3 BENG 3113 Measurement and Control for Biological Systems 3 CVEG 3223 Hydrology 3 Biological Elective 3 Technical Elective **(15 Semester hours)**
Senior Year	
First Semester 2 BENG 4812 Senior Biological Engineering Design I 1 BENG 4831 Biological Engineering Professionalism 3 BENG 4743 Food and Bio-Product Systems Engineering 3 BENG 4933 Sustainable Watershed Engineering 3 Social Science Elective-choose any course listed on the State Minimum Core. Technical Elective 3 CVEG 4243 Environmental Engineering Design **(15 Semester hours)**	**Second Semester** 3 BENG 4823 Senior Biological Engineering Design II (Satisfies General Education Outcome 6.1) 3 BENG 4663 Sustainable Biosystems Designs 3 Fine Arts Elective - Choose one course from the list below (Satisfies General Education Outcome 3.1)[3] 3 Social Science Elective - choose any course listed on the State Minimum Core. **3** Technical Elective (choose a course from the Technical Electives list maintained by the department.) **(18 Semester hours)**

Total Units in Sequence: **128**

This Social Science Elective should be selected from the following courses in order to meet State Minimum Core:
ANTH 1023, COMM 1023, GEOS 2003, GEOS 2003H, HDFS 1403, HDFS 2413, HDFS 2603, HIST 1113, HIST 1113H, HIST 1123, HIST 1123H, HIST 2093, HUMN 1114H, HUMN 2114H, PLSC 2013, or RESM 2853.
The Humanities Elective should be selected from the following courses in order to meet State Minimum Core: CLST 1003, CLST 1013, PHIL 2003, PHIL 2003H, PHIL 2003C, PHIL 2103, or PHIL 2103C.
The Fine Arts Elective should be selected from the following courses in order to meet State Minimum Core: ARHS 1003, COMM 1003, DANC 1003, MLIT 1003, MLIT 1003H, MLIT 1013, MLIT 1013H, MLIT 1333, THTR 1003, or THTR 1013.

MASTER OF SCIENCE AND DOCTOR OF PHILOSOPHY IN BIOLOGICAL ENGINEERING

FOREWORD

The Department of Biological and Agricultural Engineering desires that each graduate student receives a broad and comprehensive educational experience. This experience includes social as well as intellectual development to lead students to an increased level of maturity. Certainly, coursework is primary, but social activities—the exploration of the unknown and the exchange of ideas with fellow students and faculty—are also part of the total educational experience.

An additional part of this development process occurs through service to others. Students are encouraged to become involved in all departmental functions including teaching, research, extension, and social activities so that they may obtain the best possible education.

The core of graduate education lies in obtaining technical expertise in an area of specialization. Specifically, the objectives of the Master's and Ph.D. engineering graduate program are for students to:

- Develop the ability to comprehend and apply engineering principles in order to solve problems in research, development and design.
- Obtain sufficient understanding of the mathematical, physical and biological sciences for comprehension of literature in these and related fields.
- Acquire the skills required to use appropriate equipment, including instruments and computers, in solving problems in their areas of interest.
- Achieve the technical competence necessary to teach college-level courses and conduct an adult education program (such as in Cooperative Extension).

In the attainment of the above objectives, graduate students will combine biological or biomedical engineering courses with other engineering fields, the physical sciences, mathematics, statistics and the biological sciences in developing their program of study. The advanced degrees are primarily research degrees awarded for significant creative research or design accomplishment, and not for the completion of a specified number of courses. Therefore, a student's program concentration is on a significant thesis or dissertation problem completed under the supervision of members of the graduate faculty. This complements a program of strong course support to properly address the thesis or dissertation problem.

ADMISSION REQUIREMENTS

In general, admission to the Department of Biological and Agricultural Engineering graduate program is a three-step process. First, the prospective student must be admitted to graduate standing by the University of Arkansas Graduate School. Second, the student must be accepted into the department's program, which depends on transcripts, recommendations, a statement of purpose, and the following GPA and test scores.

A. Students with an ABET-Accredited or equivalent Engineering Degree

- Students to a M.S. program from a B.S. degree in engineering or to a Ph.D. program from a B.S. degree in engineering and a M.S. degree:
    1. A score of 301 (1100 for the tests taken prior to August 1, 2011) or above (verbal and quantitative) on the Graduate Record Examination (GRE).
    2. A TOEFL score of at least 550 (paper-based) or 213 (computer-based) or 80 (Internet-based). This requirement is waived for applicants whose native language is English or who earn a Bachelor's or Master's degree from a U.S. institution.
    3. GPA of 3.00 or higher on the last 60 hours of a B.S. degree or B.S. and/or M.S. degrees.
    4. B.S. degree in engineering from an ABET (Accreditation Board for Engineering and Technology) accredited or equivalent.
- Students to Ph.D. program directly from a B.S. degree in engineering:
    1. A score of 307 (1200 for the tests taken prior to August 1, 2011) or above (verbal and quantitative) on the GRE.
    2. A TOEFL score of at least 550 (paper-based) or 213 (computer-based) or 80 (internet-based). This requirement is waived for applicants whose native language is English or who earn a Bachelor's or Master's degree from a U.S. institution.
    3. A cumulative GPA of 3.5 or above for undergraduate work.
    4. B.S. degree in engineering from an ABET accredited program or equivalent.

- Students to a M.S. program from a non-engineering B.S. degree:

    1. A score of 301 (1100 for the tests taken prior to August 1, 2011) or above (verbal and quantitative) on the GRE.
    2. A TOEFL score of at least 550 (paper-based) or 2013 (computer-based) or 80 (internet-based). This requirement is waived for applicants whose native language is English or who earn a Bachelor's or Master's degree from a U.S. institution.
    3. GPA of 3.00 or higher on the last 60 hours of a B.S. degree.
    4. Completion of 18 hours of engineering course work (listed below under Degree Requirements). Also see additional information below under the Admission Requirements for Master of Science in Biological Engineering.

- Students to a Ph.D. program from non-engineering B.S. plus M.S. degrees:

    1. A score of 301 (1100 for the tests taken prior to August 1 , 2011 or above (verbal and quantitative) on the GRE.
    2. A TOEFL score of at least 550 (paper-based) or 213 (computer-based) or 80 (internet-based). This requirement is waived for applicants whose native language is English or who earn a Bachelor's or Master's degree from a U.S. institution.
    3. GPA of 3.00 or higher on the last 60 hours of B.S. and/or M.S. degrees.
    4. Completion of 18 hours of engineering course work (listed below under Degree Requirements). Also see additional information below under the Admission Requirements for Doctor of Philosophy in Biological Engineering.

- Students to a Ph.D. program directly from a non-engineering B.S. degree:

    1. A score of 307 (1200 for the tests taken prior to August 1, 2011) or above (verbal and quantitative) with 155 (700 for the tests taken prior to August 1, 2011) and 4.5 or above in writing on the GRE
    2. A TOEFL score of at least 580 (paper-based) or 237 (computer-based) or 92 (Internet-based). This requirement is waived for applicants whose native language is English or who earn a Bachelor's or Master's degree from a U.S. institution.
    3. A cumulative GPA of 3.5 or above for undergraduate work.
    4. Completion of 18 hours of engineering course work (listed below under Degree Requirements). Also see additional information below under the Admission Requirements for Doctor of Philosophy in Biological Engineering.

Finally, a member of the faculty who is eligible (graduate status of group II or higher) must agree to serve as major advisor to the prospective student.

Details concerning admission for both international and domestic students are provided in the University's Graduate School Handbook.

Teaching Program

Graduate Program

Graduate Students

The following students were part of the Graduate program during 2018. Several students cannot be listed due to limitations of the Family Educational Rights and Privacy Act (FERPA). Faculty advisors provided support and planning to the students throughout their career in the Department of Biological and Agricultural Engineering.

Master of Science in Biological Engineering

Student	Advisor
Prince Agyemang	Dr. Ebenezer Kwofie
Lillie Haddock	Dr. Brain Haggard
Lydia Huck	Dr. Scott Osborn
Matthew Kelly	Dr. Thomas Costello
Patrick Kuczwara	Dr. Jin-Woo Kim
Kyle Lawrence	Dr. Marty Matlock
Marguerita Leavitt	Dr. Benjamin Runkle
Yiting Xiao	Dr. Jun Zhu
Winfred Yeboah	Dr. Dongyi Wang

Doctor of Philosophy in Biological Engineering

Student	Advisor
Prathamesh Bandekar	Dr. Marty Matlock
Yihong Feng	Dr. Dongyi Wang
Jaspreet Kaur	Dr. Jin-Woo Kim
Will Richardson	Dr. Benjamin Runkle
Yiting Xiao	Dr. Jun Zhu
Yuanhang Zhan	Dr. Jun Zhu

Master of Science in Food Science

Student	Advisor
Chaitanya Pallerla	Dr. Dongyi Wang

Doctor of Philosophy in Chemical Engineering

Student	Advisor
Derrick Allotey	Dr. Ebenezer Kwofie

Master of Science in Crop Soil Environmental Science

Student	Advisor
Alyssa Ferri	Dr. Brian Haggard

Masters in Materials Science and Engineering

Student	Advisor
Sonatan Biswas	Dr. Yanbin Li

Doctor of Philosophy in Materials Science and Engineering

Student	Advisor
Joseph N. Batta-Mpouma	Dr. Jin-Woo Kim
Yaping Peng	Dr. Yanbin Li

Master of In Cell and Molecular Biology

Student	Advisor
Akrip Jati	Dr. Jin-Woo Kim

Doctor of Philosophy in Poultry Science

Student	Advisor
Wenqian Wang	Dr. Yanbin Li

MASTER SCIENCE IN ENVIRONMENTAL DYNAMICS

STUDENT	ADVISOR
Brittany McIntyre	Dr. Brian Haggard
Jeferson Pimental	Dr. Christopher Henry
Kabiraj Khatiwada	Dr. Benjamin Runkle

DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL DYNAMICS

STUDENT	ADVISOR
Riasad Bin Mahbub	Dr. Benjamin Runkle

GRADUATE DEGREES EARNED

The following students completed all requirements for their degree program and were awarded a degree from the University of Arkansas.

Spring 2022
Lillie M Haddock M.S.
Lydia Huck, M. S.

Summer 2022
Prince Agyemang M.S.
Marguerita Ellen Leavitt M.D.
Xinge Xi Ph.D.

Fall 2022
Prathamesh Avadhut Bandekar Ph.D.

The following courses are taught as part of the Biological & Agricultural Engineering curriculum for the Undergraduate, Master's, and Ph.D. programs.

BENG 2632 Biological Engineering Design Studio (Fa) Application of the engineering design process to projects involving living systems. Projects are team-based open-ended design with hands-on construction and testing of design prototypes. Emphasis is placed on understanding, quantifying and controlling complex interacting living systems involving humans, animals, plants and microbes with the goal of creating economically and ecologically sustainable systems. 4 hours of design studio per week. Pre- or Corequisite: PHYS 2054 and BIOL 1543/1541L, and (GNEG 1111 or GNEG 1103).

BENG 2643 Biological Engineering Methods (Sp) Introduction to software techniques for the graphical and geo-spatial representation of processes, structures, devices, landscapes and watersheds in biological engineering. Process layout and process flow diagrams. Two-dimensional and three-dimensional scale drawings and models. Elements of engineering drawings and plans. Mapping and introduction to geographic information systems. Surface topography, digital elevation modeling, spatial land use, soils and other GIS data sources. Stream networks, watershed delineation, grade planning and introductory runoff modeling. Introductory land surveying. Geo-referencing and integrating designed hydrologic structures with GIS-based site maps. Communicating complex designed systems. Two hours of lecture plus one 3-hour lab per week.
Corequisite: Lab component. Prerequisite: PHYS 2054

BENG 3113 Measurement and Control for Biological Systems (Sp) Principles of sensors, instruments, measurements, controls, and data acquisition systems, with emphasis on applications for biological systems; including basic circuit analysis, sensor calibration and hardware selection. Basic process monitoring and control methods, including hardware and software. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component. Prerequisite: PHYS 2054.

BENG 3113H Honors Measurement and Control for Biological Systems (Sp) Principles of sensors, instruments, measurements, controls, and data acquisition systems, with emphasis on applications for biological systems; including basic circuit analysis, sensor calibration and hardware selection. Basic process monitoring and control methods, including hardware and software. Lecture 2 hours, laboratory 3 hours per week. Corequiste: Lab component: Prerequistie: PHYS 2074 and honors candidacy.

BENG 3653 Global Bio-Energy Engineering (Fa) Global energy sources with a focus on renewable energy, solar and biomass derived fuels. Biomass energy production from crops and organic residues or waste products. Conversion of biomass to usable fuels. Utilization of renewable energy in society. Includes detailed systems analyses to examine inputs, efficiencies, usable outputs and by-products. Systems design to select and integrate components which meet client needs while maximizing sustainable global impacts. Three hours of lecture per week. Pre- or Corequisite: (MEEG 2403 or CHEG 2313).

BENG 3663. Biological Engineering Methods II (Fa). 3 Hours.
Modeling biological processes to predict system behavior as part of the design process. Development and use of spreadsheets and script programming code to represent biological phenomena and processes. Introduction to experimental design as applied to biological processes, including data collection and analysis, and elementary statistics. Use of engineering economics to aid comparisons of alternatives. Analysis of engineering designs and management practices to best meet the needs of society and the client in areas of sustainable water, food and energy systems.
Lecture 3 hours per week.
Prerequisite: PHYS 2054 and MATH 2564.

BENG 3723 Unit Operations in Biological Engineering (Sp) Design of basic unit operations typical of biological engineering practice; unit operations include pump-pipe, fan-duct, moist air (psychrometric) processes (cool/heater/humidifier/dryer), air mixing, aeration, and refrigeration; unit operations design will account for unique constraints imposed by biological systems. Lecture 2 hours and lab 3 hours per week. Corequisite: Lab component. Prerequisite: (MEEG 2403 or CHEG 2313) and (CVEG 3213 or CHEG 2133 or MEEG 3503).

BENG 3733 Transport Phenomena in Biological Systems (Fa) Basic principles governing transport of energy and mass. Estimating transfer of energy (heat) through solid bodies and liquid/gas boundary layers through conduction, convection, and radiation. Modeling the rates at which biological reactions occur (kinetics). Estimating the transfer of diffusing mass (gas or liquid) through solid bodies and liquid/gas boundary layers, including processes such as drying and oxygen

diffusion. Three hours lecture per week. Pre- or Corequisite: (CVEG 3213 or MEEG 3503 or CHEG 2133.)

Prerequisite: (MEEG 2403 or CHEG 2313).

BENG 4123 Biosensors & Bioinstrumentation (Odd years, Sp) Principles of biologically based sensing elements and interfacing techniques. Design and analysis methods of biosensing and transducing components in bioinstrumentation. Applications of biosensors and bioinstrumentation in bioprocessing, bioenvironmental, biomechanical and biomedical engineering. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component. Prerequisite: BIOL 2013 or BIOL 2533 and BENG 3113.

BENG 450V Special Problems (Sp, Su, Fa) Selected problems in biological engineering are pursued in detail. Prerequisite: senior standing. May be repeated for up to 4 hours of degree credit.

BENG 451VH Honors Thesis (Sp, Su, Fa) Prerequisite: Honors candidacy.

BENG 452V Special Topics in Biological Engineering (Irregular) Special topics in biological engineering not covered in other courses. May be repeated for up to 8 hours of degree credit.

BENG 4663 Sustainable Biosystems Designs (Fa) Process and methodologies associated with measuring, assessing, and designing sustainable systems in water, energy and food. Quantitatively rigorous methodology for life cycle analysis (LCA) for inventory, assessment and impact analyses. Use of other systems analyses and process control theory to evaluate and design sustainable systems. Application of the methods to a project to gain experience in defining, quantifying and utilizing sustainable metrics. Three hours of lecture per week. Prerequisite: BENG 3653.

BENG 4743 Food and Bio-Product Systems Engineering (Fa) Sustainable bio-product engineering through biosystem design, analysis, modeling, control, and optimization. Life cycle phases for bio-products (food, fiber, feed, and fuel). System analysis of inputs and outputs of energy, water and mass for the purpose of producing and processing biomass for human uses. Advanced bioprocess design topics to utilize enzymes, cells, tissues and organisms to create bio-products and methods for deactivating biological agents to preserve the quality and safety of food and other bio-products. Three hours lecture per week. Prerequisite: BENG 3723 and BENG 3733.

BENG 4753L Nanotechnology Laboratory (Fa) Provides students with hands-on experience in several major areas of nanotechnology, including nanoscale imaging, synthesis of nanomaterials, nanostructure assembly and manipulation, device and system integration, and performance evaluation. Students can earn credit for only one of the following courses: MEEG 4323L, BENG 4753L, BMEG 4103L, CHEM 4153L, PHYS 4793L. Corequisite: Drill component, junior standing and instructor consent. Prerequisite: MATH 2564, PHYS 2074, CHEM 1123, or CHEM 1133.

This course is cross-listed with MEEG 4323L, CHEM 4153L, PHYS 4793L.

BENG 4812 Senior Biological Engineering Design I (Fa) Initiation of comprehensive two-semester team-design projects to design processes, devices and systems to meet needs of clients in sustainable water, food and energy. Practice in following the design process, including the definition of design objectives and constraints, establishing functions and performance criteria, generating alternatives and evaluating alternatives through analysis, modeling and prototype testing; exploring relevant design considerations including performance, efficiency, costs, environmental impacts, sustainability and stewardship, safety and ethics. Developing analytic capability; and practicing design optimization to find best alternative for the client. Lecture 1 hour, laboratory 3 hours per week. Prerequisite: Instructor consent. Corequisite: Lab component.

