Center for Agroforestry Annual Report 2018
Research, Education, Outreach & Entrepreneurship

Interim Director: Michael A. Gold, Ph.D.
203 Anheuser Busch Natural Resource Building
Columbia, MO 65211
573-884-2874
www.centerforagroforestry.org

Center for Agroforestry
University of Missouri

ABOUT THE CENTER

THE CENTER FOR AGROFORESTRY AT THE UNIVERSITY OF MISSOURI

UMCA is one of the world's leading centers contributing to the science underlying agroforestry. UMCA, established in 1998, has been supported by significant collaborative funding from the USDA-ARS. Interdisciplinary research conducted by faculty, research specialists, graduate and undergraduate students, provides sound science that uncovers new environmental and economic benefits from agroforestry practices and solves production challenges.

Linked to the Center's solid science and research programs are numerous partnerships with landowners, natural resource professionals, federal and state agencies and non-profit organizations. Through these critical relationships, UMCA and its partners produce an array of positive outcomes for landowners, businesses, the natural environment and society as a whole.

UMCA Mission

To support the long-term future of rural and urban working farms and forests to achieve economic, environmental and social sustainability. The Center's long-term research, teaching, outreach and economic development efforts help make a better Missouri, USA and world by:

- Discovering, integrating and applying new agroforestry knowledge and technologies to promote economic, environmental, and social vitality;
- Educating and training students, professionals, scientists, leaders, landowners and the general public who are empowered to make a difference locally, regionally, and globally.

To accomplish our mission, UMCA:

- Conducts, coordinates and promotes interdisciplinary research on agroforestry practices to improve the productive and protective functions of agricultural and forest lands.
- Conducts, coordinates and promotes interdisciplinary research on the social, economic and market dimensions of agroforestry.
- Conducts an active outreach program including the annual Agroforestry Academy, that increases the awareness and adoption of agroforestry practices.
- Conducts, coordinates and promotes interdisciplinary research on the policy dimensions of agroforestry.
- Provides opportunities for formal education via an integrated series of online courses. In addition to campus-base graduate degree programs, both a graduate certificate and/or master's degree in agroforestry are available through MizzouOnline at the University of Missouri.
- Develops and carries out a collaborative international agroforestry program in the areas of instruction, research and outreach.

Edited by Michael A. Gold and Hannah L. Hemmelgarn
Design and Layout by Caroline S. Todd

CONTENTS

Front cover: Photo of Bill & Sue Ellen Stouffer's Cedar Hill Farms chestnut and winter wheat alley cropping.

MESSAGE FROM THE INTERIM DIRECTOR

Greetings from the Center for Agroforestry at the University of Missouri as we began our 21st year as a big "C" Center at MU. When we began 2018, our former Center Director, Dr. Shibu Jose, had settled into his second year as Director of the MU School of Natural Resources (SNR). As we closed out 2018, Dr. Jose announced (effective Jan. 1, 2019) that he had been chosen to serve as the Interim Dean of Research and Ag. Experiment Station Director in CAFNR (our College). We congratulate Dr. Jose and look forward to his future success in our College. In less than two years he made a huge and positive impact on SNR and remains a genuine supporter of our Center. In addition, we initiated our search for the future Center Director in the fall of 2018 and will announce new, exciting leadership later in 2019 (stay tuned!). The University of Missouri Center for Agroforestry is one of the premier centers of its kind in the world dedicated to agroforestry research, education, outreach and economic development. Our strength lies in the success of our dedicated and productive core Center faculty and staff, our active collaborative efforts, over 50 associated faculty, staff and external collaborators, and our graduate students and postdoctoral research associates who define, design and carry out dozens of research and outreach projects (http://www.centerforagroforestry.org/personnel). We also find strength in the diversity of our stakeholders and friends who believe in agroforestry as a major form of global land use in the coming decades.
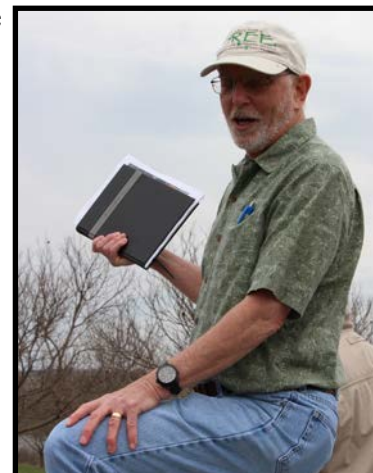
Our Center has been unusually blessed with long-term continuity in all of our endeavors. These long-term efforts are now "bearing fruit" on multiple fronts (research, education, outreach, economic development). The impacts of our research, education, outreach and economic developments activities are profound and positively impact landowners in Missouri, regionally, nationally and also have a strong global impact.

As we head into our 21st year, 2019, I want to provide you with a status update on our Center and **highlight** a few outstanding 2018 accomplishments:

- *A three year Missouri NRCS agroforestry training grant was awarded (2018-2021). This grant will enable the Center to create and offer outreach/training workshops to Missouri NRCS staff and other conservation professionals in order to increase their knowledge and technical assistance capacity on sustainable land use practices focused on agroforestry and specialty crops.*
- *In 2018, the Center completed its' 6th Annual Agroforestry Academy as a crash course to train educators and landowners in agroforestry. Over 6 years, the week long Agroforestry Academy has trained 150 future agroforesters. A combined qualitative/ quantitative outcomes assessment of the impact of the Agroforestry Academy is now underway to help inform the Center's future education and training programs.*
- *Currently, there are 47 graduate students, on campus and online, enrolled and/or funded whole or in part by the Center. This includes 18 M.S. / Ph.D. students on campus.*
- *Multi-Enzyme Platform Production of Specialty Chemicals, Biofuels, and Blood Type Conversion. Chung-Ho Lin, Hsin-Yeh Hsieh, George Stewart, Mason Schellenberg, Sagar Gupta, Shibu Jose, Ronald Wood and Kattesh V. Katti. 2018. (Provisional Patent granted)*
- *The first commercial product, **PONCHO/ VOTiVO 2.0***, based on the invention jointly developed by scientists Dr. Chung-Ho Lin at MU Center for Agroforestry, Dr. George Stewart at MU Department of Veterinary Pathobiology and Dr. Brian Thompson at Elemental Enzymes, was launched by Bayer in 2018.*

Working closely with our many partners, our collective efforts are and will continue to help to realize agroforestry's potential. On behalf of UMCA, we look forward to an exciting and productive year in 2019.

Michael A Gold, Ph.D.
Research Professor and Interim Director
The Center for Agroforestry at the University of Missouri

Awards in 2018

Dr. Ranjith Udawatta, second from right, receiving MU School of Natural Resources Outstanding Research Faculty Award from CAFNR Dean and ViceChancellor Christopher Daubert, SNR Director, Dr.Shibu Jose, right, and Dr. Anthony Lupo, left, Chair of the SNR Director's Faculty Council.

Center for Agroforestry lab manager Phuc Vo (pictured second from left) received the outstanding presentation award at National Conference on Biotechnology in Hanoi, Vietnam. Presentation title: Exploring New Commercial Opportunities for Osage Orange (*Maclura pomifera*) Using Metabolomics Approach.

Dr. Michael A. Gold, Interim Director, front row second from left, was a member of the team that received the 2018 Vice Chancellor's Diversity Award for MU Extension excellent collaborative programming for the citizens of Missouri based on a year long "Missouri Outreach and Assistance for Socially Disadvantage and Veteran Farmers and Ranchers" grant program.

Dr. Rob Meyers received the Missouri Soil and Water Conservation Society Professional Conservationist of the Year Award. He currently serves as the Chair of the Center for Agroforestry/HARC Advisory Board.

Patents & Trademarks

Multi-Enzyme Platform Production of Specialty Chemicals, Biofuels, and Blood Type Conversion. Chung-Ho Lin, Hsin-Yeh Hsieh, George Stewart, Mason Schellenberg, Sagar Gupta, Shibu Jose, Ronald Wood and Kattesh V. Katti. 2018. (Provisional Patent granted)

Mason Schellenberg, Hsin-Yeh Hsieh, Chung-Ho Lin, Shibu Jose, Ronald Wood. 2017. A novel computer implemented 3D printing method for platforms for enzyme immobilization (Invention Disclosure submitted)

Jihyun Park and Chung-Ho Lin. Spent coffee grounds for cosmetic application. 2018 (Invention Disclosure submitted)

◊ Dr. Chung-Ho Lin, UMCA research scientist, was awarded the MU School of Natural Resource Master's Advisor Award.
◊ UMCA Ph.D. student Danh Vu was awarded the MU School of Natural Resources Outstanding Thesis Award.

Agroforestry

Windbreaks

Windbreaks are planned and managed as part of a crop and/or livestock operation. Field windbreaks protect a variety of wind-sensitive crops; enhance production and conservation; control wind erosion; and increase bee pollination and limit spray drift of pesticides. Livestock windbreaks help reduce animal stress and mortality; reduce feed consumption; and help reduce visual impacts and odors. Windbreaks also may provide excellent wildlife habitat.

Forest Farming and Urban Food Forests

In forest farming, high-value specialty crops are grown under the protection of a forest canopy modified to provide the correct shade level. Crops such as ginseng, truffles, shiitake mushrooms and decorative plants are sold for medicinal, culinary and ornamental uses. Forest farming provides short-term income while high quality trees are grown for timber or wood products will provide more long-term income. An urban food forest integrates perennial nut and fruit-producing trees and shrubs with herbs, vines and ground flora that produce fruits, vegetables, and edible greens and roots, to achieve a self-sustaining, food-producing ecosystem. Urban communities are increasingly taking up the practice as a way to put underutilized city land to work and combine urban agriculture goals with goals for open space, recreation, and community development.

Silvopasture

Silvopasture is the intentional combination of trees, forage and livestock managed as a single integrated practice. In a typical silvopasture practice, perennial grasses and/or grass/legume mixes are planted between rows of widely spaced trees for livestock pasture. The trees not only provide a long-term investment with nut crops or a timber harvest, but also provide animals shade in the summer and a windbreak in the winter. In turn, the forage base provides feed for cattle, and other livestock. A silvopasture practice diversifies farm income; can minimize the need for vegetation control; and can reduce hay and feeding costs for livestock and improve animal health and welfare.