BENG 4823 Senior Biological Engineering Design II (Sp) Completion of comprehensive two-semester team-design projects to design processes, devices and systems to meet needs of clients in sustainable water, food and energy. Focus on building of prototypes or models, system optimization, evaluation and improvement. Final design details packaged to meet the needs of the client. Interaction with appropriate persons from other disciplines. Written and oral reporting. Communications with peers, supervisor, clients and the public. Lecture 1 hour per week, two 2-hour lab periods per week. Prerequisite: BENG 4812. Corequisite: Lab component.

BENG 4831. Biological Engineering Professionalism (Fa). Preparation to be job-ready, employable and

successful in transition to a professional career and further study in Biological Engineering. Introduction to job and graduate study searches. Professional and ethical responsibilities; professional registration. Conflict, change and project management. Effective communications and interactions with supervisors, peers, clients, and stakeholders. Two hour discussion section per week. Prerequisite: Senior standing.

BENG 4933 Sustainable Watershed Engineering (Sp) Provides students with expertise in using advanced tools in watershed monitoring, assessment, and design. Builds on core competencies in hydrology and hydraulics to allow student to evaluate water used by sector in water management regions; evaluate and quantify water demands by sector with emphasis on irrigation; develop risk-based simulations of hydrologic processes, including precipitation, evapo-transportation, infiltration, runoff, and stream flow; quantify and simulate constituent loading to watersheds using GIS-based models, and understand the applications of these methods in water resource management policy. Three hours lecture per week. Prerequisite: CVEG 3223

BENG 500V Advanced Topics in Biological Engineering (Irregular) (1-6) Special problems in fundamental and applied research. Prerequisite: Graduate standing. May be repeated for up to 6 hours of degree credit.

BENG 5103 Advanced Instrumentation in Biological Engineering (Even years, Sp) Applications of advanced instrumentation in biological systems. Emphasis on updated sensing and transducing technologies, data acquisition and analytical instruments. Lecture 2 hours, lab 3 hours per week. Corequisite: Lab component. Prerequisite: BENG 3113.

BENG 5253 Bio-Mems (Irregular) Topics include the fundamental principles of microfluidics, Navier-Stokes Equation, bio/abio interfacing technology, bio/abio hybrid integration of microfabrication technology, and various biomedical and biological problems that can be addressed with microfabrication technology and the engineering challenges associated with it. Lecture 3 hour per week. Prerequisite: MEEG 3503 or CVEG 3213 or CHEG 2133. (Same as MEEG 5253)

BENG 5613 Simulation Modeling of Biological Systems (Irregular) Application of computer modeling and simulation of discrete-event and continuous-time systems to solve biological and agricultural engineering problems. Philosophy and ethics of representing complex processes in simplified form. Deterministic and stochastic modeling of complex systems, algorithm development, application limits, and simulation interpretation. Emphasis on calibration, validation and testing of biological systems models for the purposes of system optimization, resource allocation, real-time control and/or conceptual understanding. Prerequisite: AGST 4023 or STAT 4003 or INEG 2313.

BENG 5623 Life Cycle Assessment (Sp) This course will examine the process and methodologies associated with life cycle analysis (LCA). The course will explore the quantitatively rigorous methodology for life cycle inventory (LCI), LCA and life cycle impact assessment (LCIA). This course is offered on-line. The principal instructor will be a UA faculty member.

BENG 5633 Linkages Among Technology, Economics and Societal Values (Sp, Fa) Addresses how macro-level change is influenced by the linkages among technology, economics and societal values. Three major course initiatives: 1) Developing a conceptual model for understanding how macro-level change has occurred over history; 2) Examining recorded history in order to develop a contextual appreciation for Society's current situation; and 3) Using statistical data to identify six overriding world trends that are likely to greatly impact society's goal of achieving sustainable prosperity and well-being in the foreseeable future. Prerequisite: Graduate standing or instructor permission. (Same as OMGT 5633)

BENG 5703 Design and Analysis of Experiments for Engineering Research (Irregular) Principles of planning and design of experiments for engineering research. Propagation of experimental error. Improving precision of experiments. Analysis of experimental data for optimal design and control of engineering systems using computer techniques. Students must have an introductory background in statistics. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component.

BENG 5801 Graduate Seminar (Sp) Reports presented

by graduate students on topics dealing with current research in biological engineering. Prerequisite: Graduate standing.

BENG 5923 Nonpoint Source Pollution Control and Modeling (Irregular) Control of hydrologic, meteorologic, and land use factors on nonpoint source (NPS) pollution in urban and agricultural watersheds. Discussion of water quality models to develop NPS pollution control plans and total maximum daily loads (TMDLs), with consideration of model calibration, validation, and uncertainty analysis. Prerequisite: BENG 4903 or CVEG 3223.

BENG 5933 Environmental and Ecological Risk Assessment (Sp) Process and methodologies associated with human-environmental and ecological risk assessments. Environmental risk assessments based on human receptors as endpoints, addressing predominantly abiotic processes. Ecological risk assessments based on non-human receptors as endpoints. Approach using hazard definition, effects assessment, risk estimation, and risk management. Application of methods to student projects to gain experience in defining and quantifying uncertainty associated with human perturbation, management and restoration of environmental and ecological processes.

BENG 5963. Modeling Environmental Biophysics. Interactions between the biosphere and the atmosphere. Connecting the physical environment of solar energy, wind, soil, and hydrology to the biosphere through plant ecophysiology. Boundary layer meteorology, photosynthesis and boundary layer modeling strategies, and the soil-plant-atmosphere continuum. Instrumentation, measurement and modeling strategies for understanding leaf-, landscape- and regional behaviors; and, the transfer, kinetics, and balance of momentum, energy, water vapor, CO2, and other atmospheric trace gases between the landscape (vegetation and soil) and the atmosphere. Applications in sustainable agriculture, irrigation, land and water resources, and modeling plant water use and carbon uptake strategies. A working knowledge of calculus and a discipline related to the course is expected. Three hours of lecture per week. Students may not earn degree credit for both BENG 4963 and BENG 5963. Prerequisite: Instructor consent. (Typically offered: Spring Even Years)

BENG 5973. Advanced Practice in Water Quality Monitoring and Analysis. Application of water quality principles to a real world problem. Team project experience leading and developing quality assurance project plans, designing monitoring systems, selecting chemical analysis methods, estimating loads, performing trend analysis, basic model calibration and validation, team management, and technical report writing and oral presentations. Working with various clientele to analyze water quality data in the context of evaluating real-world problems and issues. Three hours of lecture per week. Prerequisite: Graduate standing. (Typically offered: Spring Odd Years)

BENG 600V Master's Thesis (Sp, Su, Fa) (1-6) Graduate standing required for enrollment.

BENG 700V Doctoral Dissertation (Sp, Su, Fa) (1-18) Candidacy is required for enrollment.

Congratulations to the Class of 2022!

Undergraduate:

Spring 2022

Alexis Barber
Amanda Bogart
Lillie Bolton
Nathan Bowman
Harrison Davis
Megan Doty
Hunter Dowell
Hayden Engelbrecht
William Franke
Clarissa Fuller
Fernanda Novoa
Russell Gartner
Noah Geels
Sophia Gomez
Lauren Gregory
Janeth Jaen Jaen
Logan Jennings
Daniel Krol
Ellie Kuhn
Devyn Meyer
Jacob Miller
Ian Mills
Flora Noble
Dawson Oakley
William Osment
Aubin Payne
Shawn Pearson
Michala Smith
Olivia Torres
Spencer Warrick
Harper Williams-Dow

Undergraduate:

Summer 2022

Bao Ngoc Thi Dao
Katie Loethen
Samuel Nepomuceno

Fall 2022

Michael Janorschke
Juliana Newman
Noah Olson

In Memory of: Sammy Sadaka

Sammy Saber Sadaka, 62, of Little Rock, Arkansas, passed away on November 6th, 2022. Sammy was born on November 18, 1959, to Saber Sadaka Sharoubim and Sarah Sultan in Alexandria, Egypt.

Sammy received a Bachelor's, Master's and PhD in Agricultural Engineering from Alexandria University and Dalhousie University. In 1995 he went on to marry Heba Soliman. They went on to have two children, Monica and Kyrilos.
Sammy was predeceased by his brother, Nabil; his father, Saber and his mother, Sarah. He is survived by his wife, Heba; his daughter, Monica; son, Kyrilos; his sisters, Itedale, Nadia, Izeis and his brother, George.

Sammy was very grounded in his faith and would spend his free time building the St. George Coptic Orthodox Church in Little Rock. Sammy spent his time learning new crafts to build new and better things for his church.

After his graduation and receiving his degrees, Sammy worked as an Associate Professor at Alexandria University. Sammy and Heba moved to the United States and started a family together. Sammy started his career in the United States in Ames, Iowa working at Iowa State University where he was a Scientist and an adjunct professor. Sammy and his family then moved to Little Rock, accepting a
position at the University of Arkansas Cooperative
Extension Services as an Assistant Professor.

Later on, Sammy became an Associate Professor at the University. He was also an Associate Editor and Reviewer for the American Society of Agricultural and Biological
Engineering Journal. Sammy was well known in his field, being invited to many national conferences where he received awards and recognition for his publications,
services and work in his community.

Sammy was a loving and caring father and husband. He was a friend to many, and a spiritual example to all. He was a God-fearing man who served his Lord faithfully his whole life.

Dr. Marty Matlock receives the 2022 AEES Odum Award for Ecological Engineering Excellence

During the June AEES meeting in Baltimore, Dr. Marty Matlock was awarded the 2022 AEES Odum Award. The Odum Award is the highest honor bestowed by AEES, named in recognition for two of the most influential figures in defining and pioneering the concepts and practices of Ecological Engineering, Howard T. and Eugene Odum. This award recognizes a lifetime of achievement and contributions during their career to research, education, and practice in the field of Ecological Engineering, which led to the development and growth of AEES.

Dr. Matlock is a Professor in the Biological and Agricultural Engineering Department at the University of Arkansas. He received his Ph.D. in Biosystems Engineering from Oklahoma State University, is a registered professional engineer, a Board-Certified Environmental Engineer, and a Certified Ecosystem Designer. He has authored over 50 peer reviewed manuscripts many of which are in the field of Ecological Engineering. He has also co-authored four books including *Ecological Engineering Design: Restoring and Conserving Ecosystem Services*. He served as AEES president in 2007-2008 and has continued to be active in the society, most recently spear-heading the concept and development of the our new AEES *Journal of Ecological Engineering Design*.

Matlock joins Sec. of Agriculture Vilsack to Announce Meat and Poultry Grant Program Recipients

Marty Matlock, professor in the Department of Biological and Agricultural Engineering, as an invited guest of U.S. Secretary of Agriculture Tom Vilsack in Omaha, Nebraska on November 2 to announce the first-round awards the Meat and Poultry Expansion Program (MPEPP) as part of USDA's investment of $1 billion to expand U.S. meat and poultry

processing. Matlock served as Senior Advisor to Secretary Vilsack from 2021-22 and was one of the chief architects of the MPEPP program which includes grants, guaranteed loans, workforce development, and technical assistance.

"Since President Biden laid out a commitment at the start of this year, USDA has worked tirelessly to give farmers and ranchers a fair chance to compete in the marketplace, which in turn helps lower food costs for the American people," said Secretary of Agriculture Tom Vilsack. "By jumpstarting independent processing projects and increasing processing capacity, these investments create more opportunities for farmers and ranchers to get a fair price, while strengthening supply chains, delivering more food produced closer to home for families, expanding economic opportunity, and creating jobs in rural America." The grants announced on Tuesday included $73 million in 21, $75 million for eight projects through the Meat and Poultry Intermediary Lending Program, as well as more than $75 million for four meat and poultry-related projects through the Food Supply Chain Guaranteed Loan program. The MPEPP

Matlock invited to US Soybean Export Council discussion with China Ambassador on sustainable soybean production in the US.

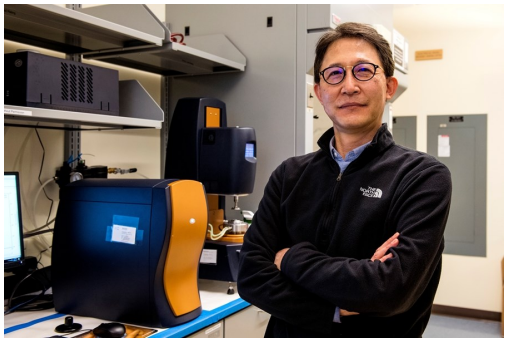
Dr. Marty Matlock, professor in the Biological and Agricultural Engineering Department and research professor in the UA System Division of Agriculture was invited to join the United States Soybean Export Council (USSEC) on Friday, September 16 in St. Louis as they hosted Qin Gang, the China Ambassador to the U.S. They participated in a roundtable event focused on sustainable and climate smart agricultural practices that included USDA Acting Deputy Under Secretary Jason Hafemeister as well as Chinese delegates and leaders from the U.S. and China's food & agriculture industry. Matlock has worked with USSEC over the past 15 years to develop goals, metrics and assessment tools for sustainability, including soil resilience, water use efficiency, energy use, greenhouse gas emissions, biodiversity, land use impacts.

In response to discussion of the role of U.S. soybean producers in leading innovation in sustainable production Amb. Qin Gang commented: "Agriculture is a key contributor to China's green development. We (China and the U.S.) have a common responsibility to promote sustainable agriculture and food security for future generations. Our market will remain open, and we will continue to collaborate with U.S. farmers, companies and entities who want to advance green development of China's food and agriculture." Jim Sutter, CEO of USSEC, responded "We all have a responsibility to act for consumers, our children, and our grandchildren. "China is the world's leading soy consumer and the largest importer of US soy, supporting edible oil and soy food for people as well as feed for Chinese pork, egg, aquaculture, and poultry production. U.S. Soy has collaborated in China since 1982.

Arkansas Nanotech Researcher Jin-Woo Kim Named IEEE Fellow

IEEE elevated Kim to IEEE fellow status for his contributions to nanoscale fabrication of bio/nano-hybrid materials. The IEEE is a professional organization for the advancement of technology with more than 400,000 members in over 160 countries. Only about 5,000 members have been named IEEE fellows. Kim was among 311 senior members bestowed with the honor in 2022. "We congratulate Dr. Kim for his induction as fellow of IEEE," said Jean-François Meullenet, senior associate vice president for agriculture-research and director of the Arkansas Agricultural Experiment Station. "We know this is a very special honor for him and a great recognition for his breakthrough work in nanoscience. Well deserved."

"It is a prestigious honor and an important career achievement," said Lalit Verma, head of the Department of Biological and Agricultural Engineering. "Dr. Kim's research and development work and innovative technology will enhance the economic well-being and quality of life in Arkansas and the world."



Kim's contributions to nanotechnology have helped develop a method to treat cancer in collaboration with the U of A for Medical Sciences.

"I have found him to always be an innovative, deep thinker and someone with a special ability to think across disciplines as he collaborates on exciting work related to our cancer detection and drug delivery interests," said Robert J. Griffin, Ph.D., of the UAMS Department of Orthopedic Surgery. "His work on DNA-based nanoparticles was particularly fascinating as he was able to ingeniously use the natural properties of DNA to create multifunctional nanomaterials with exciting potential."

$1 Million awarded to quantify Climate-Smart rice production; project highlighted by USDA Secy. Vilsack's September Arkansas visit

Biological & Agricultural Engineering's Benjamin Runkle, associate professor, is part of a group who received an $80 million award from the US Department of Agriculture's Climate Smart Agriculture Initiative. The project is led by USA Rice and Ducks Unlimited, who will coordinate the development and implementation of a wide-ranging effort to reduce the greenhouse gas emissions associated with rice production. In this 5-year grant, Runkle's team will receive approx. $1 million to oversee measurement, monitoring, reporting, and verification, to help ensure that project goals are met and are well quantified.

Runkle noted that "this project is ambitious – it aims to impact approximately one-fifth of all rice acreage in the United States. Farmers will be incentivized to carry out conservation practices that save water, reduce greenhouse gas emissions, and maintain high harvest amounts. The project is also unique in its special attention to include historically underserved farmers, through partnership with the National Black Growers Council and others. The program will also fund infrastructure development for underserved farmers to create the enabling conditions for eventual implementation of conservation practices at their farms."

This grant was one of 70 announced this month that comprised a $2.8 billion investment in the creation of Partnerships for Climate Smart Commodities by the US Department of Agriculture. These awards were highlighted on Sept. 16 by a visit to the central Arkansas rice farm of Mark Isbell and family by US Secretary of Agriculture, Tom Vilsack. In addition to highlighting that this project scored the highest of all applicants, the Secretary hosted a panel for discussion. The panel included representatives from Ducks Unlimited, the National Black Growers Council, Tyson Foods, the Winrock Foundation, and the University of Arkansas VP for Agriculture, Deacue Fields III. Both Tyson and Winrock received other awards under this program. The panelists indicated the need to develop trusted labeling of goods as climate-smart, that are ground in good science and supported throughout the supply chain.

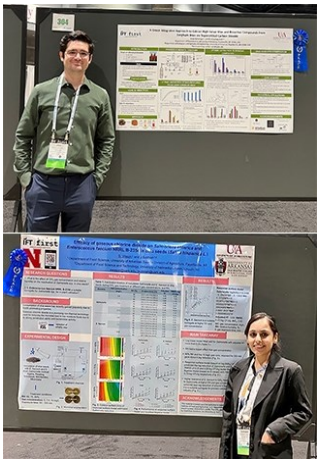
Runkle's portion of the grant will allow him to hire scientific personnel to guide project data collection, document the performance of the proposal, and report findings to the USDA and to the broader scientific community. He thinks that if the grant team is successful in its implementation, the project could spur spin-off activities to ensure a broader, lasting reduction of the climate impact of rice production through relatively small changes in field management practices. Because the project will be active in all six states where rice is produced in the U.S., the data collected will also help understanding of how to make effective changes to rice production under different management, soil, and climate conditions. Runkle noted that the project will build on his group's ongoing sustainability research at the Isbell family farm, and it will also use some of the expertise gained from his current NASA and NSF funded projects.

Accomplishments in 2022

Sadaka received two awards from the American Society of Biological and Agricultural Engineering (ASABE 2022)

Sammy Sadaka, Associate Professor-Extension Engineer, Biological and Agricultural Engineering Department, received two awards during the American Society of Agricultural and Biological Engineers (ASABE) International Meeting 2022 held in Houston, TX. Several hundred Agricultural and Biosystems Engineers, from several countries, attended the meeting this year. Sammy received the first Award (Superior Paper Award) for his published manuscript entitled "Energy and Exergy Efficiencies of Fluidized and Fixed Bed Rice Drying," published in an ASABE journal. Sammy and his former Ph. D. student, Dr. Kaushik Luthra, co-authored the manuscript. His second award, "Outstanding Publication Reviewer," was awarded by the ASABE Refereed Publications committee for his dedicated and precious ASABE manuscript review.

Food Science Doctoral Students Arda Tuhanioglu, Surabhi Wason Win IFT Contests



Arda Tuhanioglu and Surabhi Wason, both graduate students in food science, won competition awards at the recent Institute of Food Technologists First Event and Expo in Chicago.

Tuhanioglu, a Ph.D. student advised by assistant professor Ali Ubeyitogullari, won the Sustainable Food Systems division oral contest.

Wason, a Ph.D. student advised by professor and head of the Department of Food Science Jeyam Subbiah, won the Non-Thermal Processing division oral competition.

Tuhanioglu's research is "A Green Integrated Approach to Extract High-Value and Bioactive Compounds from Sorghum Bran via Supercritical Carbon Dioxide."

Wason's research is "Efficacy of Gaseous Chlorine Dioxide on Salmonella Enterica and Enterococcus Faecium NRRL B-2354 in Chia Seeds."

Student Teams Land Top Prizes in Biological and Agricultural Engineering Design Competition

Two team projects from the U of A Biological and Agricultural Engineering program took first and second place in the American Society of Agricultural and Biological Engineers Gunlogson Environmental Design Student Competition. The biological engineering Senior Capstone project coordinator is G. Scott Osborn.

The purpose of the society's open Gunlogson competition is to encourage undergraduate students to participate in the design of a relevant engineering project and to provide an arena of professional competition for environmentally and biologically related design projects.

The national society competition consists of two parts:

- Submission of a design report to be judged by an expert panel.
- Participation by the three teams earning the highest report scores in a presentation competition at the society's annual international meeting.

The first place team received $1,250, and the second place team received $1,000 at the society's Annual International Meeting in Houston on July 20.

Engineering Fellow Honored for Work Improving Environmental Outcomes for Rice Production

Postdoctoral fellow Beatriz Moreno-García was recognized Nov. 15 as the Field to Market: The Alliance for Sustainable Agriculture's 2022 Trusted Adviser of the Year for her outstanding leadership in supporting farmers' journeys of continuous improvement.

Providing valuable counsel to Arkansas farmers, Moreno-García champions sustainable solutions to reduce the environmental impact of rice production, working with farmers to help them try sustainable practices and monitor their improvements.

"I have always been concerned and worried about sustainability, especially in agriculture, because we have an increased global population, and if we continue to use natural resources as we are using them now, we won't be able to feed the world population in a few years," said Beatriz Moreno-García, a fellow in the Department of Biological and Agricultural Engineering.

That concept is what has driven Moreno-García throughout her education and into her career.

"I studied environmental sciences — I didn't study agronomy," remarks Moreno-García. "But there is, of course, a link between both because agriculture has an environmental impact."

Following her undergraduate environmental science studies at King Juan Carlos University in Madrid, Spain, Moreno-García completed a Ph.D. at the University of Zaragoza and Centro de Investigación y Tecnología Agroalimentaria de Aragón in Zaragoza, Spain, focusing on the use of organic fertilizers in rice production and their environmental impact, including greenhouse gas emissions.

She came to the U of A for her postdoctoral research and has been here ever since.

"I knew the University of Arkansas was working on the implementation of sustainable practices in rice, so I wanted to come here," she said. "Now, my work is focused on sustainable practices in rice, specifically focusing on water-saving practices."

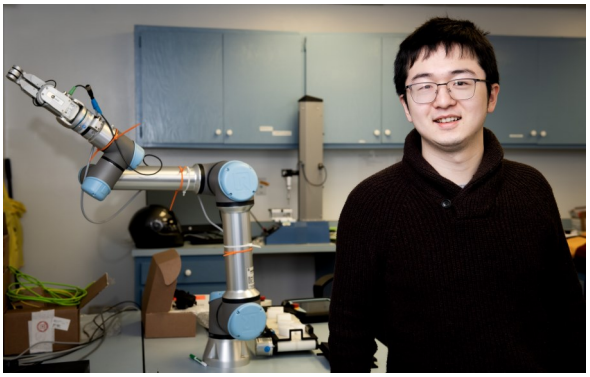
When asked why she chose rice for her studies, her answer was clear — rice is an important crop for food consumption and has a lot of room for improvement in terms of environmental impact.

"Rice provides 20 percent of the calorie consumption in the world, so it's incredibly important," she explained. "But because of the way rice is grown, it has a high environmental impact and therefore a lot of areas to improve its sustainability."

Moreno-García's adviser, associate professor Benjamin Runkle, noted that this honor is a testament to her hard work, integrity and intellect.

"Beatriz combines scientific rigor, as evidenced in her research output, with a careful understanding of field, farm and farmer characteristics that require tailor-made sustainability guidance for each rice production setting," he said. "It is fantastic that Field to Market has recognized what we have long known: Beatriz is a gifted and trusted communicator with a strong grounding in contemporary scientific knowledge."

Arkansas to lead $5 million grant-established center to advance robotics in poultry processing



Researchers in Arkansas and two other states will be using a $5 million grant to increase use of artificial intelligence and robotics in chicken processing to reduce waste in deboning and detect pathogens.

The grant from the U.S. Department of Agriculture's National Institute of Food and Agriculture will establish the Center for Scalable and Intelligent Automation in Poultry Processing. The center, led by the University of Arkansas System Division of Agriculture, will join researchers from five institutions in three states in efforts to adapt robotic automation to chicken meat processing.

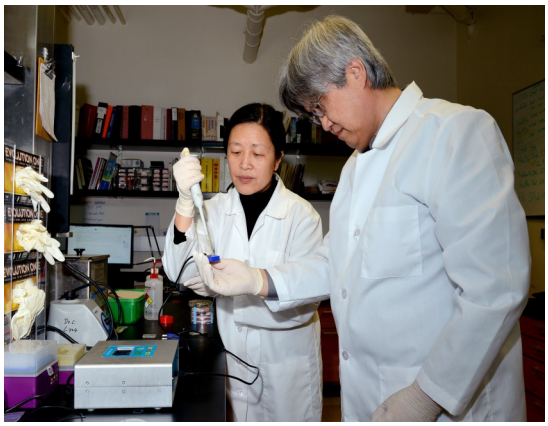
Project director Jeyam Subbiah said the Arkansas Agricultural Experiment Station, the research arm of the Division of Agriculture, will receive $2.2 million from the grant primarily to focus on food safety automation for poultry processing plants. The grant is for four years.

Subbiah is a professor and head of the food science department for the Division of Agriculture and the Dale Bumpers College of Agricultural, Food and Life Sciences at the University of Arkansas.

The Georgia Institution of Technology, better known as Georgia Tech, is a major partner in the project, Subbiah said. $2.1 million of the grant will go to Georgia Tech to focus on automating the processing lines that turn chickens into meat.

The remaining grant money will be divided between Julia McQuillan, Willa Cather professor of sociology at the University of Nebraska-Lincoln, and Brou Kouakou, associate dean for research at Fort Valley State University in Georgia.

Jeff Buhr, a USDA Agricultural Research Service scientist, will contribute his expertise in broiler physiology to guide robotic deboning of meat, Subbiah said.



Georgia is the nation's top broiler producer. Arkansas is number 3, according to 2021 figures from USDA.

Research team

Arkansas' research will involve scientists from at least three departments: Dongyi Wang and Yanbin Li from biological and agricultural engineering—Wang also has an appointment in food science, and Li is affiliated with the Center of Excellence for Poultry Science

Arkansas Engineering Faculty Member Recognized for Outreach to Aid Poultry Sustainability Efforts

Yi Liang was awarded the John W. White Outstanding Extension State Faculty Award

Alumni Kendrick Hardaway (BENG 2018) was recently awarded a Fulbright Scholarship to perform research at the Univ of Canterbury, New Zealand, on resilience and climate adaptation planning. He will work with a professor of engineering, Tom Logan, from early 2024. After Fayetteville, Kendrick has been pursuing a Ph.D. at Purdue University, where he researches climate adaptation for infrastructure systems and the environmental impacts of emerging technologies. He specifically focuses on trying to capture missing or not-yet-understood feedback loops in models of these systems. He has also started a partnership with researchers in Athens, Greece, to help with an EU Horizon project on climate resilience and with the Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium. Following the Fulbright, he plans to pursue a career in academia to continue doing exciting research and working toward collective environmental solutions.

Dr. Benjamin Runkle is the co-investigator of the National Institute of Food and Agriculture grant, it is led by a colleague at the University of Delaware, Angelia Seyfferth, it is funded by the USDA's Food Safety group. My part, funded at $316,000 over 4 years, will help test ways to predict and manage the potential for arsenic to migrate into rice grains from the soil while rice grows in the field. It will support a postdoctoral researcher as well as undergraduate assistants.

Student Industry Tour

The 2022 Industry tour toured the following locations. Hiland Dairy, Delta Plastics and Diamond Bear Brewery in Little Rock, Arkansas. Bayou Meto Project Pump Station, Scott, Arkansas and Isbell Farm England, Arkansas.

Senior Design Expo

On May 4th 2023 seniors presented their Senior Deign Projects to faculty, staff and mentors.

Dr. Ubeyitogullari has received two USDA-NIFA projects to develop 3D food printing approaches for the delivery of bioactive compounds. Dr. Ubeyitogullari's Ph.D. student, Arda Tuhanioglu, won 1st place in the IFT Sustainable Food Systems Division Oral Competition. He has also been selected to receive the 2023 Jogue Inc. Scholarship ($2,000) by the Society of Flavor Chemists. His graduate students, Sumanjot Kaur and Arda Tuhanioglu, received 1st place in the Student ePoster and Pitch Competition at the 2023 American Oil Chemists' Society Annual Meeting & Expo. Dr. Ubeyitogullari was featured in the Behind the Discovery channel of the University of Arkansas Division of Agriculture. Dr. Ubeyitogullari hosted two visiting graduate students from Ghent University (Belgium) and University of Applied Science, Weihenstephan – Triesdorf (Germany). Dr. Ubeyitogullari teaches FDSC 3103: Principles of Food Processing and FDSC 2201: Science of Chocolate.

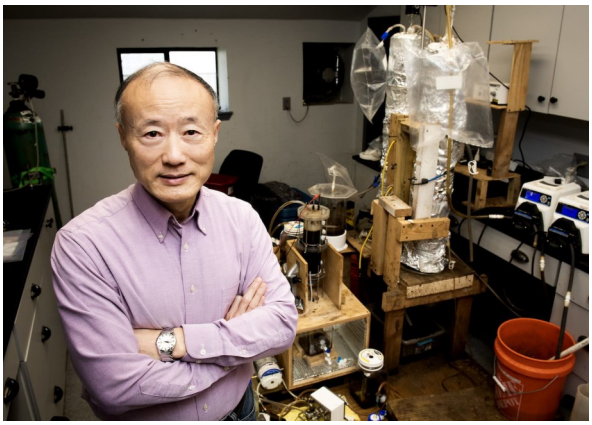
At the AOCS Annual Meeting (April 30 - May 3), my Ph.D. student, Arda Tuhanioglu, won first place in the "general group" category, and my M.S. student, Sumanjot Kaur, won first place in the "protein and co-products group" category poster competitions. These were the only two categories at the conference. Arda was also the recipient of the Honored Student Award (one of the most prestigious student awards by the AOCS). AOCS: American Oil Chemists' Society.

High-tech cameras focused on chicken breast defect detection

Some research for poultry processing automation is more than meets the eye.
A multidisciplinary team of scientists at the Arkansas Agricultural Experiment Station are testing to see if hyperspectral images can be used to detect a chicken breast defect known as "woody breast" that costs the poultry industry millions of dollars annually and decreases customer satisfaction.
Dongyi Wang, assistant professor of biological and agricultural engineering, explains that hyperspectral imaging is a non-invasive sensing technique that combines a near-infrared sensor with a high-definition color camera to capture physical and chemical information.
"The current evaluation procedure is time-consuming and needs a sample tested through cumbersome laboratory tests," Wang said.
Woody breast detection with a hyperspectral camera system would take just a few seconds with a compute instead of grading by hand.
"Woody breast detection by hand can be labor intensive," said Casey Owens, the Novus International Professor of Poultry Science at the experiment station. "If hyperspectral imaging can be used in a poultry processing plant, that labor force could be diverted to another area."
Owens said woody breast affects up to about 20 percent of chicken breast meat. Although it can be diverted for further processing, the loss in premium as a whole-muscle product accounts for a yield loss worth about $200 million annually in the United States, Wang said.

Accomplishments in 2022

Graduates from last year – Alexis Barber, Harrison Davis, and Nathan Bowman, who were recognized (Along with absent team members) for their awards last summer at the ASABE meeting in the student environmental design competition.



ONE-OF-A-KIND — Jun Zhu, professor of biological and agricultural engineering, stands before a prototype of the liquid-state poultry litter digester designed to recycle water used in creating struvite from poultry litter. The system also captures biogas from liquid-state anaerobic digestion of poultry litter.

Post Doctoral Fellow Swarna Sethu won best paper for her presentation: Sensory Predictive Analysis of freshness of Food Products under Different Lighting Conditions at the 2023 IEEE International Conference

Emily Tappana was named 2023 ASABE Outstanding senior

Faculty Research & Extension Projects

We are engaged in research and extension programs which contribute to improving the quality of life, security, economic development, and environmental stewardship for Arkansas and the world. Our engineering expertise is uniquely qualified to solve problems in food, water and energy systems. Biological and agricultural engineer's utilize the engineering tools of systems analysis and design to solve complex problems in biological systems, ranging from microbes to the global environment. Our goal is to design sustainable systems that meet our present needs while enhancing the ability of future generations to meet their needs.

Our faculty provide leadership and expertise in several centers and organizations across the university, including:

- Water Resources Center
- Office of Sustainability
- Center for Agricultural and Rural Sustainability
- Watershed Research and Education Center
- Society of Women Engineers (SWE)
- Advancement of Women in Academic Science and Engineering Careers (ADVANCE)
- Water Quality Lab
- Resiliency Center
- Institute for Nanoscience and Engineering
- Poultry Center of Excellence
- Community Design Center
- Center for Advanced Spatial Technologies
- Interdisciplinary graduate programs in Cell and Molecular Biology, Microelectronics and Photonics, Public Policy and Environmental Dynamics

The Biological and Agricultural Engineering research program is engaged in designing a sustainable future through innovation in interdisciplinary research in water, food and energy systems.

- Water systems include: watershed ecosystem services, stream bank, lake, and reservoir restoration and management, ecological engineering design, water resources, water quality and non-point source pollution management, watershed modeling and monitoring, irrigation technologies, water management at watershed and ecosystems scales, metrics for sustainable water management, and low-impact development.
- Food Systems include: food safety, bio-sensing technology, food and bio-processing, bio-products utilization, microbial risk assessment, antimicrobial technologies, nano-biotechnology, bio/abio interfacing, phytochemical extraction, and bio-driven nanostructures.
- Energy systems include: biomass production and post-harvest engineering, energy use at farm level, bio-refineries, thermo-chemical conversion of biomass and by-products, extraction of co-products, pretreatment of feed stock, farm-scale thermochemical reactors, bio-conversion and bio-processing, bio-products, equipment, poultry/animal housing energy efficiency, and energy effectiveness analysis.

Research areas of the Biological and Agricultural Engineering Department

- **Agricultural and Food Engineering**: Faculty in this area are developing more efficient and sustainable ways to produce food for a growing population. They are investigating ways to improve practices in several agricultural industries, including on-farm grain drying for transportation costs reduction, on-farm utilization of agricultural residues for biofuel and bioenergy production, space-heating poultry houses using renewable fuels, aerial emissions and mitigation from poultry housing, indoor air quality and environmental control, risk assessment of microbial hazards in poultry and food processing, predictive models of pathogenic bacteria in food products, value-added products production from agricultural renewable resources for bio-energy and chemicals, production of algae as a biofuel feedstock, livestock and poultry manure management, and

- **Biotechnology Engineering**: Faculty in this area design systems utilizing engineering tools with life sciences. Examples of biotechnology engineering include biosensors and bioinstrumentation for foodborne pathogens, avian influenza in poultry and food safety. Bio-nanotechnology for DNA-computing, nano-building block toolboxes (nano-toolboxes) for multifunctional nanocomposites with "customizable" shapes and functions, nano-therapeutics and diagnostics (nanotheranostics) with nanoparticles and nanocomposites, multimodal, multiplex, multicolor bio-detection platform for agriculture, food safety and biosecurity, bio-driven nanostructure self-assembly, nanoscale bio/abio interfacing technology, and nucleic acid technology for molecular computation, genomics and proteomics.