Alley Cropping

Alley cropping is planting rows of trees at wide spacings while a companion crop grows in the alleyways between the rows. Alley cropping can diversify farm income, improve crop production, and provide protection and conservation benefits to crops. Common examples of alley cropping plantings include pumpkins, hay, berry bushes, wheat, corn, or soybeans planted in between rows of chestnuts, black walnut or pecan trees. Trees selected for alley cropping may include valuable hardwood species, such as nut or fruit trees, or trees desirable for wood products.

Riparian Forest & Upland Buffers

Riparian forest and upland buffers are living filters comprising a continuous living cover of trees, shrubs, forb and grasses, including native plants. They enhance filtration of nutrients from surface runoff and shallow groundwater. These excess nutrients are utilized for plant growth. Riparian forest and upland buffers protect the water quality of streams and lakes and are an effective tool for controlling erosion and providing food and cover for wildlife. Decorative woody florals, nuts and berries planted in the shrub zone can provide additional income.

RESEARCH CLUSTERS

UMCA's interdisciplinary research program continues to work in <u>clusters</u> to create more synergy among scientists, enhance the Center's research creativity and productivity, and achieve better integration among diverse PIs and disciplines. Clusters serve as the vehicle to achieve an in-depth systems level understandings of agroforestry; enable UMCA and partner scientists to be more efficient in sharing resources (fiscal, physical and human), ideas and spawn new proposals to successfully leverage core funding.

Ecosystem services/Phytoremediation

Focus is to quantify fate and environmental benefits of woody/grass buffers on rural nonpoint source pollutants and bioremediation connected to urban wastewater treatment plants. Includes paired watershed studies focused on biomass crops and livestock, farm-focused edge-of-field monitoring as part of the NRCS Missouri River Healthy Watershed Basin Initiative.

Grad student Lalith Rankoth researching cover crop affects on corn production. More on page 15.

Socio-economic-marketing

The cluster's integrated approach works to understand the social and economic dimensions of a given enterprise, including institutions, networks, market, consumer and non-market valuation and the development of financial decision support tools. Research activities provide an understanding of factors that facilitate or constrain in agroforestry adoption.

Entrepreneurship

Taking research developed by Center research teams from the field and lab to the market. Focused on conducting research and promoting discovery along with applications for the technologies and intellectual property that result from our work.

Biomass/Biofuels

Focus is to quantify production of *Populus* clones, biomass sorghum, switchgrass and other species for biomass production and flood tolerance. Focus includes a flood tolerance research facility to study the effects of short- and long-term flooding on woody and non woody biomass species. Linked to ongoing efforts in entrepreneurship and phytochemistry to convert field research into lucrative business enterprises.

Specialty crops

Includes research involved in pecan, black walnut, chestnut, elderberry and pawpaw, etc. research. Foci for all specialty crop species include field studies, market, consumer and financial research and outreach.

Tree/crop interactions

Focus is on multiple above and below ground interactions between trees and crops and also includes insect predator-prey dynamics.

Education

The Center's education efforts focus on an innovative, on campus, and online agroforestry MS degree and graduate certificate. UMCA's online agroforestry MS was ranked the #1 best value online Environmental Science MS program.

Outreach

The Center's divers outreach program is centered on and adjacent to five outlying research properties with ongoing agroforestry research (HARC, Greenley, Wurdack, SW Center, Allen Research Center), and building out from these strengths. Includes an annual week-long Agroforestry Academy targeted to natural resource professionals, landowners and military veterans; annual Agroforestry High School Institute educators to teach agroforestry in the agriculture science curriculum; the annual Missouri Chestnut Roast, the Center's premier annual outreach event; numerous short-term trainings on all facets of agroforestry and specialty crops throughout the year. Socio-economic-market research is designed to mesh closely with outreach programming.

Phytochemistry/Medicinals

This cluster is focused on the elucidation and utilization of phytochemicals derived from a wide array of plant materials to be used in the health, nutrition and personal care industries.

Silvopasture/Shade tolerance

Integration of silvopasture into managed intensive grazing forage-livestock production systems. Objectives include: Research on the integration of silvopastoral practices into unimproved, standing timber; studying the effects of silvopasture practices on survival and growth of under planted white oak; impact of shade on animal welfare shade tolerance studies on big bluestem accessions and performance of big bluestem under a canopy of cherry bark oak and shortleaf pine.

PARTNERSHIPS

To accomplish our mission, the Center for Agroforestry at the University of Missouri partners with universities, natural resource agencies, agricultural organizations, nonprofits, and landowners across our state and the globe to foster an integrated approach to farming across diverse landscapes.

MU Collaborations
Ag Systems Mgt., Food Systems & Bioengineering
Bioinformatics Institute
College of Agriculture, Food & Natural Resources
Dalton Cardiovascular Research Center
School of Medicine: OB., Gyn. & Women's Health; Reproductive Medicine and Fertility & Andrology Lab; Family & Community Medicine Dept.; School of Natural Resources; University of Missouri Extension, Mizzou Advantage
Partnerships with MU faculty: Agronomy; Animal Model Core; Biochemistry; Cell & Immunobiology Core; Center for Family & Policy Research; Children & Family Across Cultures; Civil & Enviro. Engineering; Fisheries & Wildlife; Forestry; Horticulture; Human Development & Family Sciences; Life Science Center; Metabolomics Center; Metagenomics Center; Molecular Microbiology & Immunology; NMR Core; Plant Sciences; Physics; Proteomics Core; Rural Sociology; Soil, Environmental & Atmospheric Sciences; Veterinary Pathobiology
MU AES Centers: Bradford Research & Extension Center; Greenley Memorial Research Center; Horticulture & Agroforestry Research Center; South Farm Research Center; Southwest Research Center; Thompson Research Center; Wurdack Farm

External University Collaborations
Jesup Scott Honors College, Kansas State University, Lincoln University, Michigan State University, Missouri State University, Pennsylvania State University, Purdue University, Universities of California: Davis & San Francisco; University of Florida, University of Illinois, University of Kansas; University of Minnesota, University of Notre Dame, University of Tennessee, University of Toledo Dept. of Environmental Science

Federal and State Agency Partnerships
Missouri Department of Agriculture
Missouri Department of Conservation
Missouri Department of Natural Resources
Missouri Natural Resources Conservation Service
Missouri Soil & Water Conservation Districts
USDA National Agroforestry Center, Lincoln, Neb.
USDA ARS Cropping Systems & Water Quality Research
USDA ARS - Dale Bumpers Small Farms Research Center, Booneville, Ark.
USFS - Central Hardwoods Research Unit, Columbia, Mo.
USDA Forest Service Northern Research Station
USDA Hardwood Tree Improvement Research Center, Lafayette, In.
USDA Natural Resources Conservation Service
USGS Columbia Environmental Research Center

Professional Associations and Businesses
Association for Temperate Agroforestry
Chestnut Growers of America
Commonweal Foundation
Cummings, Cummings & Dudenhefer Law Firm
Danforth Center of St. Louis
Elemental Enzymes, Inc.
Forest & Woodland Association of Missouri
Forest ReLeaf of Missouri

Forrest Keeling Nursery
Green Lands Blue Waters
Hammons Products Company
Metabolon
Mid America Agroforestry Working Group
Missouri Chapter Walnut Council
Missouri Christmas Tree Association
Missouri Consulting Foresters Association
Missouri Farm Bureau
Missouri Forest Advisory Council (MOFRAC)
Missouri Forest Products Association
Missouri Northern Pecan Growers, LLC
Missouri Nut Growers Association
Missouri Prairie Foundation
Missouri Society of American Foresters
Missouri Tree Farm System
MS-Omics
National Aviary
Nutrapetsystems, LLC
Roeslein Alternative Energy, St. Louis
Savanna Institute
Thar, Inc.
Tiger Energy Solutions, LLC

Donors and Friends
AgriGro
Caribbean Probiotics, LLC
Barnes & Associates
Bartimus Frickleton Robertson & Goza
Kelly Foods Corp.
NutraPet Systems, LLC
Proviera Biotech
SCD Probiotics

UMCA/HARC Advisory Board
Lisa Allen, MO Dept. of Conservation
Joe Alley, MO NRCS
Paul Bailey, MO Dept. of Agriculture
Bob Ball, Walnut Council, MO Chapter
Scott Brundage, MO Foresters
Brandon Butler, Conservation Federation MO
Dr. Ronald Del Vecchio, MO State University
Dan Dey, USDA Forest Service
Annie Donoghue, University of Arkansas
J. R. Flores, MO NRCS
Dwaine Gelnar, MO NRCS
Larry Godsey, MO Valley College
Michael A. Gold, UMCA
Nate Goodrich, MO NRCS
Brian Hammons, Hammons Products Co.
Shibu Jose, MU CAFNR
Marc Linit, MU CAFNR
Wayne Lovelace, Forrest Keeling Nursery
Patrick Market, CAFNR SNR
Allison Miller, St. Louis University
Rob Myers, Board Chair, NCR SARE
Phillip R. Owens, USDA ARS
Alberto Pantoja, USDA ARS
Sarah J. Phipps, MO Dept. of Agriculture
Dan Pote, USDA ARS

PARTNERSHIPS

UMCA/HARC Advisory Board~continued~
Tim Reinbott, MU CAFNR
John Sadler, USDA ARS
Adam Saunders, Columbia Center for Urban Agriculture
Brian Schweiss, MO Dept. of Conservation
Kelly Smith, MO Farm Bureau
Susan Stein USDA National Agroforestry Center
Archie Tucker, USDA ARS
Doug Wallace, MO NRCS
Dusty Walter, MU CAFNR
Diomy Zamora, UMN Extension

Landowner Collaborations
Penny Clark, Goods from the Woods
Terry Durham, Eridu Farm
Greg and Jan Judy, Green Pastures Farm
Nicole McPherson, Ozark Forrest Mushrooms
Josh and Larin Payne, Payne Farms, Inc.
Dan and Jan Shepherd, Shepherd Farms
Shryocks Callaway Farms
Bill and Sue Ellen Stouffer, Cedar Hill Farm

International Collaborations
Abdul Wali Khan University, Pakistan
Beijing Forestry University, Beijing China
Bogor Agricultural University (IPB), Bogor, Indonesia
Center for International Forestry Research, (CIFOR) Bogor, Indonesia
Gadja Mada University, Yogyakarka, Indonesia
Institute Pertanian Bogor, Indonesia
International Crops Research Institute for the Semi-Arid Tropics, India (ICRISAT)
French National Institute for Agricultural Research-France
Institute of Technology of Buenos Aires, Argentina
NATO – Science for Peace and Security Program
University of Abomey Calavi, Benin
University of Costa Rica
University of Pretoria, South Africa
University of Udayana, Bali, Indonesia
World Agroforestry Centre, Nairobi, Kenya
National Sun Yat-sen University, Kaohsiung, Taiwan
Zhejiang Gongshang University, Zhe Jiang Province, China

STAFF & COLLABORATORS

Interim Director Michael A. Gold, Ph.D.

UMCA Faculty & Staff
Sougata Bardhan, Ph.D., Asst. Res. Professor
Zhen Cai, Ph.D., Asst. Res. Professor
Hannah Hemmelgarn, M.S., Education Program Coord.
Chung-Ho Lin, Ph.D., Associate Res. Professor
Gregory Ormsby Mori, MPH, Outreach Coordinator
Caroline Todd, B.S., Business Specialist
Phuc Vo, Research Lab Manager
Ranjith Udawatta, Ph.D., Research Professor

HARC Farm Staff
Barry Eschenbrenner, B.S., Farm Manager
Shibu Jose, Ph.D., Superintendent
Clint Kohlmeier, B.S., UMCA Sr. Lab Technician
Cliff McGee, UMCA Sr. Lab Technician
Mark McGee, UMCA Sr. Lab Technician
Tim Pilcher, B.S., UMCA Chestnut Harvest Technician
Cheryl Recker, B.S., Sr. Lab Technician
Aaron Templemire, M.S., Sr. Lab Technician

Associate Faculty & Staff at MU
Francisco Aguilar, Ph.D., Forestry
Steve Anderson, Ph.D., SEAS
Bruce Barrett, Ph.D., Entomology
Charles Brown, Ph.D., Veterinary Pathobiology
Johann Bruhn, Ph.D., Emeritus, Plant Sciences
Gustavo Carlo, Ph.D., Child/Families Across Cultures
Christine Costello, Ph.D., Bioengineering
Aaron Ericsson, Ph.D., Metagenomics Center
Maria Fidalgo, Ph.D., Civil/Enviro Engineering
Felix Fritschi, Ph.D., Plant Sciences
Matt Gompper, Ph.D., Fish & Wildlife
Hong He, Ph.D., Forestry
Zhiqiang 'Zack' Hu, Ph.D., Civil/Enviro Engineering
Enos Inniss, Ph.D., Civil/Enviro Engineering
Robert Kallenbach, Ph.D., CAFNR, Extension
Kattesh Katti, Ph.D., Radiology & Physics

Cerry Klein, Ph.D., Industrial/Mfg. Sys Engr.
Ben Knapp, Ph.D., Forestry
David Larsen, Ph.D., Forestry
Teng Teeh Lim, Ph.D., Food Systems & Bioengineering
Marc Linit, Ph.D., CAFNR, AES
Louis Manfra, Ph.D., Human Devlpmt & Family Science
Jane McElroy, Ph.D., Family & Community Medicine
Jeanne Mihail, Ph.D., Plant Pathology
Peter Motavalli, Ph.D., SEAS
Susan Nagel, Ph.D., Ob, Gyn & Women's Health
Henry T. Nguyen, Ph.D., Plant Sciences
Francisco Palermo, Ph.D., Family & Policy Research
Bob Pierce, Ph.D., Fisheries & Wildlife
Tim Reinbott, Ph.D., Director AES Field Ops
Mike Stambaugh, Ph.D., Forestry
Hank Stelzer, Ph.D., Forestry Extension
George Stewart, Ph.D. Veterinary Pathobiologist
Andrew Thomas, M.S., Plant Science, Southwest Center
Corinne Valdivia, Ph.D., Ag Applied Economics
Dusty Walter, Ph.D., Ag Exp. Station
Michele Warmund, Ph.D., Plant Sciences
Patrick Westhoff, Ph.D., Ag Applied Economics
Xiaoqin Zou, Ph.D., Dalton Cardio Research Center

External Collaborators
Lisa Allen, Missouri Dept. of Conservation
Joe Alley, MO NRCS
Heidi Appel, University of Toledo
Claire Baffaut, USDA ARS
Charles Barden, Kansas State University
Gary Bentrup, USDA/NAC
Deborah Brennan, USDA ARS
Karen Brinkman, MO NRCS
Scott Brundage, Missouri Consulting Foresters
Lauren Cartwright, Missouri NRCS
Melis Cercioglu, Postdoc, Dumlupinar Univ. Turkey
Gregory Cuomo, University of Minnesota

COLLABORATORS & GRADUATE STUDENTS

External Collaborators~*continued*
Daniel C. Dey, USDA Forest Service
Natalie Diesel, MDC
Jeanne Dollinger, Ph.D., French Institute Ag Research
Annie Donoghue, USDA ARS, Fayetteville, Ark.
Dwaine Gelner, Missouri NRCS
Larry Godsey, Missouri Valley College
Nate Goodrich, Missouri NRCS
Robert Harrison, University of California
Steve Hefner, NRCS
Jason Hubbart, Ph.D., W. Virginia Univ.
Abua Ikem, Lincoln University
Newell Kitchen, USDA ARS
Steven Latta, National Aviary
Robert Lerch, USDA ARS
Sarah Taylor Lovell, Univ. of Illinois
Kate MacFarland, USDA/NAC
Erin Meier, Green Lands Blue Waters
Allison Miller, St. Louis University
Phillip Moore, USDA ARS, Fayetteville, Ark.
Mel Oliver, USDA ARS
Phillip Owens, USDA ARS Booneville, Ark.
Sharyle Patton, Commonweal Foundation
Dan Pote, USDA ARS, Booneville, Ark.
Charlotte Clifford-Rathert, USDA APHIS
Adolfo Rosati, Council for Ag Research & Econ, Spoleto, Italy
Jason Rowntree, Michigan State University
Anuradha Roy, University of Kansas
John Sadler, USDA ARS
Michael Sadowsky, University of Minnesota
Tom Sauer, USDA ARS, Ames, Iowa
Jack Schultz, University of Toledo
Brian Schweiss, Missouri Dept. of Conservation
Ajay Sharma, University of Florida
Craig Sheaffer, University of Minnesota
David Stanley, USDA ARS
Susan Stein, USDA/NAC
Richard Straight, USDA/NAC
Donald Tillitt, USGS
Jerry VanSambeek, USDA Forest Service
Wilfred Vermerris, University of Florida
Kristen Veum, USDA ARS
Doug Wallace, Missouri NRCS
Ronald S. Zalesny, Jr., USFS
Diomy Zamora, University of Minnesota

Graduate Students 2018
Colleen Abels, MS
Daniel Allen, Online MS
Lindsay Allen, Online MS
Jonathan Aylward, Online MS
Pamela R. Bergstrom, Online MS
Cody Beus, Online MS
Michael Borucke, Ph.D.
Carrie Brausieck, Online Graduate Certificate
Michael Cooley, Online MS
Donna J. Davis, Online MS
Haryo Ajie Dewanto, MS
Ade Ayu Dewayani, MS
Ryan Dibala, Ph.D.
Amanda Dwikarina, MS
Novianus Efrat, MS
Meredith Evans, Online MS
Katherine Favor, Online MS
John Falco, MS
David Ferrell, Online MS
Andrew Harmon, Online Graduate Certificate
Dienda Hendrawan, MS
Summer Higdon, Online Graduate Certificate
Andrew Ireland, Online Graduate Certificate
Van Khanh Ho, MS
Shu Yu Hsu, Ph.D.
Lia Kellogg, Online MS
Brad Kindler, Online Graduate Certificate
Abel Kloster, Online MS
Dorin Kusumawardani, MS
Anna Maassell, Online MS
Jace McCown, Online MS
Sophie Mendelson, Ph.D.
Jason Neumann, Online Graduate Certificate
Muhamad Nugraha, MS
Gregory Ormsby Mori, Online MS
Chastaine Perry, Online MS
David Pritchett, Online Graduate Certificate
Stephen Quinn, Online MS
Kania Rahayu, MS
Lalith Rankoth, Ph.D.
Tyler Reece, Online Graduate Certificate
Olga Romanova, MS
Ainun Seruni, MS
Priyanka Sharma, Ph.D.
Dayu Soraya, MS
Amanda Jo Talbot, MS
Ali Hohsseini Taleghani, Ph.D.
Jodi Trendler, Online Graduate Certificate
Danielle Turley, MS
Danh Cong Vu, Ph.D.
Timothy Watkins, Online MS
John Weedon, Online Graduate Certificate
Kevin Whetstone, Online Graduate Certificate
Bennett E. Wickenhauser, Online MS
Jessica Wilson, MS
Michelle Woolbright, Online Graduate Certificate

Bioremediation and Phytochemistry in Agroforestry

Black walnuts contain heart-healthy nutrients that can stave off obesity and cardiovascular disease

Black walnuts (*Juglans nigra*) are a major industry in the Midwest, with about 23 million pounds processed annually in Missouri alone, and they are a ubiquitous presence on lawns in early fall. But while many tree nuts, such as English walnuts (*Juglans regia*), have received attention for their nutritional benefits, comparatively little research has focused on our native black walnuts.

In a first-of-its-kind study, researchers at the MU have confirmed that black walnuts contain molecular compounds called phytosterols, which have been shown to help prevent obesity, diabetes and cardiovascular disease while promoting lower cholesterol, lower inflammation and anticancer activity in the body. Phytosterols have previously been found in English walnuts, but researchers discovered black walnuts are a richer source of the health-promoting molecule.

"The black walnut is already an important crop in the Midwest, but we are beginning to see it still has enormous potential," said Chung-Ho Lin, an associate research professor at UMCA. "The health benefits of phytosterols are well known, and now we have critical information for both consumers and producers that shows black walnuts are a great diet option for those looking to reduce their risk of cardiovascular disease."

Lin and his colleagues — including Danh Vu, a graduate student in the School of Natural Resources — compared the phytosterol profiles of English walnuts and six of black walnuts. Taking advantage of recent advances in phytosterol analysis and MU's new Metabolomics Center, researchers performed the first systematic analysis and comparison of the heart-healthy nutrients across different black walnut. Two, known as 'Tomboy' and 'Chesler', surpassed the English walnut with the potential health benefits of their phytosterol compounds.

UMCA has the largest collection of black walnut cultivars in the United States and an active breeding program to create improved cultivars for the future of the industry.