- **Ecological Engineering and Water Resources**: Faculty in this area combine the science of ecology with the practice of engineering to solve complex ecosystem problems. These solutions include designing systems to restore lakes, disinfect water, remove nutrients and contaminants, repair eutrophic reservoirs, and monitor water quality. Studies are conducted on agricultural and urban Best Management Practices and efficiencies, water quality management and trends, stream restoration**,** eco-hydrology, ecological risk assessment, designing water risk protocols for governments and industries under climate change scenarios, non-point source pollution engineering, water quality impacts of row crop irrigated agriculture in Arkansas, irrigation scheduling, water resource development, irrigation system technology development and alternative irrigation systems, crop water use, chemigation, irrigation scheduling, pumping plant performance and irrigation energy use.

- **Sustainability and Green Engineering**: Sustainability concerns inform all the areas of biological and agricultural engineering. Researchers in this department are using lifecycle assessment of agricultural, urban and supply chain systems, designing sustainable global food supply systems, devising corporate strategies for risk reduction and management, and reducing environmental impacts. Impacts of climate change are being studied by evaluating evapotranspiration, surface water nutrient fluxes and source partitioning, land-atmosphere exchange of carbon-dioxide, methane and water vapor, and wetlands eco-hydrology in agricultural practices. Researchers are also collaborating with national and international organizations to develop industry standards and contribute to the global conversation about sustainability.

- **Biological and Agricultural Engineering extension programs** offer information and skill-development to assist Arkansans in maintaining and improving their access to sustainable food, water and energy systems. Our programs provide a biological and systems perspective to the state-wide extension team. Expertise exists in nutrient management, design and practices for animal manure management; farm safety, grain drying, storage and handling, web and mobile-device information delivery, modeling of watersheds, climate-change variables, and biomass resources; irrigation, water use efficiency, air-emission quantification for control and mitigation of air-pollution, poultry-house indoor air-quality; poultry farm energy efficiency, thermal energy-conversion, and residential energy conservation and efficiency.

Arkansas Water Resources Center and Biological and Agricultural Engineering Department

University of Arkansas system Division of Agriculture

Brian Haggard, Professor

ISSUE:

The observation of harmful algal blooms (commonly known as HABs) in freshwaters are increasing globally, and we are finding these in Arkansas's streams, rivers, and lakes. The culprit is cyanobacteria, and select cyanobacteria can produce toxins – the most widely observed toxins are microcystins, which are present in freshwaters in various forms and magnitudes. The challenge is understanding the drivers of why toxins are produced in these cyanobacterial HABs under a variable and changing climate. However, we still need to help local and state and agencies identify management strategies to protect public and animal health from cyanobacterial HABs and toxins.

ACTION:

The Arkansas Water Resources Center (AWRC) has used its 104B programmatic funding to address cyanobacterial HABs including environmental drivers in toxin production, thresholds to inform management and public health, and options to treat or reduce these blooms and toxins. The AWRC funded various projects, including:

Weekly monitoring of Lakes Fayetteville's cyanobacterial blooms to identify drivers in toxin production by caynobacteria;

Nutrient bioassays to understand triggers in microcystin concentration and production increases in cyanobacteria;

Effects of rice and barley straw on cyanobacterial growth and toxins; and

Effect of photcatalytic particles on cyanobacterial HABs.

These projects are independent, but when combined together and with other HABs research funded by other water centers are helping to build our body of knowledge on cyanobacterial HABs and toxins. electricity generation potential of a PV system, but also financing terms and how fast tax benefits can be recouped.

FINDINGS:

Independently, these projects are producing some interesting results.

The data from Lake Fayetteville are providing a decision framework to inform recreational lake managers on the risk of elevated toxins to recreational users; we are finding that water temperature (25°or greater), phycocyanin which is a photosynthetic pigment in only cyanobacteria (4000 raw fluorescence units (RFUs) or greater), and ratio of phycocyanin to chlorophyll pigments which are in all algae are important factors (RFU ratios between 0.5 and 1.5).

The bioassays showed that dissolved nutrients vary seasonally, but the addition of nitrate stimulates cyanobacterial growth and toxins concentrations during the growing season; however, toxin production was only stimulated at two distinct points.

Rice straw might be a valuable and effective options to manage cyanobacterial blooms in farm and livestock ponds; we should continue to study the role of phenolic compounds released during straw degradation on cyanobacterial growth and toxins.

Nanoparticles dispersed in water and spray coated on nylon mesh were effective at removing microcystin from water, especially with the help of ultraviolet radiation; this study suggests this might be a feasible option to in situ treat cyanobacterial HABs.

Combined, we are starting to understand drivers in cyanobacterial HABs and toxin productions, as well as mitigation options for these blooms in streams, rivers and lakes.

Arkansas Water Resources Center and Biological and Agricultural Engineering Department

University of Arkansas system Division of Agriculture

Brian Haggard, Professor

AWRC Newsletter Short Story Submitted to National Institutes for Water Resources

Original Version 250 Words

Hemingway Editor Grade 15 Complexity

Harmful algal blooms in freshwater lakes caused by cyanobacteria are a critical issue across our Nation.

Let us affectionately call these "cyanoHABs", so that we are specific to cyanobacterial blooms that produce toxins in freshwaters.

The Arkansas Water Resources Center has been sampling a lake that has cyanoHABs every year; data is from 2019 to present at this recreational lake.

The weekly lake samples have been coupled with various experiments to understand when these cyanoHABs produce toxins and how might we use this information to help inform people of the risk of recreating during cyanoHABs and the occurrence of toxins.

We measure water temperature, nutrients, pH, conductivity, dissolved oxygen, chlorophyll-a pigment, raw fluorescence of chlorophyll and phycocyanin, and cyanobacterial types.

Phycocyanin is a pigment used in photosynthesis by cyanobacteria; it is only in cyanobacteria, while chlorophyll is an all algae..

The challenge has been the story of what triggers cyanoHABs to produce toxins is different, but there are some consistent patterns emerging – these would be water temperature, nutrient supply (particularly dissolved nitrogen), and types of cyanobacteria.

These data are providing a framework to inform lake users about the risk that toxins might be present in the cyanoHABs.

The risk of toxins increases in this lake when water temperature exceeds 25°C, phycocyanin raw fluorescence is greater than 4000, and the ratio between cyanobacterial phycocyanin and chlorophyll raw fluorescence is between 0.5 and 1.5; this means warm water with mostly cyanobacteria.

When the lake waters show this pattern, we could turn the wheel up to elevated risk.

The 104B Program funding has been critical to maintaining this research.

Arkansas Water Resources Center and Biological and Agricultural Engineering Department

University of Arkansas system Division of Agriculture Brian Haggard, Professor

Edited Version 205 Words
Hemingway Editor Grade 8/9 Complexity

The Arkansas Water Resources Center funds research to solve the HABs puzzle.
Harmful algal blooms are a critical issue for water resources across our Nation.
Cyanobacteria often dominate these blooms and can produce toxins, like microcystin.
The Arkansas Water Resources Center funded several projects and supported many students to address this critical water issue.
First, the center has been sampling a local lake weekly since 2019. This recreational lake has HABs every year. We want to understand when and why toxins are produced there.
We find that the triggers for toxin production by HABs are different each year. This will present a challenge for managing HABS at Lake Fayetteville, and beyond.
Yet, some consistent patterns are emerging. These patterns may provide a framework to inform lake users about HABs and toxins in the lake. Imagine having a simple system to communicate risk, like fire danger in our national lands.
Other projects are looking at cyanobacteria DNA, the genetic signatures in lakes. We want to connect the genes that trigger toxin production with toxin detection.
Another project is looking at innovative ways to kill cyanobacteria and remove toxins. This research has proven that nano tubes can be designed to remove cyanobacteria and their toxins. Imagine the possibility large fishing nets that function to catch fish while also killing HABs.
The 104B Program funding has been critical to maintaining this research.

Edited Version 150 Words
Hemingway Editor Grade 10 Complexity

The Arkansas Water Resources Center funds research on HABs, a critical water issues across our Nation.
Cyanobacteria dominate these blooms and can produce toxins, like microcystin. We want to understand when and why toxins are produced. We find that the triggers for toxin production by HABs are different each year, a big challenge for managing HABS.
Yet, some consistent patterns are emerging. These patterns may provide a framework to inform lake users about HABs and toxins in the lake.
Center research projects are looking at cyanobacteria DNA, the genetic signatures in lakes. We want to understand the connection between these genes and factors triggering toxin production.
Projects are also looking at innovative ways to kill cyanobacteria and remove toxins. This research has proven that nano tubes can be designed to remove cyanobacteria and their toxins.
The 104B Program funding has been critical to maintaining this research.

Arkansas Irrigation Yield Contest: A Novel Extension Approach to Promoting Irrigation Conservation

Chris Henry, Professor

Issue: Regional water management programs have identified a number of technologies and management practices that have the potential to reduce the overdraft on the Mississippi Valley Alluvial and Sparta Aquifers, thereby ensuring that soybean producers can achieve sustainable groundwater yields while maintaining overall profitability. In Arkansas groundwater withdraws from the alluvial aquifers are only about 42 percent sustainable and 54.6 percent sustainable from the Sparta/Memphis aquifer. Without sustainable irrigation practices, yields could be 30- 50% less in the future if water becomes limited in the region. Aquifer overdrafts in this region pose a real concern about the future of row crop production in the region. For example, in Arkansas 3.8 Million acres are expected to have limited or no water resources by 2050 according to a recent study, which is about the annual soybean acres currently grown in Arkansas.

Action: A program was initialed in to promote IWM through an irrigation yield contest. Participants acquire a portable flow meter, where the installation is verified and sealed to prevent tampering. Rain was predicted for each site using a computer-based tracking system. Yield was measured on 3 acres for a minimum sized 30 acre field. Participant made their own irrigation decisions. County Agents served as advisors for irrigation management and judges for the yield measurement. Some contestants used the tools they learned about in Irrigation Schools to improve their irrigation management. Contests were established for three commodities, corn, soybeans, and rice. Rice is divided into separate divisions for furrow irrigated and levee cultural practices. Financial support was provided by commodity boards and industry. All corn and soybean fields were furrow irrigated.

Research was conducted between 2012 and 2021 to develop a new production system for furrow irrigated rice that improved irrigation efficiency. The system was patented in 2019 and on-farm tests have been installed and conducted on 5 Arkansas farms. One farm used the system in 2022 and used it in the irrigation contest.

Results: There were 15 soybean, 6 corn, 7 levee rice and 7 row rice entries from south to northeast Arkansas.

In the soybean category, 4 contestants achieved over3bushels per inch, in 2019 there were 3, and in 2018 there were none. Participants are improving their WUE as a result of the contest program. In corn and soybeans especially there is a clear and defined trend of increasing WUE over time. In rice it is mixed, but few are using IWM practices in furrow irrigated rice.

Participants are increasing their adoption of IWM practices, in 2018 only 50% of the participants used soil moisture sensors, in 2022 81% used them. Computerized hole selection adoption has increased from 43% to 79%.

Impact: This program is providing key data on water use, yields, and water use efficiency. The participants are demonstrating extremely high yields, low water use and high water use efficacies. Most importantly the contest demonstrates the full effect and results that can be achieved when irrigators apply highly managed crop production and irrigation management practices. The program is demonstrating how a comprehensive approach to IWM can achieve sustainability.

In summary the yields, water use efficiency and extremely low irrigation depths participants were able to achieve are nothing but short of amazing. The program has also demonstrated how research developments can be transferred to clientele to achieve the desired outcome and create awareness. Irrigation application rates were nearly half or more than half of the long term average water demand assumed and reported. This program demonstrates that through management and the use of off the shelf irrigation and new technology, large gains are possible to attaining a sustainable yield from the aquifer.

Contacts: Chris Henry, University of Arkansas (cghenry@uark.edu) 870-673-2661

Funding Sources: Arkansas Soybean Promotion Board, Arkansas Corn and Grain Sorghum Promotion Board, Ricetec, Irrometer, Delta Plastics, Trellis, McCrometer, USDA NRCS, Seametrics, Trellis, and Agsense.

Nanotoolbox Technology for Programmable Self-Assembly of Multifunctional Hierarchical Structures for Biomimetic Advanced Materials and Devices

Jin-Woo Kim, Professor

ISSUE:
Engineering multiple nanoscale materials into single multifunctional structure with predefined biophysicochemical characteristics has much promise for advanced materials and devices. Geometric factors, such as shape, size, and material compositions, influence the biophysicochemical properties of materials. Hence, the assembly of various nanoparticles (NPs) of different sizes, shapes, and compositions into desired patterns and geometries could realize programmable platforms for a variety of applications, ranging from optoelectronics and nanophotonics to biosensing, biosecurity, and nanomedicine. As a result, there has been considerable interest in the assembly of multifunctional structures with defined shapes, sizes, and functions that incorporate diverse NPs. Particularly, self-assembly has emerged as a powerful and practical strategy for controlled synthesis of such hierarchical structures. However, the accurate, scalable, and high-rate assembly of various nanocomponents into multifunctional architecture with specifically designed shapes and sizes remains difficult to attain.

ACTION:
To meet the challenge, Dr. Kim's group focuses on a transformative research to develop a nano-building block toolbox ("nanotoolbox") for the programmable self-assembly of advanced biomimetic materials with arbitrary shapes and arbitrary functions. This is accomplished with our novel nano-building block ("nBlock") technology and its further generalization that enable controls over the number, placement, and orientation of bio-functional ligands, including DNA, RNA, and peptide, on various NPs, including metallic NPs, quantum dots, bio-based NPs (e.g., cellulose nanocrystals), etc. Since the nBlock technology could incorporate NPs of different composition, generating toolboxes of various NPs with bio-ligands at defined locations and in defined 3D orientations on a NP, it promises not only complicated shapes, but also the ability to tune the function of the assembly. When DNA is used, such well-defined and controlled functionality and directionality of various NP building blocks promise precisely controlled self-organization of structures with greater complexity for "customized" size, shape, and functionality for specific applications.

IMPACT:
The ultimate significance of the nanotoolbox technology is that it addresses the urgent need in the field of nanotechnology for functional, reliable and scalable techniques for "programmable and customizable" integrations of highly functional bio-hybrid systems, on the basis of target applications, in desired patterns and geometries at all scales and in all dimensions, beyond the inherent limitations of existing technologies, further driving innovations in novel hybrid fused technologies. The nanotoolbox technology holds high promise to transform many fields of research, ranging from optoelectronics, nanophotonics, and nanomedicine to agriculture, food safety, and biosecurity, contributing to the enhancement of economic well-being and quality of life not only in the State of Arkansas but also in the world, and making significant contributions toward the land grant mission.

CONTACT: Jin-Woo Kim, Biological and Agricultural Engineering, jwkim@uark.edu.

COLLABORATORS:
Steve Tung, UA Mechanical Engineering Dept., Joshua Sakon, UA Chemistry and Biochemistry Dept., Vladimir Zharov, UA for Medical Sciences, Russell Deaton, University of Memphis, and Haewook Han, Pohang University of Science and Technology, Korea.

FUNDING:
National Science Foundation (NSF; award#: ECCS-1810014), National Institute of Health (NIH; award#: 1R21HG010055) and Arkansas Biosciences Institute (ABI)

Portable Biosensors for In-field Detection of Pathogenic Bacteria in Food Production, Processing and Supply Chain Yanbin Li, Distinguished Professor

Issue:

Contaminated food, mainly by pathogenic microorganisms, is estimated to cause 76 million illnesses, 325,000 serious illnesses resulting in hospitalization, and 5,000 deaths in the US each year. USDA/ERS estimates the medical costs and productivity losses associated with E. coli O157, Salmonella, Listeria monocytogenes and Campylobacter alone amount to at least $6.9 billion annually. Current methods for the detection of foodborne pathogens rely upon culture plating, PCR and ELISA. However, these methods are time consuming, expensive, and require trained operators with laboratory facilities. Therefore, rapid methods are needed to detect foodborne pathogens in-field or on-site in agricultural and food supply systems.

Action

The objective of this project is to develop portable, automated, nanomaterials-based biosensors for rapid detection of foodborne bacterial pathogens in poultry. The biosensor system consists of a magnetic bioseparator for separation of target bacteria from a poultry sample, a 3D-printed detection chamber for holding and mixing a sample, and a fluorescent detector for measuring the signal generated by the presence of target bacteria. Magnetic nanobeads are immobilized with specific antibodies or aptamers to capture target bacterial cells and then separate the cells from a food sample. Quantum dots are coated with specific antibodies or aptamers to attach to the bacterial cells captured on the magnetic nanobeads. After the nanobead-cell-quantum dot complexes are isolated, the intensity of fluorescence emitted by the excited quantum dots is proportional to the concentration of target bacteria. The portable, automatic biosensor system has been designed, fabricated, and evaluated for screening of Salmonella in samples from poultry on farm, processed chicken carcasses in plants and poultry products in market. The biosensor can provide the necessary specificity (strain level), sensitivity (10-100 cfu/ml or cfu/g) and time (less than 1 h). The testing data can then be directly transmitted to the network or a cloud platform through a smart phone without delay. The biosensor can be modified to detect different foodborne pathogens in different food products.