"This is an exciting development because it opens the door to other commercial applications for the black walnut," Lin said. "They are a great nutritional option when eaten, but some dietary supplements are also fortified with phytosterols, so this walnut has a

Dr. Chung-Ho Lin presenting the keynote lecture "Identifying value added, health-promoting compounds from waste plant materials" at the 44th National Annual Conference of the South African Association of Botanists (SAAB) 2018.

valuable component that could be separated and used in other ways. This nut could have a real impact on the Midwestern economy in a number of ways."

Lin said a large amount of waste material is generated when processing black walnuts. This study suggests that some of that waste material could be turned into valuable products, including supplements and cosmetics with anti-inflammatory and anti-oxidant properties. Cosmetic applications would reach the market quicker than other uses because they do not need to be approved by the Food and Drug Administration, Lin said.

The study, "Identification and quantification of phytosterols in black walnut kernels," was published in the *Journal of Food Composition and Analysis*. Other researchers involved in the study were Zhentian Lei and Lloyd Sumner of the MU Metabolomics Center, and Mark Coggeshall of the U.S. Forest Service Hardwood Tree Improvement Research Center. Research funds were provided by UMCA and the Missouri Specialty Crop Block Grant Program.

Air quality measurement tool could be beneficial for children's health.

Children spend as many as 10 hours per day and five days per week in child-care and preschool centers. Given the significant amount of time spent indoors, researchers at MU are working together to determine how harmful volatile organic compounds, which could be released in the air by cleaning products, school supplies, toys and air fresheners, impact children's health. Until recently, measuring air quality in child-care centers has been difficult and expensive. Now the researchers have created a portable, low-cost measurement tool that can efficiently measure air-quality at child-care centers. "The volatile organic compounds found in the air come from common school supplies, cleaning products, paints, solvents and refrigerants," said Chung Ho Lin, research associate professor at UMCA. "Past research has indicated that these compounds might have adverse effects for children, such as triggering asthma."

Lin and Danh Vu, a graduate student in the School of Natural Resources, assembled small air pumps that were able to collect air for analysis. The pumps are connected to a tower that can be adjusted to capture air at several heights. The researchers analyzed the air samples and found 47 of 73 known volatile compounds that have been linked to health issues. "Children are particularly susceptible to chemical exposure from volatile organic compounds as their heart and respiration rates are faster than adults, meaning they take in more air," said Gustavo Carlo, professor of human development and family science and co-director of the Center for Children and Families Across Cultures in the College of Human Environmental Sciences. "Moreover, they can be exposed longer and their immune systems are still developing."

The researchers say that parents and caretakers should not be alarmed by the findings and that efficiently measuring volatile organic compounds in the air is a necessary step for improving air quality. The research team suggests that those concerned about indoor air quality can take several measures to reduce exposure to volatile compounds including opening the windows, using 'air friendly' art supplies, installing air filters and avoiding chemical based fragrances and air fresheners.

"While people might think that measuring air quality is simple, it can be quite challenging given that many things—room size, air flow and proximity to doors or windows—can impact the measurement," Lin said. "We also need to accommodate for children being near

Electronic nose that detects volatile organic compounds.

the tool and find a way to measure air quality that isn't distracting to their learning environment," added Vu.

"Determination of volatile organic compounds in child-care centers by thermal desorption gas chromatography-mass spectrometry," was recently published in *Analytical Methods,* a journal of the Royal Society of Chemistry. The work was supported by the MU Center for Family Policy Research, UMCA, and the Center for Children and Families across Culture.

Carlo, Lin and Vu are working with a collaborative team of researchers from various departments at the University of Missouri along with the Kansas City Head Start program to study environmental impacts on child health. The team also includes:

- Jane McElroy, associate professor of family and community medicine in the MU School of Medicine
- Susan Nagel, associate professor of obstetrics, gynecology and women's health in the MU School of Medicine
- Francisco Palermo, assistant professor of human development and family science in the MU College of Human Environmental Sciences
- Zehra Gulseven, graduate student in human development and family science
- Phuc Vo, UMCA lab manager
- Alexandra Davis, assistant professor at the University of New Mexico College of Education; and
- Thi Ho, (MU alumni) researcher of the Center of Core Facilities

in the Cuu Long Delta Rice Research Institute in Vietnam, also contributed to the study.

Soil Health\Upland Buffers

PLFA analysis shows that cover crops improve soil microbial populations

Missouri ranks nationally 6th in soybean and 9th in corn production (2017 Agricultural Statistics Annual Bulletin Missouri). The average farm size in Missouri is 293 acres and 97,300 farms occupy 2/3 (28.3 million acres) of the state's land area. The large number of farms, both small and large, are important as agriculture contributes $88 billion to Missouri's economy. The sustainability of agriculture is largely dependent on environmentally friendly, socially acceptable, and economically profitable farming practices.

 The use of cover crops is becoming popular due to numerous benefits to the farming environment. Cover crops are known to reduce soil erosion by providing a ground cover. They also enhance soil quality by improving nutrient cycling, soil organic matter, carbon inputs and soil microbial biomass. Cover crops influence the size and activity of soil microbial population and their community structures. Soil microbes play a major role in soils as well as in farming systems by mediating various processes like organic matter decomposition, nutrient dynamics and plant growth. Thus, increases in various types of microbial populations bring benefits to the farming system and improve the environmental quality.

A research team of MU soil science professors, Clark Gantzer USDA research soil scientist and UMCA Research Professor Ranjith Udawatta, initiated a watershed scale research in 2012 to study the cover crop effects on soil and water quality where soil microbial population and community structure is a major component of the project. The study was conducted at the Chariton County Cover Crop Soil Health research and demonstration farm in north central Missouri (Fig. 1). Soil samples from 0-10 cm depth representing cover crop and no cover crop areas have shown stimulating results by means of phospholipid fatty acid (PLFA) profile analysis. PLFA is a component in live cell membranes thus active microbes can be identified by different PLFA biomarkers.

The results have shown significantly ($p < 0.05$) greater total microbial biomass in cover crop treatment compared to no cover in 2016 and 2018 Significant cover crop and no cover treatment

effects were also observed on soil microbial community structure. Total bacterial biomass, total fungal biomass and actinomycetes biomass were significantly greater in cover crop treatment compared to no cover in 2016 and 2018. On average 2.4, 2.5 and 2.3 times greater bacterial, fungal and actenomycetes biomass in 2016 and 1.7, 1.6 and 1.7 times greater bacterial, fungal and actenomycetes biomass in 2018 were found in cover crop plots compared to no cover.

Spatial distribution of total microbial biomass (Fig. 2) varied from year to year. In 2016 and 2018, all the areas with greater microbial biomass were located in cover crop treatment indicating positive effects of cover crops on soil microbes. However, in 2017 no cover crop areas also had a greater microbial biomass and this was caused by a dense henbit growth in that area before the cash crop was established.
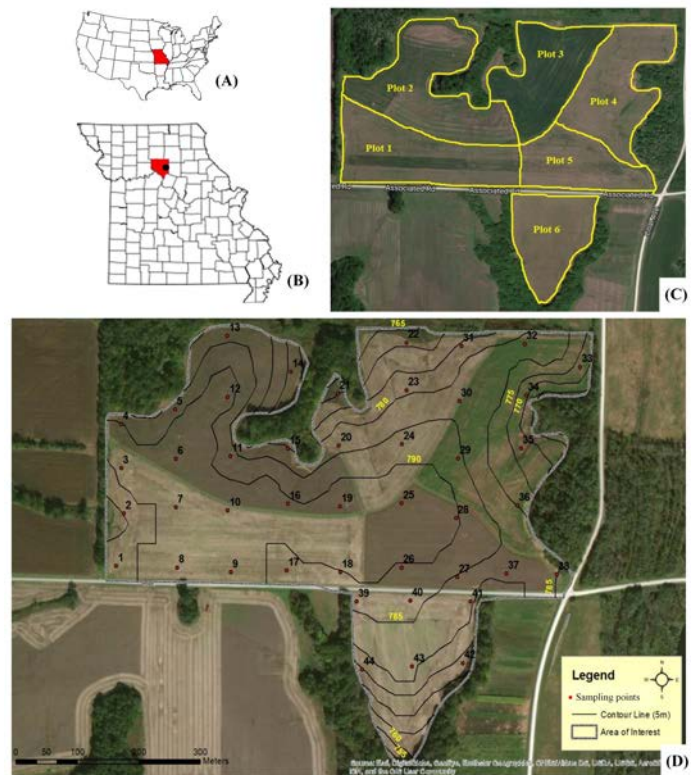
Fig. 1. Missouri state within United States and approximate study site location in Chariton County (A and B). Plots with cover crops (1 to 5; C), no cover crops (Plot 6; C), Contour lines (D), and 45 sampling points (D).
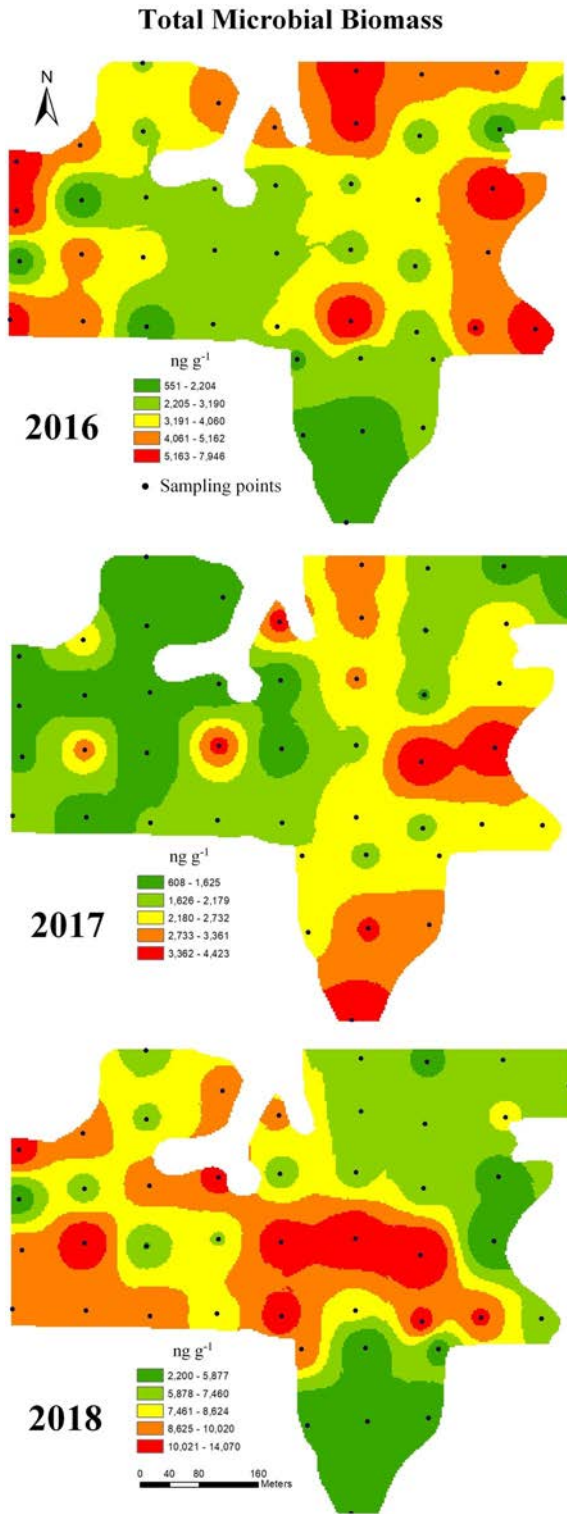
Total Microbial Biomass

ng g⁻¹ — 2016 legend:
- 551 - 2,204
- 2,205 - 3,190
- 3,191 - 4,060
- 4,061 - 5,162
- 5,163 - 7,946