Impact:

The food industry and federal regulatory agencies could adopt this novel biosensing method in food inspection and quality control to ensure food safety. Society could benefit from this technology in terms of reducing foodborne diseases and related medical costs. Applications of the portable biosensors would also enable the food industry to benefit economically in terms of prevention of product recalls due to microbial contamination of food products.

Contact:

Yanbin Li, Distinguished Professor, Department of Biological & Agricultural Engineering, Center of Excellence for Poultry Science, yanbinli@uark.edu / 479-575-2881

Cooperators:

Steve Tung (Mechanical Engineering Dept.), John Marcy (Poultry Science Dept.), Jingyi Chen (Chemistry and Biochemistry Dept.)

Funding:

Walmart Foundation, ABI, USDA-NIFA

Are Solar Panels Right for your Farms

Yi Liang, Associate Professor

What was addressed?

Commercial poultry production requires a large amount of fossil fuel energy for space heating when brooding young chickens and power ventilation fans for cooling during hot summer. The escalated energy prices in recent years not only hurt the economic livelihood of the producers, but also contribute to carbon emissions and climate change. Solar photovoltaic technology has become attractive in recent years in areas with good solar radiation, high electricity tariffs and net-metering policies. The objective of this program is to investigate the economic feasibility of adopting solar photovoltaic (PV) technology on broiler farms and increase educational effort to raise awareness and allow producers to make informed decision.

What was accomplished?

In response to increasing energy expenses, the declining solar project cost and favorable net metering policy in the state of Arkansas, I developed web contents on solar photovoltaic technology. The web contents include photovoltaic system cost trend, the significance of state renewable energy net metering policy, tax and non-tax incentives, the importance of individual utility analysis to determine the value of an on-site electricity production, and a simple Excel financial calculator. By providing several input variables, any interested farmer can generate cash flow of a potential solar project and compare different scenarios presented by solar developers, hence make informed decision. I facilitated press stories with the UADA communication team and Arkansas Democrat Gazette, etc., featuring benefits of solar projects on AR poultry farms. By collaborating with UADA communication team we produced a video showcasing two poultry growers adopting solar PV technology on their farms (https://www.youtube.com/watch?v=Uomvm2q4hAk). We organized a Solar-for-Poultry workshop in July 2022 attracting more than 30 participants, debuting a comprehensive solar decision tool developed by colleague, Dr. M. Popp, that includes not only electricity generation potential of a PV system, but also financing terms and how fast tax benefits can be recouped.

Anticipated Impact

Increasing awareness of renewable energy implementation in poultry production is critical in promoting adoption by producers. The application of photovoltaic systems on poultry farms will improve sustainability by lowering energy cost in the long-run and reducing greenhouse gas emissions.

Assisting Arkansas Agricultural and Environmental Sustainability Efforts via Development and Maintenance of a P Index Calculator and Nutrient Management Planning Tool

Karl VanDevender, Professor

Issue:

The production of animal derived food and products generates manure byproducts. The management of these byproducts has potentially significant impacts on food production, societal economic wellbeing, human and animal health, as well as environmental quality. Concerns regarding these potential impacts on farmers, neighbors, and consumers has resulted in numerous regulations and policies that livestock producers and those that manage manure byproducts must adhere too. Central to most of these is the development of farm specific Nutrient Management Plans based on farm conditions, phosphorus and nitrogen runoff risk, and crop agronomic requirements.

Action:

In keeping with the land grant mission of dispersal of research-based information and service, a Microsoft Excel workbook based nutrient management planning tool (ARNMP) has been developed and refined over a number years. In the past the tool has been provided to nutrient management planners to facilitate and expedite their plan writing process. Over time, both the Arkansas Department of Environmental Quality, the Arkansas Natural Resources Commission, and the Natural Resources Conservation Services have come to expect plans be written using ARNMP. In the past ARNMP has been distributed via email. Several years ago a version was posted to www.uaex.uada.edu/manure . This posting has been advertised via email to key personnel within the agencies listed above with a request to forward to their appropriate internal and external personnel. In addition, the required online Nutrient Planner Certification course provides training on the tool and directs students to the web site for current versions.

Impact:

The results of this long term and continuing efforts is a nutrient management tool that is focused at Arkansas landowner and nutrient planner needs. The tool is provided at no charge to potential users. This provides Arkansas's limited number of certified planners a tool targeted at the writing of nutrient management plans that meet certification requirements. In addition, the tool coupled with Extension's planner certification training helps to ensure that written plans are structurally uniform which facilitates agency review. Both of which helps to reduce the development/approval time of a plan as well as increase the number of plans that can be written/ revised. A benefit to Arkansas' landowners and their downstream neighbors.

Contact:

Karl VanDevender, kvandevender@uada.edu, UA Division of Agriculture, 501-671-2244

Collaborating Scientists: Includes Various University of Arkansas Division of Agriculture Departments, The Arkansas Natural Resources Conservation Commission, The National Resource Conservation Service, The Arkansas Department of Environmental Quality, and Various organizations representing livestock producers.

Funding Sources:

Various general base state and federal funds.

A wavelet-based toolkit to estimate methane ebullition in natural and managed landscapes

Benjamin Runkle Associate Professor

Issue: Improved monitoring of methane (CH4) dynamics and transport mechanisms is needed for correct parameterization of climate change models. From wetland and lake ecosystems, three predominant transport pathways exist: plant-mediated transport through aerenchyma tissue, diffusion from the water or soil column, and ebullition of gas bubbles through the soil-water matrix. The fractional contribution of methane emission pathways determines how much soil microbial methane is oxidized into CO2 before being finally emitted into the atmosphere. Thus better skills in modeling emission pathways can reduce the predictive uncertainty of CH4 emission under warming, given each pathway respond dramatically different to a warmer climate (Ma et al., 2017). Ebullition is particularly challenging to measure and predict due to its spatiotemporal variability, mix of driving mechanisms, and sensitivity to climate change. Fortunately, a new measurement-based method was developed (Iwata et al., 2018) to detect ebullition as deviations in the wavelet domain similarity of concurrently measured times series of CH4, CO2 and/or H2O concentrations. That this method performs at the ecosystem-relevant scale of an eddy covariance tower (10-1000 m) is critical to enable quasi-continuous detection of ebullitive events over a variety of spatial scales.

Action: In work led by current Ph.D. student, and former BENG BS graduate and research analyst Will Richardson, our research group recently enabled transferability of the Iwata et al. method to different measurement sites by normalizing the empirical ebullition-threshold parameter to site- and flux-specific conditions (Richardson et al., 2022). This research also included collaborative support from USDA-ARS scientist Michele Reba. Our method interrogated the Iwata et al. approach more deeply to confirm and/or improve its accuracy in a rice paddy ecosystem. Upon achieving this initial objective our aims were to conduct a sensitivity analysis on the method's empirical parameters as well as to assess the relative importance of ebullition across the growing season and identify its primary environmental drivers. During preliminary analysis, we found that the ebullitive fluxes based on the published method often disagreed with the magnitude of ebullition that would be expected based on scalar similarity observed in the high frequency data. To improve the method's ability to reliably detect ebullition, we made several modifications, of which the most important was to account for the standard deviation of methane concentration observations when identifying the breakdowns in scalar similarity that are indicative of ebullition.

Our modified method produced lower ebullitive fluxes with smaller variance and a unique diel cycle as compared to the original method. Ebullitive fluxes accounted for an average of 10% of total methane fluxes, with the relative contribution of ebullition being higher in later crop growth stages. Statistical modeling showed that wind speed, ecosystem respiration, and sensible heat flux were the most informative predictor variables for ebullitive fluxes. These findings are significant because they substantially improve the robustness of the partitioning method, enabling its application to data collected at a broader range of long-term eddy covariance sites. These advancements have strong potential to improve the accuracy of global methane budgets and the representation of methane emission processes in land surface models. The code is also published open-source, enabling its uptake and use in the research community.

Collaborators:
Michele Reba, Hydrologist, USDA-ARS, Delta Water Man. Res., Jonesboro, AR
Shuang Ma, postdoctoral scientist, Jet Propulsion Laboratory
Anthony Bloom, scientist, Jet Propulsion Laboratory; University of California, Los Angeles

Funding and follow-up opportunities:
We are using the initial results developed in Richardson et al. (2022) as evidence to drive a new proposal to the Department of Energy, Environmental System Science. Titled "A data-driven wavelet-based approach to estimate global methane ebullition from wetlands and lakes", this proposal will be submitted in February, 2023, and has already passed a pre-application phase in late 2022. This proposed study will use the new approach to create a synthesis estimate of the ebullition fraction of methane emissions globally, by validating it at sites with concurrent ebullition data and eddy covariance measurements, and to apply it widely, across a range of sites where methane measurements are

A wavelet-based toolkit to estimate methane ebullition in natural and managed landscapes

Benjamin Runkle Associate Professor

The existing study was funded by the U.S. National Science Foundation CBET division CAREER Award 1752083 and NASA award 80NSSC20K0923 to support Atmospheric Carbon and Transport (ACT)—America, a NASA Earth Venture Suborbital 2 project funded by the NASA Earth Science Division.

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Development of Intelligent Monitoring and Autonomous Solutions for Food Manufacturing Challenges

Dongyi Wang, Assistant Professor

Current Project 1: Illumination robust computer vision algorithm developments for ag/food product monitoring.

Problems:

In the recent decade, significant advances of deep learning and artificial intelligence have pushed the agricultural and food research onto a new track. The global market value of precision agriculture area is expected to increase from $6 billion in 2020 to $23 billion in 2030. Specifically, imaging-based solutions have attracted great attention in precision agriculture and food manufacturing applications. However, current computer vision algorithms rely on reliable environmental illumination or illumination system. Various illumination conditions will not only affect human perception but also the performance of artificial intelligence algorithms and machine vision systems. Therefore, there's a need to evaluate how the illumination variations affect computer vision algorithms and develop illumination robust algorithms for ag/food product monitoring.

Methods:

We will use consumer acceptability prediction from food appearances as an example to investigate how illumination will affect the image understanding models and develop a new illumination-robust model to predict consumer acceptability reliably.

Impacts:

The research will broadly benefit precision agriculture and smart food engineering applications, which can make computer vision and artificial intelligence algorithms more widely used in real-world conditions. Meanwhile, it will help consumers to understand how illumination conditions will affect their perceptions on food products which can minimize potential impulsive purchasing of consumers.

Collaborators:

Han-Seok Seo (FDSC), Shengfan Zhang (INEG)

Funding:

NSF RII Track 1: Data Analytics that are Robust and Trusted (DART) seed grant

Development of Intelligent Monitoring and Autonomous Solutions for Food Manufacturing Challenges

Dongyi Wang, Assistant Professor

Current Project #2: *Develop hyperspectral imaging-based food and agricultural product quality evaluation:*

Problems: Evaluating the food chemo-physical properties of bioproducts in both production field and processing plant conditions is a critical job, whose output can be used for farming management to achieve sustainable farming and optimized the crop properties, and for food and bioproduct grading to ensure product quality. However, current evaluation procedure is a time-consuming, which needs to sample individual product and to test the product through cumbersome laboratory tests. In my lab, two applications are focused on. The first application is for detecting woody breast chicken fillet, and woody breast is a breast muscle myopathy which leads to large quantities of wasted poultry estimated to cost $200 million dollars annually in the U.S. alone due to decreased yield. The second application is to evaluate the sugar and pH value of grapes in the harvest stages. Grapevines are one of the most important and longest horticulture crops to be cultivated. The United States is one of the biggest producers of grapes and wine. Arkansas, is not the largest wine region in the USA, has long history of planting grape and wine industry. For the wine industry, the monitoring attributes, such as Soluble Solids content (SSC) and pH, of the ripening process are crucial considerations to determine the grape harvesting timeline.

Methods: Hyperspectral imaging is a non-invasive sensing technique which integrates the advantages of NIR system and regular color camera to simultaneously capture both spatial (physical) and spectral (chemical) information of the target. Machine learning algorithms are built to process the spectral data for woody breast classification in the first application and grape chemical properties regression in the second application.

Impacts: The research will broadly benefit precision agriculture and smart food engineering applications. The hyperspectral imaging techniques can extend computer vision system from intuitionistic physical property evaluation
to indirect chemical property evaluation for high-throughput online applications. Artificial intelligence algorithms can also be integrated to improve the spectral signal analysis performance for expanding the hyperspectral imaging application scopes.

Collaborators: Renee Threfall (FDSC), Casey Owens (POSC)

Funding: Southern Region Small Fruit Consortium

Development of Intelligent Monitoring and Autonomous Solutions for Food Manufacturing Challenges

Dongyi Wang, Assistant Professor

Current Project #3: *Development of digitalized broiler fleshing scores measurement instrument for precision farm management*

Problems:
Precision poultry farming is regarded as an advanced technology to monitor livestock, their products, and the farming environment, for aiding farmers to optimize farm management practice. Fleshing score measurement is an important procedure to monitor birds' body conformation uniformity. The fleshing information can be used for improving feeding strategies and ensuring meat or egg production efficiency. Current fleshing score determination procedure relies on specialists' subjective judgements, which can hardly ensure the grading consistency across the flocks and across the poultry houses. Meanwhile, compared to the digital data, human grading data is difficult to be recorded, organized, transferred, visualized, and analyzed.

Methods:
The project is to design a digitalized fleshing score measurement instrument, whose outputs are correlated with human graded fleshing scores, and the outputted data can be saved locally or uploaded to the clouds on site. Farmers can retrieve the historical fleshing score data, and utilize the fleshing data along with other information to adjust and optimize the management strategies for sustainable and cost -efficient poultry management.
Impacts: The team collaborates with Tyson in this project, which can accelerate the digitalization procedures of poultry management, and benefit for sustainable and cost-efficient poultry management. The outcomes from this study are expected to help the development of local stakeholders and local economy.

Collaborators: Casey Owens (POSC)

Funding: UADA Research Incentive Grant

Poultry production wastes treatment for Arkansas producers

Jun Zhu, Professor

ISSUES:

The fast growth of the poultry industry in the northwest region of Arkansas results in a significant increase in litter production, and the concentrated production of a large volume of poultry litter in the region causes local disposal problems because poultry litter contains a large quantity of nutrients including N and P from the chicken feces and the bedding material used during the poultry production cycle such as straw, sawdust, wood shavings, shredded paper, and peanut or rice hulls. After each production cycle, the litter containing both manure and beddings is removed from the poultry house for disposal, normally through land application, which is traditional practice and becomes increasingly problematic due to overloading the soils with rich plant nutrients such as nitrogen (N), phosphorous (P), and potassium (K). When the litter is applied on farmland at the agronomic rate for N, excessive amounts of plant extractable P in the soil can become a great concern due to the high concentration of P relative to N in the litter, especially in the two counties (Benton and Washington) in northwest Arkansas where over half of all broilers in the State are raised. Over-application of poultry litter to farmland can increase the potential of leaching nutrients to groundwater because the excessive nutrients in poultry litter exceeds the land capacity to take it. Therefore, continuing land application of poultry litter will threaten the natural water resources in the region and beyond. While transporting the litter out of the region is not a viable option due to prohibitive costs, developing new and cost-effective technologies to treat litter on farm is the only option, which constitutes the basis on which our research program is developed. Conducting cutting-edge research and addressing the poultry litter treatment issues to support the growth of the poultry industry in Arkansas in a sustainable manner obviously becomes an urgent task.

Over the years, techniques to treat poultry litter have been researched extensively including composting, direct combustion, pelletization, and anaerobic digestion; however, none of these technologies are found to be economically and/or environmentally friendly applicable in the real world. It has been reported that combustion, pelletization, and composting can cause air pollution and are not cost effective. Anaerobic digestion is mostly appropriate for liquid waste while poultry litter has very low moisture content. In order to harness the benefits associated with anaerobic digestion, we have developed a system consisting of anaerobic digestion, struvite production, and water reclamation to treat poultry litter. The reclaimed water can be used to dilute the incoming poultry litter for digestion, thus reducing usage of fresh water. With the funding from the Division and the USDA/NIFA/AFRI Foundational and Applied Science Program, the multi-state project is moving forward with promising results, and we hope that by the end of the project, the proposed system can be developed into a cost-effective technology for individual poultry producers to operate on farm to solve the excessive poultry litter issue.

ACTION:

The experiments of co-digestion of poultry litter with wheat straw is nearing completion. The startup of the anaerobic co-digestion (ACoD) process of poultry litter (PL) and wheat straw (WS) in the anaerobic sequencing batch reactor (ASBR) was conducted by gradually increasing the organic loading rate (g VS/L/d), where VS was the volatile solids content in the substrate. The results showed that the gradually increased organics were efficiently consumed by the ACoD process during startup. At the steady state, the ACoD process had a daily biogas production (DBP) of 13.06 ± 0.21 L with a methane content of 54.38 ± 0.53 % (daily methane production (DMP), 116.80 ± 1.30 mL CH4/g VS added), with a COD removal rate of 84.7 %. The highest average DMP was 161.79 ± 12.20 mL CH4/g VS added. The ACoD process has also achieved reductions of COD, TN, NH4-N, TS, and TVS by 81%, 55%, 64%, 87%, and 91%, respectively. The final stage of the project is to integrate all three components of the treatment system, i.e., anaerobic digester, electrolytic reactor with a magnesium plate, and a forward osmosis membrane reactor, to treat poultry litter in a continuous manner, which will be completed in late 2022 or early 2023.