• Sampling points

ng g⁻¹ — 2017 legend:
- 608 - 1,625
- 1,626 - 2,179
- 2,180 - 2,732
- 2,733 - 3,361
- 3,362 - 4,423

ng g⁻¹ — 2018 legend:
- 2,200 - 5,877
- 5,878 - 7,460
- 7,461 - 8,624
- 8,625 - 10,020
- 10,021 - 14,070

0 40 80 160 Meters

Fig. 2. Spatial distribution of total microbial biomass in 2016, 2017 and 2018. In all figures, the highest concentration was represented by red and the lowest by green (Legend value ranges are different from map to map).

This study explained that use of cover crops has significantly increased total microbial population level in two out of three years compared to no cover crop. And that increase was due to an increase in most of the major microbial categories including gram (+) bacteria, gram (-) bacteria, arbuscular mycorrhizal fungi and saprophytes. This reflects that cover crops can improve soil microbial population levels and microbial community structure and contribute to added benefits to farming systems.

Weerasekera, C.S., R.P. Udawatta, C.J. Gantzer, R.J. Kremer. S. Jose, and K.S. Veum. 2017. Effects of cover crops on soil quality: selected chemical and biological parameters. *Communications in Soil Science and Plant Analysis.* 48:2074-2082.

Soil Health/Upland Buffers

Experiment investigates effects of plant diversity, harvest and manure application on native prairie feedstock for biogas production.

Integration of agroforestry and other conservation practices into row crop agricultural management practices can contribute to surface soil water content, increased water infiltration and storage. In addition, agroforestry buffers can reduce soil water through enhanced water consumption, and this reduced soil water content will improve water infiltration and reduce runoff. These improved soil water dynamics can increase water storage under agroforestry and grass buffers and thereby reduce surface runoff carrying sediment, nutrients, and pesticides from row crop agricultural watersheds. However, a good understanding of water use within the soil profile is needed to design sustainable management practices including agroforestry buffer strips and biomass crops.

Drs. Ranjith Udawatta and Stephen Anderson with their graduate students Lalith Rankoth and Salah Alagele installed soil water sensors at the long-term experimental site with three adjacent north-facing watersheds located at the University of Missouri Greenley Memorial Research Center, Novelty, Knox County, in northeast Missouri, USA (Fig. 1). The

Fig. 2. Trees in an agroforestry buffer.

row crop treatment. This could be due to more water use (higher transpiration and more water depletion) by trees, grass, and switchgrass relative to row crops. This decrease in water content by the perennial vegetation may help to reduce nutrient and sediment runoff during subsequent rainfall events as well as improve water recharge in the soil profile.

Fig. 1
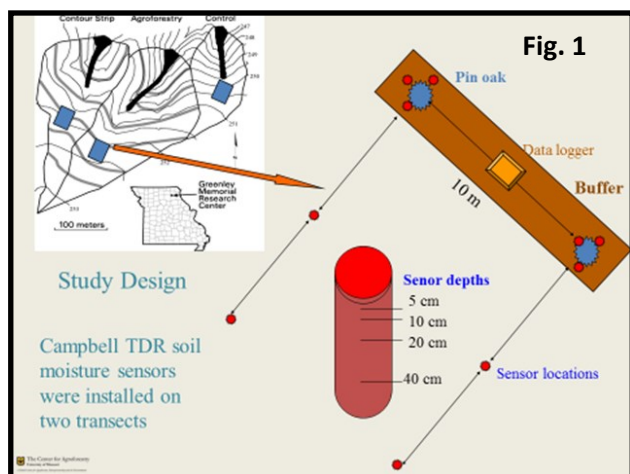
study design consisted of an agroforestry buffer (Fig. 2), a contour grass buffer, row crops and biomass crops. Soil water content was determined by Campbell CS-616 (Campbell Scientific Inc, Logan, UT) sensors installed at 5 cm, 10 cm, 20 cm, and 40 cm depths with three replications (Fig. 3).

Results showed significant differences ($p<0.05$) in weekly soil water content among treatments for all four soil depths. Soil water content decreased more rapidly during the summer in agroforestry buffers, grass buffers, and biomass crops compared with the

Fig. 3. Soil moisture sensors at 5 cm, 10 cm, 20 cm and 40 cm soil depths.

During recharge periods, a larger increase in soil water content due to better infiltration was observed in the perennial vegetative management practices relative to row crop areas. These changes can be attributed to enhanced soil pore characteristics (macroporosity), root systems, root channels/decay, and changes in soil carbon in agroforestry, grass, and biomass areas.

For the 40 cm sampling depth, water content values were higher compared to the 5 cm, 10 cm, and 20 cm soil depths (Fig. 4). This occurred because bulk density for the 40cm soil depth was lower than other depths due to an increase in clay content and subsequent swelling of clays through these subsoil horizons.

Results of the study show that establishment of agroforestry upland buffers, grass buffers, and biomass crops on strategic locations within row crop watersheds can help reduce non-point source pollution from row crop agriculture, particularly for eroded claypan landscapes. The lower soil water content found in the buffer and biomass treatments during pre-recharge periods and the subsequent increased water infiltration and profile recharge during rainfall events will reduce surface runoff and soil loss under these perennial vegetative management practices relative to grain crop production. Reductions in losses of top soil and nutrients can directly benefit landowners. In addition, planting perennial vegetation systems such as trees and grasses improve soil health parameters. However, as trees mature, appropriate cultural practices including root pruning, removing branches, and thinning are needed to reduce the competition for resources and other ecosystem benefits.
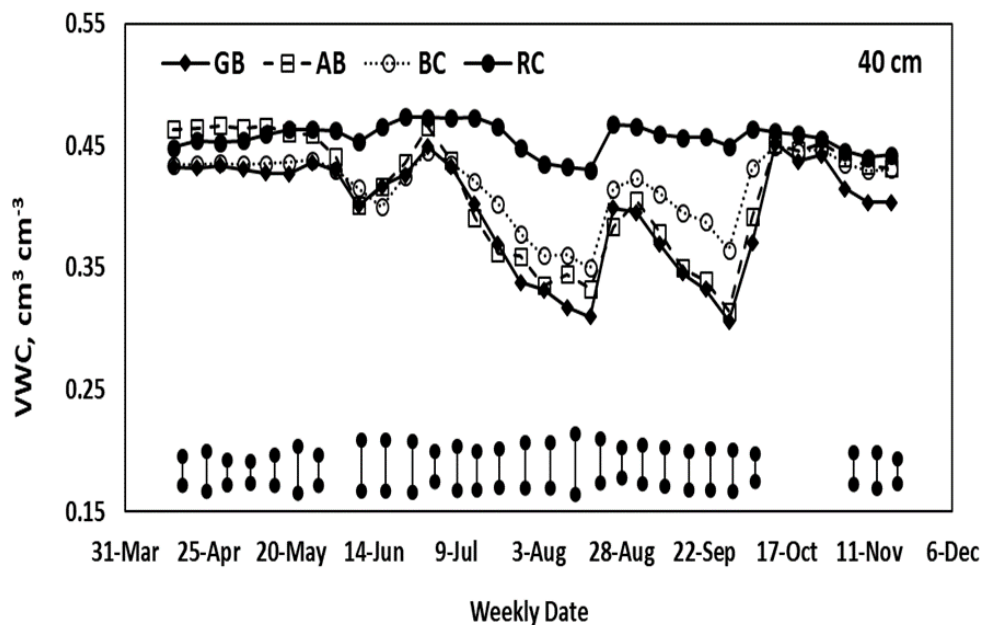

Fig. 4 Weekly soil water contents for grass buffer (GB), agroforestry buffer (AB), biomass crop (BC) and row crop (RC) treatments at 5cm and 40 cm depths. Bars indicate the leaset significant difference.

Alagele, S.M., S.H. Anderson, and R.P. Udawatta. 2018. Biomass and buffer management practice effects on soil hydraulic properties compared to grain crops for claypan landscapes. *Agroforestry Systems*. Doi.org/10.1007/s10457-018-0255-1

Come celebrate the 200th Anniversary of the
Historic Hickman House
Listed on the national register of historic places
during the 13th Annual Chestnut Roast Festival
Saturday, October 5, 2019 10am to 4pm
Horticulture & Agroforestry Research Center
New Franklin, Missouri
https://harc.missouri.edu/events

Water Quality\Upland Buffers

Cover crops affect corn plant water dynamics

Missouri is the 9th largest corn producer in United States and around 4 million acres are harvested with an average yield of 175.5 bushels per acre annually. Missouri is also the 9th largest corn exporting state and brings $347.6 million every year to the state's economy. (Missouri Crop Resource Guide, MU). The cultivated acreage, yield and income are highly dependent on the weather conditions and available soil water for the growth of plants.

Cover crops, a form of continuous living cover, are being widely used by farmers due to numerous benefits to farming lands, including soil conservation, nutrient dynamics and organic matter improvement. Greater carbon inputs can improve soil water holding capacity and provide water to corn plants during summer or periods with low soil water. In contrast, cover crops can also use more soil water and leave less for the following cash crop. The best way to identify this phenomenon is testing corn plants water uptake and total transpiration.