Poultry production wastes treatment for Arkansas producers

Jun Zhu, Professor

IMPACT:

Since Arkansas is the top state in the nation that produces broilers, the impact of this research on the poultry industry in the state is immense. At the moment, the broader impact from the project rests with its providing ongoing information on the new treatment technology under development that can alleviate the concerns of the public about the environmental pollution problems associated with poultry production. In the past, the Arkansans were really plagued by the broiler production waste due to the lack of cost-effective techniques to handle a major waste stream generated from producing animal protein operations. With the progress made by this project, such concern could be palliated to some extent because the environment can possibly be protected when the anaerobic digestion system is fully developed, tested, and deployed by the poultry industry.

PUBLICATIONS:

Journal publications:

Ndeddy Aka Robinson Jr., Sarah (Xiao) Wu, Jun Zhu, Yuanhang Zhan. 2022. Optimization of a dual-chamber electrolytic reactor with a magnesium anode and characterization of struvite produced from synthetic wastewater. Environmental Technology DOI: 10.1080/09593330.2022.2077131.

Zhan, Y., X. Cao, Y. Xiao, X. Wei, S. Wu, J. Zhu. 2022. Start-up of co-digestion of poultry litter and wheat straw in anaerobic sequencing batch reactor by gradually increasing organic loading rate: methane production and microbial community analysis. Bioresource Technology 354:127232.

Zhan, Yuanhang, Yiting Xiao, Leland C. Schrader, and Jun Zhu. 2022. A float meter-based system for self-regulated discharging and feeding in a laboratory semi-CSTR for anaerobic digestion of chicken litter. J. ASABE 65 (3): 481-490. https://doi.org/10.13031/ja.14804.

Conference papers/presentations:

Yuanhang Zhan, Yiting Xiao, Leland C. Schrader, Ndeddy Aka Robinson Jr, Sarah Wu, Jun Zhu. 2022. Considering micro-aeration strategy for enhancing methane production in anaerobic digestion of agricultural wastes. ASABE 115th Annual International Meeting. Paper#: 2200429. Houston, TX. July 17-20.

Yiting Xiao, J. Zhu, Yuanhang Zhan. 2022. Optimization of decolorization and COD removal rate in anaerobic digester effluents through photocatalytic titania nanofiber. ASABE 115th Annual International Meeting. Paper#: 2200334. Houston, TX. July 17-20, 2022.

Research Grants

The following active grants during 2022 fund research in specific areas.

Matlock, Marty D. (Professor)

Funded
Evans White, Michelle Allayne (Primary Investigator), Naithani, Kusum (Co-Investigator), Matlock, Marty D (Co-Investigator), "REU SITE: Assessment and sustainable management of ecosystem at the nexus of food, energy, and water systems," Sponsored by National Science Foundation, Federal, $0.00. (March 1, 2021 - February 29, 2024).

Funded
Messadi, Mohammed T (Primary Investigator), Matlock, Marty D (Co-Investigator), "Environmental Life Cycle Assessment and Economic Life Cycle Cost Analysis of CLT-Built Adohi Hall at the University of Arkansas Campus-Fayetteville," Sponsored by U. S. Department of Agriculture - Forest Products Laboratory, Federal, $0.00. (July 1, 2020 - August 15, 2023).

Funded
Matlock, Marty D (Primary Investigator), "Climate impact implications of crop protection chemicals," Sponsored by CropLife America, Private Non-Profit, $171,607.08. (July 13, 2021 - May 31, 2023).

Funded
Matlock, Marty D (Primary Investigator), Evans White, Michelle Allayne (Co-Investigator), "NSF INCLUDES Planning Grant: Transcending Barriers for Success," Sponsored by National Science Foundation, Federal, $25,000.00. (January 1, 2021 - April 30, 2023).

Funded
Thoma, Gregory J (Primary Investigator), Matlock, Marty D (Co-Investigator), "Publishing Life Cycle Inventory Data using NAL Life Cycle Assessment Collaboration Server," Sponsored by U.S. Department of Agriculture, Federal, $0.00. (September 21, 2017 - September 20, 2022).

Funded
Thoma, Gregory J (Primary Investigator), Matlock, Marty D (Co-Investigator), "Climate Adaptation and Mitigation in Fruit and Vegetable Supply Chains," Sponsored by U.S. Department of Agriculture, Federal, $0.00. (July 1, 2017 - June 30, 2022).

Osborn, G S. (Associate Professor)

Funded
Osborn, G Scott (Co-Investigator), "Enhancing Teaching and Learning in Ecological Engineering," Sponsored by USDA NIFA Capacity Building, Federal, $149,919.00. (August 1, 2020 - July 31, 2023).

Funded
Osborn, G Scott (Primary Investigator), "Commercializing the Carbo Rock-It," Sponsored by Chancellor's Innovation Fund - Commercialization, Other, $49,830.00. (October 1, 2021 - March 31, 2023).

Funded
Osborn, G Scott, "Commercializing the Carbo Rock-It:A beverage carbonator for the craft brewing market," Sponsored by UA Chancellors Fund Commercialization Grant, College/School, $49,830.00. (November 9, 2021 - March 8, 2023).

Runkle, Benjamin R. (Associate Professor)

Runkle, Benjamin R (Primary Investigator), "Multi-Source Imaging of Long-Term Irrigation Status and Type Changes in the Mississippi Alluvial Valley," Sponsored by NASA - Washington, Institution of Higher Education, $54,981.00. (2022 - 2025).

Funded
Runkle, Benjamin R (Primary Investigator), "Multi-Source Imaging of Long-Term Irrigation Status and Type Changes in the Mississippi Alluvial Valley," Sponsored by NASA - Washington, Federal, $19,923.00. (July 1, 2022 - June 30, 2025).

Funded
Runkle, Benjamin R, "Multi-Source Imaging of Long-Term Irrigation Status and Type Changes in the Mississippi Alluvial Valley," Sponsored by NASA / University of North Texas, Federal, $54,981.00. (January 2022 - December 2024).

Funded
Runkle, Benjamin R (Primary Investigator), "National rice irrigation system type mapping using multi-source land imaging strategies," Sponsored by U.S. Geological Survey, Federal, $12,665.00. (November 29,

Funded
Runkle, Benjamin R, "National rice irrigation system type mapping using multi-source land imaging strategies," Sponsored by USGS (subaward to U North Texas), Institution of Higher Education, $35,961.00. (September 2024).

Funded
Runkle, Benjamin R (Primary Investigator), "A national quantification of methane emissions from rice cultivation in the U.S.: integrating multi-source satellite data and process-based modeling," Sponsored by NASA - Washington, Federal, $655,744.00. (June 1, 2021 - May 31, 2024).

Funded
Runkle, Benjamin R (Primary Investigator), "A national quantification of methane emissions from rice cultivation in the U.S.: integrating multi-source satellite data and process-based modeling," Sponsored by NASA - Washington, Federal, $1,069,563.00. (May 2021 - May 2024).

Funded
Runkle, Benjamin R (Primary Investigator), "Improving, Evaluating and Extending Satellite-Based High Resolution Cropland Carbon Monitoring System," Sponsored by NASA - Washington, Federal, $24,830.00. (April 27, 2021 - April 26, 2024).

Funded
Evans White, Michelle Allayne, Runkle, Benjamin R, "REU SITE: Assessment and sustainable management of ecosystem at the nexus of food, energy, and water systems," Sponsored by NSF, Federal, $403,166.00. (April 2021 - March 2024).

Funded
Runkle, Benjamin R (Primary Investigator), "CAREER: Developing climate-smart irrigation strategies for rice agriculture in Arkansas," Sponsored by National Science Foundation, Federal, $500,199.00. (April 1, 2018 - March 31, 2024).

Funded
Haggard, Brian Edward (Key Personnel), Runkle, Benjamin R (Primary Investigator), "A network of evapotranspiration observation sites to constrain ET estimation methods and water availability models in the Mississippi Alluvial Plain," Sponsored by Department of Interior, Federal, $379,000.00. (September 25, 2021 - September 24, 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Methane dynamics described through vegetation-soil interactions in bald cypress and other bottomland hardwood forests," Sponsored by U.S. Department of Energy, Federal, $49,141.00. (August 15, 2021 - August 31, 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Methane dynamics described through vegetation-soil interactions in bald cypress and other bottomland hardwood forests," Sponsored by Murray State University, Institution of Higher Education, $49,141.00. (September 2021 - August 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Riviana Lighthouse rice sustainability," Sponsored by Unilever US, Inc., Industry, $280,836.00. (March 15, 2021 - July 15, 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Quantify Changes in Water Quality and Greenhouse Gas Emissions Due to Innovative Rice Production Practices," Sponsored by U.S. Department of Agriculture, Federal, $147,510.44. (June 1, 2018 - May 31, 2023).

Funded
Runkle, Benjamin R, "A framework for heavy metal prioritization and mitigation for reducing metal intake: Rice and spinach case studies," Sponsored by Institute for the Advancement of Food and Nutrition Sciences, Private Non-Profit, $62,475.00. (April 2022 - April 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "A framework for heavy metal prioritization and mitigation for reducing metal intake: Rice and spinach case studies," Sponsored by The Institute for the Advancement of Food and Nutrition Sciences, Private Non-Profit, $62,475.00. (April 1, 2022 - April 30, 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Closing the Si cycle in rice agroecosystems to sustainably control arsenic and cadmium uptake by rice grown under alternate wetting and drying (AWD)," Sponsored by U.S. Department of Agriculture, Federal, $146,150.00. (March 15, 2018 - March 14, 2023).

Funded
Runkle, Benjamin R (Primary Investigator), "Conservation Water Management Practice for Reducing Greenhouse Gas
Emissions and Sustaining Productivity in Irrigated Rice Systems," Sponsored by U.S. Department of Agriculture, Federal, $71,573.60. (January 1, 2022 - October 31, 2022).

Funded
Runkle, Benjamin R, "Conservation Water Management Practice for Reducing Greenhouse Gas Emissions and Sustaining Productivity in Irrigated Rice Systems," Sponsored by USDA-ARS, Federal, $141,062.00. (January 2021 - October 2022).

Funded
Runkle, Benjamin R (Primary Investigator), "Energy partitioning, evapotranpiration, and CO2 exchange of the forage component of a silvopasture system," Sponsored by U.S. Department of Agriculture, Federal, $44,204.00. (September 1, 2018 - August 31, 2022).

Funded
Runkle, Benjamin R, Le, Thi Hoang Ngan, "Robot design for agricultural applications and outdoor research," Sponsored by UA College of Enginering, College/School, $24,994.00. (July 2022 - Present).

Funded
Runkle, Benjamin R (Primary Investigator), "Conservation Water Management Practice for Reducing Greenhouse Gas
Emissions and Sustaining Productivity in Irrigated Rice Systems," Sponsored by U.S. Department of Agriculture, Federal, $71,753.60.

Haggard, Brian E. (Professor)

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Monitoring in the Upper Illinois River Watershed and Upper White River Basin," Sponsored by Arkansas Natural Resources Commission, State, $292,241.00. (October 1, 2022 - December 31, 2025).

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Monitoring in the Upper Illinois River Watershed and Upper White River Basin," Sponsored by EPA ANRD 319 Program, Federal, $292,241.00. (October 1, 2022 - December 31, 2025).

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Analysis for Audubon: Independent Contractor Agreement," Sponsored by National Audubon Society, Inc., Private Non-Profit, $75,900.00. (July 1, 2022 - May 31, 2025).

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality analysis - Independent Contractor Agreement," Sponsored by EPA ANRD 319 Program through Audubon, Federal, $75,900.00. (July 1, 2022 - May 31, 2025).

Funded
Haggard, Brian Edward (Primary Investigator), "Upper Saline Watershed Modeling and Management Planning," Sponsored by The Nature Conservancy, Private Non-Profit, $61,928.00. (November 17, 2022 - November 30, 2024).

Funded
Haggard, Brian Edward (Primary Investigator), "Upper Saline HUC-8 Watershed Modeling and Management Planning," Sponsored by EPA ANRD 319 Program through TNC, Federal, $61,928.00. (October 1, 2022 - November 30, 2024).

Funded
Haggard, Brian Edward (Primary Investigator), "ROUTINE WATER QUALITY MONITORING IN BEAVER LAKE WATERSHED, ARKANSAS," Sponsored by Beaver Water District, State, $37,500.00. (October 1, 2022 - September 30, 2023).

Funded
Haggard, Brian Edward (Primary Investigator), "Scope of Work University of Arkansas Subcontract with Tarleton State University via Texas Commission on Environmental Quality," Sponsored by U.S. Environmental Protection Agency, Federal, $20,000.00. (October 1, 2021 - August 31, 2023).

Funded
Haggard, Brian Edward (Primary Investigator), "WATER QUALITY AND DATABASE LOGISTICAL SUPPORT," Sponsored by Arkansas Natural Resources Commission, State, $100,000.00. (October 1, 2021 - July 31, 2023).

Funded
Haggard, Brian Edward (Primary Investigator), "Water quality monitoring in the Upper Illinois River Watershed and Upper White River Basin, 2019-2022," Sponsored by U.S. Environmental Protection Agency, Federal, $262,384.00. (October 1, 2019 - December 31, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "ROUTINE WATER QUALITY MONITORING IN BEAVER LAKE WATERSHED, ARKANSAS," Sponsored by Beaver Water District, State, $37,500.00.

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Analysis for Audubon: Independent Contractor Agreement," Sponsored by National Audubon Society, Inc., Private Non-Profit, $75,900.00.

Funded
Haggard, Brian Edward (Primary Investigator), "ROUTINE WATER QUALITY MONITORING IN BEAVER LAKE WATERSHED, ARKANSAS," Sponsored by Beaver Water District, State, $32,494.00. (October 1, 2021 - September 30, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "A network of evapotranspiration observation sites to constrain ET estimation methods and water availability models in the Mississippi Alluvial Plain, 6/10/2020.," Sponsored by U.S. Department of Inter- U.S. Bureau of Mines USGS, Federal, $3,933.00.

Funded
Haggard, Brian Edward (Primary Investigator), "Assistance to State Water Resources Research Institutes," Sponsored by USGS 104B Program, Federal, $133,770.00. (September 1, 2022 - August 31, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "Development of Metrics for the Beaver Watershed Alliance," Sponsored by Beaver Watershed Alliance, Private Non-Profit, $28,000.00. (October 1, 2021 - August 31, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "WRRI 104b Annual Grant Program," Sponsored by Department of Interior, Federal, $125,000.00. (September 1, 2021 - August 31, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "WRRI 104b Annual Grant Program," Sponsored by Department of Interior, Federal, $133,770.00.

Funded
Haggard, Brian Edward (Primary Investigator), "Development of Metrics for the Beaver Watershed Alliance," Sponsored by Beaver Watershed Alliance, Private Non-Profit, $28,000.00. (September 22, 2021 - June 30, 2022).

Funded
Haggard, Brian Edward (Primary Investigator), "Upper Saline Watershed Modeling and Management Planning," Sponsored by The Nature Conservancy, Private Non-Profit, $61,928.00.

Funded
Haggard, Brian Edward (Primary Investigator), "A network of evapotranspiration observation sites to constrain ET estimation methods and water
availability models in the Mississippi Alluvial Plain, 6/10/2020.," Sponsored by U.S. Geological Survey, Institution of Higher Education, $3,933.00.

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Monitoring in the Upper Illinois River Watershed and Upper White River Basin,"

Funded
Haggard, Brian Edward (Primary Investigator), "Water Quality Monitoring in the Upper Illinois River Watershed and Upper White River Basin," Sponsored by Arkansas Natural Resources Commission, State, $292,241.00.

Henry, Christopher G. (Professor)

Funded
Henry, Christopher Garrett (Primary Investigator), "Life After the Flood: Disrupting Rice Farming by Integrating Automated, IoT-Irrigation Technologiesinto a
Low-Water-Use Production System," Sponsored by National Institute of Food and Agriculture United States Department of Agriculture, Federal, $29,999.00. (August 15, 2022 - August 14, 2025).

Funded
Huang, Qiuqiong (Primary Investigator), Henry, Christopher Garrett (Co-Investigator), Nayga, Rodolfo Mercado (Co-Investigator), "Performance Feedbacks and Peer Comparisons in Irrigation Management," Sponsored by National Institute of Food and Agriculture United States Department of Agriculture, Federal, $0.00. (April 1, 2021 - March 31, 2024).

Funded
Henry, Christopher Garrett (Primary Investigator), "Performance Feedbacks and Peer Comparisons in Irrigation Management," Sponsored by National Institute of Food and Agriculture United States Department of Agriculture, Federal, $41,441.00. (April 1, 2021 - March 31, 2024).

Kim, Jin-Woo (Professor)

Funded
Tung, Chao-Hung Steve (Primary Investigator), Kim, Jin-Woo (Co-Investigator), Tung, Chao-Hung Steve (Primary Investigator), Kim, Jin-Woo (Co-Investigator), "A Microscale Power Generator Driven By Bacterial Flagellar Motors," Sponsored by National Science Foundation, Federal, $0.00. (August 1, 2018 - July 31, 2023).

Funded
Song, Young Hye (Primary Investigator), Kim, Jin-Woo (Co-Investigator), "Development of Collagen-Cellulose Nanocrystal Composite Nanocrystal Composite Scaffolds for Peripheral Nerve Repair," Sponsored by University of Arkansas Engineering Research & Innovation Seed Funding (ERISF), College/School, $25,000.00. (July 1, 2022 - June 30, 2023).

Funded
Kim, Jin-Woo (Primary Investigator), Sakon, Joshua (Co-Investigator), "Nanocellulose-based Hydrogel Nano-delivery Systems for Controlled Release of Anti-cancer Drugs," Sponsored by Arkansas Biosciences Institute, College/School, $49,737.00. (July 1, 2022 - June 30, 2023).

Funded
Kim, Jin-Woo (Co-Investigator), Sakon, Joshua (Primary Investigator), "Nanocellulose-based Formulation for Reducing Herbicide Drift," Sponsored by University of Arkansas Chancellor's Gap Fund, University of Arkansas, $64,995.00. (January 31, 2023).

Funded
Kim, Jin-Woo (Primary Investigator), Sakon, Joshua (Co-Investigator), Kandhola, Gurshagan (Key Personnel), "Nanocellulose-based Hydrogel Nano-delivery Systems for Controlled Release of Anti-cancer Drugs," Sponsored by Arkansas Biosciences Institute, College/School, $49,737.00. (July 1, 2021 - June 30, 2022).

Funded
Tung, Chao-Hung Steve (Primary Investigator), Kim, Jin-Woo (Co-Investigator), Tung, Chao-Hung Steve (Primary Investigator), Kim, Jin-Woo (Co-Investigator), "Maximizing Spatial Resolution of DNA Sequencing Using Single Carbon Chain," Sponsored by National Institutes of Health, Federal, $0.00. (May 1, 2018 - April 30, 2022).

Li, Yanbin (Distinguished Professor)

Funded
Li, Yanbin (Co-Investigator), "Fully Printed Electronics and Energy Devices via Low-Dimensional Nanomaterials for Smart Packaging," Sponsored by USDA NIFA, Federal, $476,868.00. (February 1, 2021 - January 31, 2025).

Funded
Kent, John Levi (Co-Investigator), Rainwater, Chase Everette (Primary Investigator), Lacity, Mary C (Co-Investigator), Kidd, Michael T (Co-Investigator), Li, Yanbin (Co-Investigator), "Poultry Excellence in China: Improving Food Safety in Poultry Supply Chain (Phase II)," Sponsored by Walmart Foundation, Foundation, $0.00. (September 1, 2019 - February 28, 2023).

Funded
Rainwater, Chase Everette (Primary Investigator), Zhao, Jiangchao (Co-Investigator), Lacity, Mary C (Co-Investigator), Li, Yanbin (Co-Investigator), Maxwell, Charles (Key Personnel), Pohl, Edward A (Key Personnel), "Improving Food Safety of Pork Supply Chain," Sponsored by Walmart Foundation, Foundation, $0.00. (October 1, 2020 - October 31, 2022).

Funded
Li, Yanbin (Primary Investigator), Zhao, Jiangchao (Co-Investigator), "Improving Food Safety of Pork Supply Chain," Sponsored by Walmart Foundation, Foundation, $467,800.00. (October 1, 2020 - October 31, 2022).

Funded
Li, Yanbin (Primary Investigator), "Improving Food Safety of Pork Supply Chain in China," Sponsored by Walmart Foundation, Industry, $3,200,000.00. (October 1, 2020 - September 30, 2022).

Liang, Yi

Funded
Bottje, Walter (Primary Investigator), Lei, Xingen (Co-Investigator), Dridi, Sami (Co-Investigator), Tabler, G Tom (Co-Investigator), Liang, Yi (Co-Investigator), "Empowering US Poultry Farmer Sustainability through Innovative Genetic Selection, Environmentally Responsible Production, and Animal Wellbeing," Sponsored by USDA-NIFA, Federal, $10,000,000.00. (2019 - 2024).

Funded
Liang, Yi (Primary Investigator), Bottje, Walter (Co-Investigator), "Effects of in-house air cleansing on reducing ammonia and improving growth performance in broilers," Sponsored by CerroZone, Inc., Industry, $60,806.00. (November 1, 2022 - October 31, 2023).

Funded
Huang, Miaoqing (Primary Investigator), Luu, Khoa (Co-Investigator), Liang, Yi (Co-Investigator), "Artificial Intelligence System for Poultry Behavior Monitoring," Sponsored by University of Arkansas, University of Arkansas, $88,142.00. (March 2023).

Wang, Dongyi

Funded
Wang, Dongyi, "Software application for predicting consumer food acceptability based on appearances under different illumination conditions," Sponsored by NSF I-Corps, Federal, $50,000.00. (November 2022 - December 2023).

Funded
Wang, Dongyi, Seo, Hanseok, "LP: Toward fair and reliable consumer acceptability prediction from food appearances," Sponsored by NSF, State, $99,921.00. (October 2021 - September 2023).

Funded
Wang, Dongyi, "Development of digitalized broiler fleshing scores measurement instrument for precision farm management," Sponsored by UAES Research Incentive Grant, College/School, $29,843.00. (July 2022 - June 2023).

Funded
Wang, Dongyi, Shou, Wan, "Developments of multimodal sensors for reliable robotic chicken handling," Sponsored by UofA Engineering Research and Innovation Seed Funding, College/School. (July 2022 - June 2023).

Funded
Wang, Dongyi, Threlfall, Renee, "Evaluating non-destructive spectral imaging techniques for predicting wine grape attributes," Sponsored by Southern Region Small Fruit Consortium, Other, $5,000.00. (March 1, 2022 - February 28, 2023).

Funded
Wang, Dongyi (Primary Investigator), Shou, Wan (Co-Investigator), She, Yu (Co-Investigator), Owens Hanning, Casey, Crandall, Philip G, "Collaborative Research: NRI: Multimodal sensors guided robotic chicken grasping and rehanging for integrated and autonomous poultry processing.," Sponsored by NSF USDA/AFRI, Federal, $1,001,541.00.

Funded
Wang, Dongyi, "Texture Analysis System for Chicken Fillet Quality Evaluation," Sponsored by UADA Equipment Grant, Department, $10,000.00.

PUBLICATIONS

BOOKS, BOOK CHAPTERS

Kandhola, G., Chivers, C., Lim, J.-W., Park, S. B., Kim, J. E., Chung, J. H., **Kim, J.-W.** (2022). Carbon-based nanomaterials (탄소 기반 나노 소재). Bioengineering (생체공학) (pp. 385-423). Seoul: Munundang.

PEER-REVIEWED JOURNAL ARTICLES

Roswall, T., **Haggard, B. E.**, Toor, G. S. (2022). Fate and transformations of dissolved phosphorus forms in runoff: Effect of poultry litter and products extracted with variable water extraction ratios. Chemosphere, 308(Part 2), 136220. https://www.sciencedirect.com/science/article/abs/pii/S0045653522027138 https://doi.org/10.1016/j.chemosphere.2022.136220 Roswall2022_Chemosphere_308-1.pdf

Lasater*, A. L., O'Hare*, M., **Haggard, B. E.** (2022). Water quality trends and shifts vary across constituents in the Upper Poteau River Watershed. Journal ASABE, 65(3), 541-554. doi: 10.13031/ja.14704 Lasater2022_JASABE_65_3-1.pdf

Sharpley, A. N., Burke, J., Brye, K. R., Berry, L., Hays, P. D., Daniels, M. B., Vandevender, K. W., Glover, T., **Haggard, B. E.** (2022). Water quality adjacent to swine slurry holding ponds associated with a concentrated animal feeding operation. Agrosystems, Geosciences and Environment, 5(2), e20267. https://acsess.onlinelibrary.wiley.com/doi/10.1002/agg2.20267 https://doi.org/10.1002/agg2.20267 Sharpley2022_AGE5e20267-1.pdf

Lasater*, A. L., O'Hare*, M., Austin**, B. J., Scott**, E., **Haggard, B. E.** (2022). A cost-efficient method to remotely monitor stream in small-scale watershed. Journal ASABE, 65(2), 275-286. doi: 10.13031/ja.14730 LasaterA2022_JASABE_65_2-1.pdf

Austin**, B. J., **Haggard, B. E.** (2022). Measurable microcystin in Ozark streams was rare during summer 2018 baseflow conditions. *Agricultural and Environmental Letters, 7*(1), e20069. https://doi.org/10.1002/ael2.20069 Austin2022_AEL2_20069-1.pdf

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Publications

Invited presentations

Other Peer Reviewed Publications

Henry, C. G. and T. Clark. 2022. Evaluating Irrigation Timing, Depletion, Water-use and Efficiencies in Furrow Irrigated-Rice. In B.R. Wells Arkansas Rice Research Series 2021 editors J. Hardke, X. Sha, and N. Bateman. University of Arkansas, August 2022, Research Series 685. Pp244--247.

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Non-refereed Publications and Articles

Technical Report

Haggard, B. E., Grantz, E., Scott, J. T. (2022). Defining hydrologic conditions as sampled during the Joint Study (MSC 393 ed.). Arkansas Water Resources Center. https://awrc.uada.edu/publications/msc/

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Liang, Y. (2022). Making Sense of Your Utility Bills with Demand (vol. FSA 1101). University of Arkansas Division of Agriculture. FSA1101 Revised Proof-1.pdf

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Ali, M., Wu, B., Wheeler, C., **Wang, D.,** Tao, Y. (2022). Active-Laser Scanning and Intelligent Picking for Automated Loading of Agricultural Commodities to Processing Machines. ASABE.

Conference Proceedings

Nguyen, A. P., Luu, K., **Liang**, Y., Huang, M. (2022). Self-supervised domain adaption in crowd counting. (Virtual) ICIP 2021: IEEE International Conference on Image Processing. Alaska, US.

Professional Presentations

Invited presentations

Costello, T. A. (Presenter), Liang, Y. (Co-Author), 59th Annual Meeting of the Arkansas Section of ASABE, "Federal Support for Renewable Energy (2021-2022)," Arkansas Section of ASABE, Virtual Conference via Zoom, Fayetteville, AR. (October 7, 2022).

Haggard, B. E., BENG 4933 Sustainable Watershed Engineering, "Microcystin Thresholds and Response to Nutrient Additions at Lake Fayetteville, Arkansas," Classroom, Fayetteville, AR. (November 2022).

Haggard, B. E., ENSC 4023/5023, "Water quality monitoring with grab samples: What do you want to do with the data? It matters," Classroom, Fayetteville, AR. (November 2022).

Haggard, B. E., GENEG 1301H, "Microcystin thresholds and response to nutrient additions at Lake Fayetteville, Arkansas," Classroom. (September 2022).

Haggard, B. E., ASABE Annual Meeting, "Water quality monitoring with grab samples: What do you want to do with the data? It matters.," American Society of Agricultural and Biological Engineers, Houston, TX. (July 2022).

Haggard, B. E., UT Biosystem Engineering Graduate Seminar, "Microcystin thresholds, bioassay response and ecological engineering at a recreational reservoir with annual cyanobacterial HABs," UT Biosystem Engineering and Soil Science Department, Classroom, Knoxville, TN. (March 2022).

Henry, C.G. 2022. Taking the Uncertainty out of scheduling for FIR, corn and soybeans: New Technology for increased yields and profitability Part 1 and 2.

Henry, C.G. 2021. Irrigation Contest Winners. Arkansas Soil and Water Conference, virtual, January 27, 2021.

Henry, C.G. 2022. Give us something to shoot for. Irrigation Association, December 6, 2022, Las Vegas, NV.

Henry, C.G. 2022. Variable Flow Tailwater Recovery – the pit-less pump as an alternative to tailwater pits. NRCS Engineering Meeting, September 7. 2022, Hot Springs, AR.

Henry, C.G. 2022. Water Management Studies with Rice. Cambodia Tour Group, Feb 17, 2022, Stuttgart, AR.

Henry, C.G. 2022. Water sustainability Revelations in the Mid-south. USDA-ARS Stakeholder Workshop. August 5, 2022. Stuttgart, AR.

Henry, C.G. 2022. Irrigation Water Management Stop: 300 BPA Climate-Smart Automated Furrow Irrigated Rice Project. August 5, 2022, Stuttgart, AR.

Henry, C.G. 2022. Water Management Studies with Rice. iLead cohort F2F seminar. February 17, 2022. Stuttgart, AR.

Henry, C.G. 2022. University of Arkansas System Division of Agriculture Water Management Program Projects. Ground Water Summit. June 21, 2022, Lonoke, AR.

Henry, C.G. 2022. Improving Irrigation Scheduling and Irrigation Efficiency for Corn Production in Arkansas. Corn and Grain Sorghum Promotion Board Meeting. February 15, 2022. Little Rock, AR.

Henry C.G. 2022. Most Crop per Drop contest. Rice Federation Annual Meeting, February 8, 2022. Jonesboro, AR.

Henry, C.G. 2022 Climate Smart 300 Bushel row rice in 12 Inches of Automated Irrigation. Rice Research and Promotion Board. Little Rock, AR.

Henry, C.G. 2022. University of Arkansas Irrigation Water Management Program. Arkansas State University Water Summit. July 31, 2022, Little Rock, AR.

Kim, J.-W. (Plenary Speaker), IEEE Nanotechnology Materials & Devices Conference (IEEE-NMDC), "Nanoscale Fabrication of Advanced Bio/Nano-Hybrid Materials in Bio/Nano Medicine," IEEE, Nanjing, China (Hybrid Format). (November 17, 2022).

Li, Y. 2022. Smart biosensing technology for enhancing ag-food system monitoring. A keynote speech at the 2022 World Agri-Food Innovation Forum – Smart Agricultural Innovation Development Sub-forum, September 25-26, 2022, Beijing, China.

PUBLICATIONS

Invited presentations

Li, Y. 2022. An international collaboration on food safety monitoring and prediction for port supply chain in China. An invited presentation at ASABE 2022 Annual International Meeting, American Society of Agricultural and Biological Engineers, July 17-20, 2022, Houston, TX. Paper No. 21200041.

Liang, Y., "How Sprinkler and Cool Cells Meet the Demand of Broiler Cooling". Water Conservation in Poultry Production and Sustainability, University of Arkansas Center of Excellence for Poultry Science, Don Tyson Agriculture Center, Fayetteville, United States. (May 25, 2022).

Liang, Y., Ross Asia Technical Conference, "Poultry House Sustainability: Solar Power," Aviagen, Virtual, Bangkok, Thailand. (October 18, 2022). Solar power presentation Liang-1.pdf

Osborn, G. S., LinkedIn UA Tech Ventures communications, "Featured Inventor," UA Tech Ventures, LinkedIn broadcast. (November 2022).

Osborn, G. S., Brothers, C. (Core Brewing Representative), Wooley, S. (Core Brewing Representative), Inventors Appreciation Banquet, "Example of Successful Faculty Research Commercialization," UA Technology Ventures - Office of Economic Development, UA Student Union, Fayetteville, AR. (October 2022).

Osborn, G. S., Chart Water Industries Annual Technology Meeting, "BlueInGreen Technology Review," Chart Industries, Chart Water Offices, Fayetteville, AR. (February 2022).

Osborn, G. S., Podcast, "Arkansas Food, Farms, and Forests - Better Beer," UADA, UADA Podcast. (January 2022).

Osborn, G. S., Arkansas Commercialization Retreat, "Timing is everything -how to spot trends and realize when the time is right to commercialize your research," UA Office of Entrepreneurship, Winrock, Morrilton, AR. (September 2022).

Runkle, B. R., "Towards a climate-smart rice production system," ECO REU program, University of Arkansas, Fayetteville, AR, United States. (June 2, 2022).

Runkle, B. R., "Climate-smart solutions for the rice agro-ecosystem," Geosciences Colloquium, University of Arkansas, Fayetteville, AR, United States. (March 11, 2022)., Chicago, IL, United States. (December 2022).

Invited presentations

Runkle, B. R., Li, B., Leavitt, M., Reba, M., Moreno-Garcia, B., Reavis, C., Tajfar, E., Oikawa, P., Guan, K., Peng, B., American Geophysical Union Fall Meeting, "The adaptation of a hierarchical CH4 model for rice fields in Arkansas," American Geophysical Union, Chicago Convention Center

Runkle, B. R., CMS PI Meeting, "A national quantification of methane emissions from rice cultivation in the U.S.: integrating multi-source satellite data and process-based modeling," NASA, AGU Conference Center, Washington, DC, United States. (September 27, 2022).

Runkle, B. R., Southeast Symposium on Contemporary Engineering Topics & Arkansas Engineering Forum, "Biological engineering for nature-based climate solutions," Arkansas Engineering Forum, University of Arkansas at Little Rock, Little Rock, AR, United States. (September 16, 2022).

Runkle, B. R., 5th International Paddy Rice Research America Sub-Group Meeting Global Research Alliance on Agricultural Greenhouse Gases, "The GHG impacts of AWD and other rice production practices: eddy covariance studies in Arkansas," USDA ARS, Embassy Suite Hilton Hotel, Jonesboro, AR, United States. (July 12, 2022).

Runkle, B. R., Workshop: What science is needed for robust, scalable, and credible implementation of natural climate solutions, "Flux tower research for natural climate solutions," Indiana University, IU Advancement Center, Washington, DC, United States. (June 28, 2022).

Runkle, B. R., iLEAPS, "Rice agriculture: what we are learning," NASA CMS-iLEAPS Remote Sensing of Wetland Methane Emissions workshop, remote. (May 18, 2022).

Runkle, B. R., Institute of Biological Engineering, "Biological engineering for nature-based climate solutions," University of Georgia, Athens, GA, United States. (April 2022).

Wang, D., FDSC 1011 Exploring Topics in Food Science, "Food Science and Engineering in the era of artificial intelligence and automation," Fayetteville, AR, United States. (December 2022).

Wang, D., UArk Analytical Chemistry Seminar, "Recent advances in artificial intelligence based spectral signal analysis for agricultural applications.," Fayetteville, AR, United States. (October 2022).