A research team of MU soil science professors, Clark Gantzer USDA research soil scientist, UMCA Research Professor Ranjith Udawatta and Ph. D. graduate student Lalith Rankoth, are evaluating the effects of cover crops on corn plant water uptake and sap flow dynamics. The research is being carried out at the Bradford Research Center, University of Missouri. A Dynamax Flow32-1K sap flow measurement system and CR1000 data logger with SGB25 sensors were used in the experiment. Dynamax system can measure sap flow rate in corn plants in every 15 minutes. Dynamax sensors are attached to the stem of corn plants (Fig. 1) and then connected to the data logger (Fig. 2). The sensor gives a constant heat pulse to the stem and measures the sap flow rate. Volumetric soil moisture contents at 10, 20 and 30 cm depth were also measured at 15-minute intervals using Campbell Scientific soil water reflectometers (Fig. 3).

Water uptake in corn plants under no cover crop treatment showed higher levels than that of cover crop treatment for the tasseling to grain filling period in 2017. After maturity, corn plants in the cover crop plot used more water compared to no cover crop indicating a longer soil water holding capacity in cover crop soil. Results explained that cover crops conserve soil water and allow corn plants to use more water during dry periods.

Fig. 1. Corn plant with a sensor with a wire that connects to a data logger.

Fig. 2. Corn plant with the insulation cover to protect the sensor..

Fig. 3. Soil water reflectometers installed at 10 cm, 20 cm, 30 cm depths.

Influence of trees and integrated application of biochar and nitrogen on soil health in marginal lands

Agroforestry systems impact organic matter addition to soil system through litterfall, root residues, and plant root exudates in the root zone rhizosphere. Biochar is form of black charcoal formed when biomass is subjected to super-heated temperatures in an oxygen-limited environment. When used as a soil amendment, biochar has been reported to enhance soil fertility and improve soil quality. Research conducted by UMCA Assistant Research Professor Dr. Sougata Bardhan and Ph.D. candidate Pryanka Sharma seek to develop a deeper understanding of combined effects trees, biochar, and nitrogen management on soil health in marginal lands. Soil degradation has an adverse impact on the environment, agricultural productivity and on world food security. Drastic reduction in soil organic matter, depletion of plant nutrient reserves, and a decline in soil structure negatively affect soil health and productivity. Soil health is the soil's capacity to function as a living system, to maintain or enhance air and water quality, to sustain plant and animal productivity, and to promote plant and animal health. Healthy soils maintain a diverse community of soil microorganisms which helps to control plant diseases and improves soil physio-chemical properties ultimately leading to improved crop production.

For decades, the focus of modern agriculture has primarily been on achieving high levels of production from fertile lands by intensive use of fertilizers and pesticides, use of improved crop varieties and irrigation, leaving marginal lands for other uses. Sustainable land management includes the use of soil amendments and land use practices that improve soil structure and function, making the soil more suitable for production.

Although there have been several studies investigating the use of biochar-based soil amendments and tree-based systems on soil quality, little attention has been paid on their effects on nutrient-poor marginal lands. Furthermore, to our knowledge, no research has been carried out to see the combined effects of trees, biochar and nitrogen management on soil health in marginal lands prone to hydrologic (wet/dry) extremes. This research study is investigating the mechanisms through which these factors affect soil physio-chemical and biological properties. Given the widely observed benefits of biochar application and tree

incorporation on soil, integrating trees and biochar is expected to enhance soil quality, perhaps even with synergistic effects. Biochar is expected to reduce N fertilizer application requirement by improving nutrient use efficiency.

The objective of this study is to determine the combined effect of biochar and nitrogen on soil chemical properties and plant biomass in a tree and grass-based system. Switchgrass and poplar were grown in pots and the pots were arranged in a shadehouse in a randomized complete block design with each treatment replicated three times.

The treatments include biochar application at rates of:

0   metric ton ha-1 (B0)
5   metric ton ha-1 (B1)
15 metric ton ha-1 (B2)
20 metric ton ha-1 (B3)

The treatments include nitrogen application at rates of:

0   Kg/ha (N0)
90   Kg/ha (N1)
120 Kg/ha (N2)

Initial Results:

Plants were harvested after five months of growth and the biomass yield was measured to determine the synergistic effect of biochar and nitrogen on plant growth. The combined application of biochar and nitrogen significantly increased the biomass yield as compared to the sole application of biochar or nitrogen for both switchgrass and cottonwood. In almost all treatments, the biomass yield of switchgrass is found to be higher than the biomass yield of poplar after one season. Increase in nitrogen application without the addition of biochar did not have any significant effect on poplar biomass yield. Nitrogen treatments did have a beneficial effect on the growth of switchgrass. Increase in biochar application without the addition of any nutrient source (Nitrogen) does not have any significant effect on the yield of plants.

Biomass\Upland Buffers

Native warm season polyculture mixes for bioenergy and soil health

Bbiomass plot at the polyculture experiment.

Prairie communities change through time, driven by competition between species, the variability of soil and weather, effects of past land use, current management practices (e.g., use of fertilizer) and interactions among these factors. An ongoing biomass polyculture experiment will provide information about biomass yield potential and soil properties as influenced by species composition. Subsequent experiments will be conducted to monitor the degradation of veterinary antibiotics in these prairie agroecosystems.

Growing native perennial herbaceous plant species as continuous living cover feedstock for bioenergy and ecosystem sustainability compared to non-native and annual plants has many advantages. Diverse mixtures of native prairie plants, when carefully managed on agronomically and economically marginal lands, can prevent soil erosion, retain soil nutrients, improve water quality, sequester atmospheric carbon, provide critical wildlife and pollinator habitat, and provide bioenergy feedstock simultaneously.

Soil microorganisms play a vital role in nutrient cycling, organic matter dynamics, and degradation of chemicals in soil. Several studies have reported that aboveground plant species can influence the composition of underlying soil microbial communities. These influences can be due to differences in canopy cover, rooting depth, litter quality, and quantity or due to indirect effects of plants on soil pH, moisture, and nutrient levels. It is possible to alter the microbial community composition and activity by altering the aboveground plant species composition and diversity. The effect of such an impact would be both on the productivity of biomass as well as soil health.

A polyculture experiment at the MU Bradford Research Center was established in 2016 and has been managed by Dr. Sougata Bardhan since 2017. The 3 acre plot consists of five plant treatments: fescue monoculture ("control"), switchgrass monoculture (native ecotype), "low-diversity" prairie mix (9 species; two grasses, six forbs, one legume), "high-diversity" prairie mix (18 species; four grasses, 12 forbs and two legumes), and a "moderate diversity" mix (12 species; three grasses, seven forbs and two legumes). There are three harvest treatment levels: no harvest, annual harvest (after senescence) and green harvest every third year (any time after July 15, according to grassland bird protection protocols).

Different plant species included in the experiment are listed in Table 1. Annual evaluation of the presence of each species was made. Based on those findings, most of the planted species were observed in the second growing season in all three diversity plots except for Big bluestem and plains coreopsis. Biomass was harvested at the end of the growing season for the different plots, as determined by the harvest regime. After harvest, fresh biomass was converted to dry weight. Biomass yield significantly differed among the different treatments. Yield for all diversity mixes was significantly higher than the fescue monoculture and low and moderate diversity plots yielded significantly higher than the switchgrass monoculture. There was no significant difference between the different diversity mixes. Interestingly, the highest average biomass yield was observed for the low diversity mix, followed by moderate and high diversity mixes.

Further measurements are being conducted in the biomass yield for the various other plots for two-year yields. Soil properties, both physicochemical and biological, will be analyzed to quantify the differences due to the different species combinations.

Plant species in the biomass polyculture experiment (common names):

Forbs	Grasses
Common milkweed	Big bluestem
Butterfly milkweed	Little bluestem
Stiff goldenrod	Indiangrass
Yellow coneflower	Switchgrass
Pale purple coneflower	Candad wild rye
Plains coreopsis	Fescue
Willow-leaved sunflower	
Compass plant	Legumes
Rosinweed	Purple prairie clover
New England aster	white prairie clover
Rough blazing star	
Black-eyed Susan	Woody
Wild bergamot	Willow

Design and Study of Three-Tier Agriculture

Agroforestry Ph.D. candidate Ryan Dibala studied plant interactions in the early stages of growth after silvopasture establishment. One of the unifying themes in Ryan's research is the use of perennial tree and shrub fodder as an alternative forage for livestock, particularly during the summer slump, when high value grasses and legumes become limited. Some shrubs have leaves containing levels of protein equal to or greater than commonly planted herbaceous forages and have been shown to retain green foliage even during the worst droughts due to their deep root systems. Moreover, the introduction of woody fodder into a diet comprised of solely herbaceous forages can increase overall intake and forage conversion efficiency. One species whose fodder has been shown to have exceptional nutritional benefits is white mulberry (*Morus alba*). While fodder production and yield of *M. alba* has been studied extensively, that of the native and shade tolerant red mulberry (*Morus rubra*) has received little attention. In the spring of 2016, 160 red mulberry seedlings were planted under a shade gradient in the Cherrybark Oak (*Quercus pagoda*) plantation at the Horticulture and Agroforestry Research Center (HARC) in New Franklin, Missouri. Beginning May of 2017, data were collected on red mulberry growth, survival, biomass yield, and nutritive content. The objective of this research is to assess red mulberry growth and nutritive value response to different levels of shading to provide initial data to farmers who may be interested in integrating this species into their silvopastures as an extra source of forage and fruit

Photos from the mixed native species plantation established in 2005 at the IDB ranch near Playa Venao, Panama, illuminating stark differences between the rainy (left) and dry (right) seasons.

(for swine). This alternative forage has the potential to enhance forage diversity, leading to improved animal nutrition amidst an increasingly unpredictable climate.

Mulberry seedling survival was significantly affected by year, shade treatment, and the interaction. One year after planting, only 57.5% of seedlings survived, with no differences in survival between shade treatments. In May of 2017, dead seedlings were replaced with seedlings of comparable size and remeasured four times in 2018. In all four measurements after replanting, the two most open overstory tree densities (30' x 30' and 40' x 40') had significantly higher survival than the two most dense overstory tree densities (10' x 10' and 20' x 20'). Growth patterns indicate that seedlings grown under trees on a 30' x 30' spacing produce similar heights and diameters to those growing under trees on a 40' x 40' spacing (Table 1).