Wang, D., FDSC 4713: Product Innovation for Food Scientists, "Food Science and Engineering in the era of artificial intelligence and automation," Fayetteville, AR, United States. (April 2022).

Submitted/selected oral or poster presentations

McIntyre, B., **Haggard, B. E.,** Austin, B., Rios, J., Southwest Section Annual Meeting, "Literature review and management options for Harmful Algal Blooms (HABs," American Water Works Association, Rogers, AR. (October 2022).

McIntyre, B., **Haggard, B. E.,** Austin, B., Rios, J., Arkansas Water Resources and Watersheds Conference, "Biochar: Literature review and management options for Harmful Algal Blooms (HABs)," Arkansas Water Resources Center, Fayetteville, AR. (July 2022).

Haddock, L., **Haggard, B. E.,** Austin, B., Ferri, A., Wagner, N., Scott, T., Arkansas Water Resources and Watershed Conference, "Cyanobacterial and microcystin response to nutrient additions at Lake Fayetteville throughout the 2021 growing season," Arkansas Water Resources Center, Fayetteville, AR. (July 2022).

Ferri, A., **Haggard, B. E.,** Grantz, E., Austin, B., Arkansas Water Resources and Watershed Conference, "Harmful algal blooms vary between and within years at Lake Fayetteville," Arkansas Water Resources Center, Fayetteville, AR. (July 2022).

Haggard, B. E., UCOWR Annual Meeting, "Microcystin thresholds and response to nutrient additions at Lake Fayetteville, Arkansas," University Council on Water Resources, Greenville, SC. (June 2022).

Grantz, E., **Haggard, B. E.,** BENG 4973/5973, UCOWR Annual Meeting, "Volunteer monitoring in the Upper White River Basin, Arkansas: What can we learn?," University Council on Water Resources, Greenville, SC. (June 2022).

Grantz, E., **Haggard, B. E.,** UCOWR Annual Meeting, "Water quality changes and perspectives in the Buffalo Nation River over the last two decades," University Council on Water Resources, Greenville, SC. (June 2022).

Grantz, E., **Haggard, B. E.,** UCOWR Annual Meeting, "Watershed prioritization to reduce nutrient export: A framework for the State of Arkansas based on ambient water quality monitoring," University Council on Water Resources, Greenville, SC. (June 2022).

Haggard, B. E., Harmful Algal Bloom Virtual Research Symposium, "Microcystin thresholds and bioassay response at a recreational impoundment, Lake Fayetteville," North Central Region Water Network, Virtual. (January 2022).

Submitted/selected oral or poster presentations

Henry, C.G. 2022. Furrow Irrigated Rice Irrigation Technology, Delta States Irrigation Conference, February 1th, 2022. Jonesboro, AR

Henry, C.G., D. Gholson., T. Young, J. Mitchell, S. Taylor. 2022. Soil Moisture Roundtable: Using Soil Moisture Sensors Across the Entire Farming Enterprise: Lessons Learned from those who are Doing It. Delta States Irrigation Conference, virtual, Delta States Irrigation Conference, Virtual, February 1th, 2022, Jonesboro, AR

Kim, J.-W. (Corresponding Author), Kuczwara, P. (Presenter), Kandhola, G., 22nd IEEE International Conference on Nanotechnology (IEEE-NANO), "Development and Characterization of Cellulose Nanocrystal Based Inks for 3D Bioprinting," IEEE, Palma de Mallorca, Spain. (July 6, 2022).

Jia, F., B.Y. Li, Y.W. He, Y.F. Shen, J.H. Chen, X.N. Li, and **Y. Li***. 2022. A CRISPR-SERS biosensor for specific, sensitive, and rapid detection of *Salmonella* Typhimurium. Presented at ASABE 2022 Annual International Meeting, American Society of Agricultural and Biological Engineers, July 17-20, 2022, Houston, TX. Paper No 2200115.

Sobhan, A., F. Jia, L. Kelso, L. Wei, C.Y. Cao, and **Y. Li***. 2022. A novel activated biochar-based immunosensor for rapid detection of *E. coli* O157:H7. A poster presented at IFT 2022 Annual Meeting, Institute of Food Technologists, July 10-13, Chicago, IL.

Wang, W.Q., L. Kelso, M. Kidd, and **Y. Li***. 2022. A localized surface plasmon resonance biosensor based on polydopamine molecular imprinted polymer for detection of multi-antibiotics in chicken meat: Assay optimization and comparative study with ELISA. A poster presented at IFT 2022 Annual Meeting, Institute of Food Technologists, July 10-13, Chicago, IL.

Liang, Y. and Costello, T. "The Impact of Renewable Energy Generation on Electricity Use of a Broiler Farm", Sustainable Energy for Sustainable Future Conference, ASABE, San Jose, Costa Rica. (October 24, 2022).

Publications

Submitted/selected oral or poster presentations

Klauss, N., Miles, M., Thompson, M., Ross, S., El-Masri, B., Stinchcomb, G., **Runkle, B. R.,** Moon, J. B., Kentucky Academy of Sciences, "Contribution of Taxodium distichum "knees" to greenhouse gas emissions in a bottomland hardwood wetland," Morehead State University, Morehead, KY, United States. (November 2022).

Ross, S., Moon, J. B., Miles, M., Thompson, M., Klauss, N., El-Masri, B., Stinchcomb, G., **Runkle, B. R.,** Kentucky Academy of Sciences, "Does Taxodium distichum "knee" density affect CO2 and CH4 emissions in bottomland hardwood forests?," Morehead State University, Morehead, KY, United States. (November 2022).

Miles, M., Thompson, M., Ross, S., Klauss, N., El-Masri, B., Stinchcomb, G., **Runkle, B. R.,** Moon, J. B., Kentucky Academy of Sciences, "Methane Dynamics of Stems in Bottomland Hardwood Wetlands of the Upper Mississippi Alluvial Valley," Morehead State University, Morehead, KY, United States. (November 2022).

Tajfar, E., Reba, M., Fong, B., Suvocarev, K., Reavis, C. W., Moreno Garcia, B., Chiu, Y.-L., **Runkle, B. R.,** Ameriflux, "Effects of irrigation management practices on net ecosystem exchange of CO2 in the U.S. mid-South rice fields," University of Michigan Biological Station, MI, United States. (September 2022).

Bin Mahbub, R., Reba, M., **Runkle, B. R.,** Ameriflux, "Evaluating the potential of in-situ phenology data on improving the estimation of satellite driven gross primary productivity of rice in Arkansas," University of Michigan Biological Station, MI, United States. (September 2022).

Reavis, C., Reba, M., Shults, D., **Runkle, B. R**., Ameriflux, "Understanding the impacts of alternative management on methane emissions in US rice," University of Michigan Biological Station, MI, United States. (September 2022).

Askey, J., Huang, Q., Henry, C., **Runkle, B. R**., Agricultural & Applied Economics Association Annual Meeting, "Changes in pumping times associated with irrigation best management practices? Empirical Evidence from Eastern Arkansas," Anaheim, CA, United States. (July 31, 2022).

Magdaleno Hernandez, G., Bin Mahbub, R., **Runkle, B. R.,** AWRC Annual Meeting, "Furrow-Irrigated Rice from Space: A Case Study from Arkansas," Fayetteville, AR, United States. (July 13, 2022).

Bin Mahbub, R., Reba, M., **Runkle, B. R.,** Arkansas Soil and Water Education Conference, "Estimating the gross primary productivity of rice in Arkansas using satellite-driven biogeochemical model." (January 2022).

Submitted/selected oral or poster presentations

Leavitt, M., Moreno Garcia, B. R., Reavis, C., Reba, M., **Runkle, B. R.,** Arkansas Soil and Water Education Conference, "The Effect of Water Management and Ratoon Rice Cropping on Greenhouse Gas Emissions and Harvest Yield in Arkansas." (January 2022).

Tajfar, E., Volk, J., Reba, M., Fong, B., Novick, K., White, P., Bhattacharjee, J., Anapalli, S., **Runkle, B. R.,** American Geophysical Union Fall Meeting, "Bias-corrected Crop Coefficients for Different Land Cover Types in the U.S. Mid-South derived from Eddy Covariance Measurements and the gridMET Dataset," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Reba, M., Reavis, C., Chiu, Y.-L., Massey, J., Adviento-Borbe, A., **Runkle, B. R**., Fong, B., American Geophysical Union Fall Meeting, "Field-scale methane measurements from row irrigated rice in US Mid-South rice production," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Moon, J. B., Miles, M., Ross, S., Klauss, N., Radford, I., Stinchcomb, G., **Runkle, B. R.,** El Masri, B., American Geophysical Union Fall Meeting, "Methane Dynamics of Stems and Exposed Woody Root Structures in Bottomland Hardwood Forests of the Upper Mississippi Alluvial Valley," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

El Masri, B., Moon, J. B., El Asselta, J., Stinchcomb, G., **Runkle, B. R.,** Miles, M., American Geophysical Union Fall Meeting, "Methane Dynamics of Vegetation-Soil Interactions in Bald Cypress and Other Bottomland Hardwood Forests," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Stinchcomb, G., El Masri, B., Moon, J. B., **Runkle, B. R.,** El Asselta, J., Miles, M., American Geophysical Union Fall Meeting, "The importance of tree species and soil phosphorus in driving soil greenhouse gas emissions in humid, subtropical forests," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Bin Mahbub, R., Reba, M., **Runkle, B. R**., American Geophysical Union Fall Meeting, "The potential of in-situ phenology data to estimate satellite driven gross primary productivity of rice in Arkansas," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Reavis, C., Reba, M., **Runkle, B. R.,** Shults, D., Chiu, Y.-L., Massey, J., American Geophysical Union Fall Meeting, "Understanding the Impacts of Alternative Management on Methane Emissions in US Rice," American Geophysical Union, Chicago Convention Center, Chicago, IL, United States. (December 2022).

Publications

Submitted/selected oral or poster presentations

Sethu, S., Sabari, N., Zhang, S., Seo, H., **Wang, D.,** 27th NSF EPSCoR National Conference, "Toward fair and reliable consumer acceptability prediction from food appearances.," NSF, Portland, ME, United States. (November 13, 2022).

Ali, M., Wu, B., C., **Wang, D.,** Tao, Y., 2022 ASABE Annual Meeting, "Active-Laser Scanning and Intelligent Picking for Automated Loading of Agricultural Commodities to Processing Machines.," ASABE, Houston, TX, United States. (July 2022).

Sethu, S., Torres, O., Blindauer, R., Zhang, S., Seo, H., **Wang, D**., 2022 Arkansas NSF EPSCoR / DART Annual All-Hands Conference, "Toward fair and reliable consumer acceptability prediction from food appearances.," NSF, Little Rock, AR, United States. (May 2022).

Ali, M., **Wang, D.,** Tao, Y., Envisioning 2050 in the Southeast: AI-driven Innovations in Agriculture., "Active-Laser Scanning and Intelligent Picking for Automated Loading of Agricultural Commodities to Processing Machines.," Auburn University, Auburn, AL, United States. (April 2022).

Yuanhang Zhan, Yiting Xiao, Leland C. Schrader, Ndeddy Aka Robinson Jr, Sarah Wu, **Jun Zhu**. 2022. Considering micro-aeration strategy for enhancing methane production in anaerobic digestion of agricultural wastes. ASABE 115th Annual International Meeting. Paper#: 2200429. Houston, TX. July 17-20.

Yiting Xiao, **J. Zhu**, Yuanhang Zhan. 2022. Optimization of decolorization and COD removal rate in anaerobic digester effluents through photocatalytic titania nanofiber. ASABE 115th Annual International Meeting. Paper#: 2200334. Houston, TX. July 17-20, 2022.

Ndeddy Aka, RJ., D. Mohotti, A. Nasir, L. Zhu, Y. Zhan, **J. Zhu**, S. Wu. 2022. Evaluating a Dual Chamber Magnesium Electrolytic Process for Struvite Precipitation. ASABE 115th Annual International Meeting. Paper#: 2200903. Houston, TX. July 17-20, 2022.

Xueyao Zhang, **J. Zhu**, S. Wu, Zhi-Wu Wang. 2022. A comparison of forward osmosis and membrane distillation for water sustainable anaerobic digestion of poultry litter. ASABE 115th Annual International Meeting. Paper#: 2201008. Houston, TX. July 17-20.

Other Creative Endeavors

Submitted/selected oral or poster presentations

Zhang, X, **J. Zhu**, S. Wu, Z. W. Wang. 2022. Water recirculation in a sustainable poultry litter treatment system via membrane process. WaterJam Conference, September 12-15, Virginia Beach, VA, USA (Winner of WaterJAM 2022 Fresh Ideas Young Professional Poster Contest (Drinking Water Category). Award by American Water Works Association (AWWA). Available at: https://twitter.com/bse_vt/status/1577337752475033603)

Zhang X.Y., **Zhu J.**, Wu X., Wang Z.W. 2022. Application of low-energy membrane technologies for closing the water loop of poultry litter anaerobic digestion. 17th IWA World Conference on Anaerobic Digestion, June 19-22, Ann Arbor, Michigan, USA.

Other Creative Endeavors

Chris Henry

Mobile App Development. I have developed a mobile application for Multiple Inlet for Rice Irrigation. It is available on Google Play for android devices. The application provides a map for the user to draw field boundaries, levee boundaries, and pipe location. The user enters in the flow rate for the well and the application determines the pipe size, length, number of rolls required and provides a gate punch and setting plan for the field. Multiple fields can be entered and saved and the user can have the plan emailed to them and saved as a pdf. The iOS version of this application was released in 2017 and updated in 2021. Currently there are 592 users that have planned 1059 farms, 2,131 fields, 19,266 individual levees, and 3.1M feet of pipe designed. Over 208,230 acres are planned using the app, which on average reduce irrigation water use by 8 ac-in/ac. These planned acres using the mobile app represent about 17% of the rice acres in Arkansas, and is estimated to conserve 34 billion gallons of irrigation water annually. Updates are on-going but not yet released.

UA Irrigation Water Management Team. 2021. Rice Irrigation. Mobile Application Software. http://itunes.apple.com

UA Irrigation Water Management Team. 2021. Rice Irrigation. Mobile Application Software. https://play.google.com/store/apps/details?id=org.uark.riceirrigation

Other Creative Endeavors

Chris Henry

A second app, Arkansas Watermark Tool, is a mobile app that interprets soil moisture sensor readings. The app is available for iOS and Android devices. This app has been installed 386 times previously and was installed 3,500 times in 2022 (a considerable amount given that it is a specialized app) and the average usage is 4.3 sessions per month. This is fairly high usage rate because the app is only used for 2-3 months during the year. This app is a good example of integrating research and Extension, soybean sap flow experiments being conducted and soil water retention curves are integrated into the algorithms in the app to provide Arkansas specific soil moisture sensor recommendations. This approach immediately integrates commodity board funded research with an Extension outreach tool, putting complex research results into an easy to use product. The app allows for easy implantation of research and puts it "in the hands" of my clientele using their smartphone. New updates were included that expanded the action section of the app.

UA Irrigation Water Management Team. 2022. Arkansas Watermark Tool. https://play.google.com/store.
UA Irrigation Water Management Team. 2022. Arkansas Watermark Tool. http://itunes.apple.com.

Another app is a simple soils mapping app that will be integrated into the soil moisture sensor calculator app. The app reports soils information from the SSURGO database managed by NRCS for a user's given location.

UA Irrigation Water Management Team. 2022. The Soils Map App. Not yet released on Google Play.

Considerable effort has been made to develop a tool to help farmers implement Computerized Hole Selection. Currently many farmers (40% in the region) use a program developed by Delta Plastics, the manufacturer of lay flat irrigation pipe, called Pipe Planner (pipeplanner.com). One challenge with CHS is that plans can be difficult to implement because many plans have many hole size changes.

Other Creative Endeavors

This project is developing a tool to increase adoption of CHS by automating this process as the pipe is installed. First the app is used to download Computerize Hole election plans developed using Delta Plastics Pipe Planner (pipeplanner.com). The app imports the CHS plans and then communicates with a GPS receiver and an embedded printer system to print the CHS plan hole on pipe as it is installed on a tractor and pipe installation machine. The second part of this app, allows for the user to create their own CHS plan rather than import the one from Pipe Planner. Since the app only works with the embedded system it is not published on Google Play. However, the app is very robust and functional and has been extensively tested in the field. The CHS feature has just been added and is nearly ready to be released. It is also being coded in iOS, once finished, the app will be ready for extensive testing by end users and release.

UA Irrigation Water Management Team. 2022. Poly Printer and CHS Planning App. Unpublished. Near completion.

Novel Tail-water Pump Technology Transfer. During 2019 and 2021, I have installed four of the novel pit-less tailwater recovery systems on farmer fields in Arkansas. These systems are the first technology transfer of the IP for the patented "Irrigation System: 20190307083A1 (See Henry, C. G. et al., 2019 in IP section). These four systems are demonstrating the pit-less technology for furrow irrigated rice. The results have been very successful and the farmers are promoting the technology among their peers. This project will allow the technology to be adopted as an incentive payment within the Environmental Quality Incentives Program, which allows for farmers to receive government funding to install the technology on their farms. One farmer's installation will be the front cover story of the 2021 fall issue of the "Rice" magazine trade publication. This system was approved for incentive payments in November of 2022 and is now available for conservation planning within the Environmental Quality Incentive Program.

Additionally, in 2022 successful operated a fully automated irrigation system centered around the pit-less tailwater recovery system, demonstrating the full application of the patented system.

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