The incorporation of fodder shrubs as a mid-story component in silvopastoral systems can have both positive and negative effects on surrounding vegetation. In a separate study in Panama, Ryan examined the effects of two drought resistant fodder shrubs, *Leucaena leucocephala* and *Tithonia diversifolia*, on the growth and production of neighboring seedlings and grasses. These two shrubs are known for their fertilizer effects, the former fixing atmospheric nitrogen and the latter mobilizing phosphorus. Ryan tested the hypothesis that the integration of

Age (months)	Tree Density (ft)				
	10x10	20x20	30x30	40x40	Overall
0	100 aA	100 aA	100 aA	100 aA	100
12	57.5 aB	60 aB	57.5 aB	55 aB	57.5
16	70 aC	77.5 aC	87.5 bC	95 bA	82.5
24	70 aC	77.5 aC	87.5 bC	92.5 bA	81.88
26	70 aC	77.5 aC	87.5 bC	90 bC	81.25
28	70 aC	77.5 aC	87.5 bC	90 bC	81.25

Table 1. Percentage of M. rubra seedlings (N=20) surviving during each measurement period. Replanting activities occurred at the dotted line. Numbers that share a letter are not statistically different from one another at a = .05 (lower case indicates treatment differences; upper case indicates difference in measurement period).

these shrubs into silvopastoral systems should increase the height and diameter of adjacent seedlings along with dry matter production of neighboring grasses. If true, farmers may be able to use these plants to increase overall forage supply during the dry season while reducing their fertilizer application rates.

Just as fodder shrubs may help mitigate summer slump and dry season losses, the same may be true for full grown trees. Another experiment in Panama assessed the growth of three cultivars of Guinea grass (*Megathyrsus maximus* cv. 'Massai', cv. 'Mombaza', and cv. 'Tanzania') planted under open (O), moderate (M), and dense (D) tree coverage. Ryan hypothesized that changes in soil chemical and physical properties, moisture, grass dry matter production and nutritive content would be optimized in moderate shade.

Results showed no beneficial changes in soil chemical properties due to higher tree densities, but bulk density decreased significantly with increasing tree cover. Open canopy produced significantly greater quantities of dry matter than moderate and dense tree coverage. 'Massai' produced significantly greater amounts of forage than 'Mombaza', but not for 'Tanzania'. Nutritive value improved in the shade. No differences in nutritive value were found among cultivars.

'Massai' showed the greatest tolerance to drought, producing the most forage accumulation in the early part of the dry season, but only in moderate shade. (Figs. 3 and 4). Results suggest that forage accumulation is greatest in moderate shade for
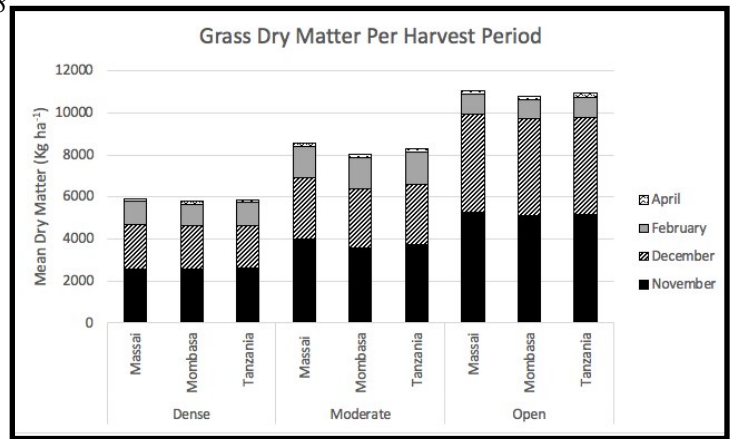

Fig. 4. Grass dry matter production for four sampling periods, two during the rainy season (November and December) and two during the dry season (February and April).

'Massai' early in the dry season, but greatest in open over the year. This observed extension of the growing season under moderate tree densities could result in improved animal weight gains between the months of January and April for this region.

Both temperate and tropical research projects aim to identify important limiting factors for production in multi-strata silvopastoral systems and will provide recommendations for novel, potentially complementary planting regimes. With climate change intensifying and drought conditions becoming more prevalent and pervasive throughout the world, the integration of trees into ranching systems may serve as an important buffer and defense against severe losses in production. Research is needed on livestock performance in these systems to complement, corroborate, or reject the conclusions of these studies.
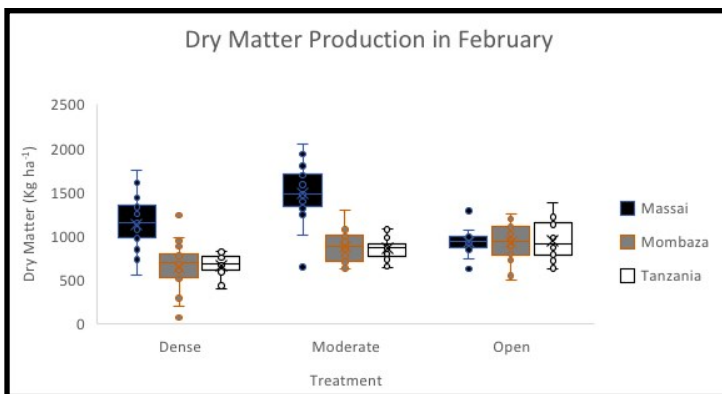

Fig. 3. Grass dry matter production for three cultivars of *M. maximus* in open (O), moderate (M), and dense (D) treatments for the month of February. 'Massai' in M produced greater dry matter than both D and O.

Did you know....

In a study done at the University of Missouri (Kallenbach 2009), cattle in an integrated silvopasture system – a management approach where silvopasture is used part of the time – lost approximately 10% less weight in winter, and were 12% less likely to experience calving difficulty than those using a traditional pasture. Additionally, calves using the integrated silvopasture system were 25% heavier at weaning than those in the traditional system.

Impact of silvopasture management techniques on ecology of ticks and tick-borne diseases

John Falco, V.M.D., took a multidisciplinary approach to uncover the public health benefits and disadvantages linked to agroforestry systems by investigating the ecology of infectious disease in agroforestry systems. Using the case study of Lyme disease within temperate silvopasture systems in the United States, his project provided information on the relationship between habitat microclimate and host biodiversity on the transmission of infectious diseases of public health importance. Anaplasmosis and Ehrlichiosis, two highly pathogenic tick-borne diseases, have high prevalence in Missouri. Individuals who work outside in brushy or forested environments, like those on farms practicing agroforestry, are highly susceptible to these types of infections.

The second field season for this project occurred between May and July of 2018 at the MU Horticulture Agroforestry Research Center in New Franklin, Missouri. Habitats representing established silvopasture, grazed forest, open pasture and forested land were used as sampling locations for tick collection. An analysis of the data collected showed that tick totals within established silvopasture sites were more closely related to the totals found in open pasture, whereas totals in grazed forest more closely resembled those totals found in forested landscapes. Overall, pasture and silvopasture landscapes had a significantly reduced tick burden compared to both grazed and un-grazed forested lands. This outcome suggests that following standard silvopasture

management strategies may help reduce the public health risk of tick-borne disease compared to using un -managed forest grazing techniques. The data gathered during the two field seasons are being used to validate an agent-based epidemiologic model developed in conjunction with this field work. Additional modeling work continues to investigate questions related to the transmission dynamics of tick-borne diseases in different agroforestry environments.

UMCA graduate student, John Falco, V.M.D. wears a special tyvec suit while collecting ticks to avoid being bitten and possibly infected with a tick-borne disease.

John R. Falco, graduate student in Fish and Wildlife (Advisors: Matthew Gompper and Shibu Jose) was chosen to attend the 2018 American Association for the Advancement of Science (AAAS) CASE Workshop in Washington D.C. This workshop aimed to catalyze graduate student involvement in science policy and government relations. John participated in lectures exploring topics including the federal government budget and appropriations process, the use of science for policy development, and the role of policy in the promotion of scientific research. In addition to the lectures, participants were tasked with meeting their state senators and representative to discuss the importance of science in public policy. He met with Senators Roy Blunt and Claire McCaskill as well as Representative Vicky Hartzler and discussed his research into agriculture and public health as well as the importance of university funding. John was also accepted to the University of Dresden Summer Course on agent-based modeling approaches to ecology and social science research. This program will assist him in strengthening and finalizing the computational model he uses for his research into disease spread across landscapes.

SPECIALTY CROPS

Growing demand for native pawpaw fruit

The North American pawpaw (*A simina triloba* L. Dunal) is a high-value native specialty fruit crop that offers multiple opportunities for commercial value-added products. A survey was conducted by Center for Agroforestry economist Dr. Zhen Cai to obtain a better understanding of the current pawpaw market from consumer and producer perspectives. Survey results indicated that consumers have strong preferences for the flavor and texture of fresh pawpaws. Price, origin, and type of production process had significant impacts on consumers' purchase preferences. The characteristic that most influenced demand was local production—consumers were willing to pay a premium of $2.36 per pound for locally produced pawpaws compared to pawpaws of unknown region of origin. Consumers also preferred certified organic and pesticide-free pawpaws compared to fruit produced using chemical fertilizers, pesticides, and herbicides. The average price premiums consumers were willing to pay for certified organic and pesticide-free fruits were $1.90 and $1.49 per pound, respectively. Providing information about the region of origin and organic and pesticide-free production processes can

Native pawpaws grow on the MU campus.

potentially increase consumer demand for pawpaws and their share of the fresh and value-added fruit market.

In terms of producers, most of the producers surveyed indicated that there is a strong demand for their pawpaw products and all the producers believe that the demand will increase in the next five years. The developing pawpaw industry is not competitive, and pawpaw products have few substitutes. However, lack of public awareness of pawpaws; short shelf life; unstable pawpaw product supply; lack of knowledge in growing, harvesting and marketing pawpaws; and strict shipping and food safety policies make it difficult to enter and successfully operate the business for potential and current producers.

The MU Southwest Center and Horticulture and Agroforestry Research Center both maintain collections of pawpaw cultivars research.

Cai, Z., Gold, M. and Brannan, R. 2018. An Exploratory Analysis of US Consumer Preferences for North American Pawpaw. *Agroforestry Systems*.
DOI: 10.1007/s10457-018-0296-5

HARC research technician Aaron Templemire samples pawpaw ice cream during the 2018 Agroforestry Academy.

Entrepreneurship

Economic development research translates to major commercial application

The first commercial product, **PONCHO/ VOTiVO 2.0***, based on the invention jointly developed by scientists Dr. Chung-Ho Lin at MU Center for Agroforestry, Dr. George Stewart at MU Department of Veterinary Pathobiology and Dr. Brian Thompson at Elemental Enzymes, was launched by Bayer in 2018. The developed technology has been applied to approximately 10 million acres in the US already, during the first year's growing season. It will be expanded to 40 million acres in the US alone in the next growing season.

From the Manufacturer – Bayer:
What benefits does **PONCHO/VOTiVO 2.0*** provide to the grower?
Poncho/VOTiVO 2.0 will provide early-season protection from above- and belowground insects and corn plant pathogenic nematodes, as well as enriched soil health around the root system.

What's new in **PONCHO/VOTiVO 2.0***?
The new complementary bacterium in Poncho/VOTiVO 2.0 increases the productivity of soil around the root resulting in an increase of available nutrients for the plant to use. The Poncho/VOTiVO 2.0 seed treatment system includes a new bacterium that enhances the microbial activity around the plant roots by providing a stabilized enzyme that provides more food (sugars) for the native microbes. The enhanced microbial population results in improved nutrient availability for plant uptake and once taken up by the plant, these nutrients, including nitrogen, phosphorus and potassium, optimize the plant's growth. The payoff is greater plant growth above and below the soil surface.

EDUCATION

High School Teacher Training Program
The majority of Missouri's more than 35,000 high school agriculture students will become farmers and agriculture professionals after graduation, which is why UMCA recognizes this population as a key to the future of agroforestry in this state. In order to reach these young land stewards, an agroforestry curriculum was developed for high school agriculture programs; teacher trainings for this content have been held in New Franklin (2016), Mount Vernon (2017), Springfield (2017, 2018), and Kirksville (2018) with the support of a SARE Professional Development Program grant (2017-2019). In 2018, an additional 24 teachers were trained (12 in Kirksville, 12 in Springfield) to use the agroforestry curriculum's lesson plans featuring hands-on, problem-solving, and peer-to-peer learning approaches. At each location, the number of hours the trained teachers expected to dedicate to agroforestry more than doubled after completing the program. The outcomes of these trainings were presented this year at the MU School of Natural Resources Research Day, the Sustainable Agriculture Research and Education 'Our Farms Our Futures' Conference, the Sustainable Agriculture Education Association Conference, and the Missouri Environmental Education Association Conference.

Youth Education
The Natural Resources Career Academy for Missouri high school students, a program supported by Prairie Fork Conservation Area, included a full-day visit this summer to the Horticulture and Agroforestry Research Center for a research tour and experiential lessons on grafting and mushroom cultivation. These 20 students were selected to attend this Academy based on their academic achievement and the quality of their written applications expressing their interests in conservation. As rising juniors and seniors, these students are well prepared to continue their education and career paths in natural resources conservation.

Another program supported by Prairie Fork Conservation Area, the *Engaging and Empowering Urban Youth through Schoolyard Habitat Restoration and Conservation Education* project was initiated this year. Regular meetings with Gentry Middle School science teachers, Prairie Fork CA educators, and MU SNR faculty and graduate students have resulted in a developing plan to convert a ½ acre green space on the Gentry campus to native prairie and savanna as educational infrastructure for conservation programs. Planting is set to begin in spring of 2019.

UMCA has also collaborated with Missouri River Relief on floodplain forest education for all Columbia Public Schools fourth graders. During

EDUCATION

Missouri River Days in April and September, groups of fourth graders spent a half day at Eagle Bluffs Conservation Area to participate in several place-based education stations, including an interpretive forest walk exploring the ecological community characteristics and importance of riparian forests.

Online Agroforestry M. S. and Graduate Certificate Programs

Responding to unmet needs of full-time working professionals interested in obtaining in-depth agroforestry knowledge via formal agroforestry graduate education, UMCA developed the online Agroforestry M.S. (30 credit) and Graduate Certificate (12 credit) program which launched in 2011 with all courses online by the fall of 2013. MU agroforestry program courses are all online, including courses on biophysical and socioeconomic foundations of agroforestry. As long as an individual has an Internet connection, it is feasible to complete the coursework.

Interest in the online programs has grown rapidly in the U.S. and abroad. As of December 2018, there are 12 enrolled in the online graduate certificate and 14 in the online MS. Since its inception a total of 25 students graduated with online M.S. and/or online graduate certificate (you can receive both).

Military Tuition Award for Online Students

The University of Missouri provides military personnel, veterans and their families (qualified dependents) with a 10 percent reduction on base tuition for undergraduate and graduate distance degree and certificate program credit hours. The Mizzou Online Military Tuition Award applies to distance students after they are admitted to the university and enrolled in their respective programs.

OUTREACH

The Center for Agroforestry seeks to educate and inform producers, natural resource professionals and others about advances and opportunities in agroforestry, introducing them to the economic and environmental benefits of agroforestry practices. The UMCA outreach team engages with farm and forest land-managers through on-site consultations, educational workshops and informational exhibits, to demonstrate how agroforestry practices can be successfully applied to their operations. UMCA's comprehensive outreach approach is a multi-faceted effort with a sustained commitment to advancing the knowledge infrastructure for agroforestry. Altogether, the aim of these efforts is to achieve greater adoption of agroforestry practices and specialty crop value-added industries across Missouri and the region and realize improved environmental and economic outcomes for all. The UMCA Outreach team hosts a range of events throughout the course of the year including training workshops, the Agroforestry Academy, producer events and field days and also participate as presenters and exhibitors in many agricultural and natural-resources related conferences and events.

Agroforestry Symposium

Since its inception in 2010, the UMCA Annual Agroforestry Symposium has steadily grown year after year to become a signature event on the MU Campus. It is an opportunity to share the work of UMCA with members of the MU community and the public while bringing together experts in the field for a focused examination of a current and compelling agroforestry related topic. In addition to the presentations at the daylong event, there is also a poster session, panel discussions, exhibit hall and closing reception. In January 2018 more than 300 attendees listened to the diverse symposium speakers, with many more viewing online through livestreaming. Soil health was the topic of the day at the 9th Annual Agroforestry Symposium held on January 25, 2018. Titled "Soil Health in Diverse Cropping Systems" the event featured Dr. Wayne Honeycutt of the Soil Health Partnership as the keynote speaker.

2018 Symposium: David Doctorian, USDA/NRCS Soil Health Specialist uses a rain simulator to demonstrate run-off on several examples of soil composition.

The upcoming 10th annual UMCA Agroforestry is scheduled for January 30-31, 2019 at the Bond Life Sciences Center on the University of Missouri campus in Columbia, MO. The 2019 Symposium will explore the theme of "Research to Entrepreneurship: Fostering a Culture of Research Translation" and will showcase examples of MU collaboration bringing innovations to successful commercial development. Keynote speakers at the event include Dr. Kelly Sexton, Associate Vice President for Research - Technology Transfer and Innovation Partnerships for the University of Michigan and Dr. Rodolphe Barrangou, Associate Professor of Food Science and the Todd R. Klaenhammer Distinguished Scholar in Probiotics Research at North Carolina State University. Information on future symposia and recorded presentations of past symposia can be found on the UMCA website at: http://centerforagroforestry.org/events/symposia.php

Agroforestry Academy

In 2018, UMCA hosted its sixth annual Agroforestry Academy July 22-27 at the University of Missouri, Columbia campus. During this week-long intensive, 24 participants learned the ins and outs of temperate agroforestry practices, promising specialty crops, and the planning and design steps to be successful agroforestry entrepreneurs. With support from the USDA Office of Advocacy and Outreach 2501 program and the Armed to Farm program, 15 of the 2018 Agroforestry Academy participants were veteran and underserved farmers who attended with a full scholarship. These participants were recruited during the "Grow Your Farm" and "USDA ABC's" workshop series held as part of the OAO 2501 activities in diverse areas around the state, including Eldon, St.Charles, Kansas City, and Hannibal. Academy attendees participated in field visits to exemplary farms employing agroforestry, classroom lectures and discussions with UMCA and USDA National Agroforestry Center experts, and a farmer case study design project throughout the week. There have now been 150 farmers, landowners, agriculture and natural resources professionals trained at UMCA's annual Agroforestry Academies.

2018 Agroforestry Academy. Greg Judy explains his mushroom inoculcation process.

Also this year, UMCA began a long-term follow-up effort with those who have participated in the Agroforestry Academy since the program's inception in 2013. The purpose of this effort is to develop a more thorough understanding of the role that the Academy plays in relation to the Agroforestry Adoption process, as well as how that role might be leveraged to better support such processes in the future.

The follow-up effort consists of both interviews and a survey with Academy participants in order to invite both a breadth and depth of perspectives. Interviews are currently underway and will continue through the spring, after which a survey will be developed with input from interview participants. Preliminary analysis of interview data indicate the importance of hands-on learning and guided practice opportunities; the significant (and dynamic) role that social context factors play leading up to, during, and following participation in the Academy; and the opportunities (and challenges) of accounting for the unique personal interests and contexts of participants.

2018 Agroforestry Academy attendees and instructors.

OUTREACH

Annual Chestnut Roast Festival

The Center for Agroforestry's annual Missouri Chestnut Roast Festival, held at the Horticulture and Agroforestry Research Center, is a fun and engaging opportunity for public education. More than 1,500

Photos from 2018 Chestnut Roast.

people attended this year's Chestnut Roast Festival, despite morning rain showers. During the event, speakers on the main stage shared about the importance of native plants for pollinators (Dr. Nadia Navarrete-Tindall), the uses of chestnuts and other perennial tree crops in delicious meals (Benjamin Hamrah), and the long-view of the Center for Agroforestry's work (Interim Director Dr. Michael Gold). This year's chestnut celebration highlighted the work that UMCA has accomplished over the last 20 years, with farm tours, music from Ironweed bluegrass band, and an expanded kids area with pumpkin picking and hay rides. Be sure to join us for the 2019 Missouri Chestnut Roast Festival, scheduled for Saturday, October 5th, 10am to 4pm.

Agroforestry workshops and demonstrations

In recent years, UMCA outreach has placed an increased emphasis on forest farming and silvopasture as promising land use practices and income generating strategies for small producers in Missouri. UMCA continues to engage with stakeholders around the region to coordinate research, outreach and technical support for adoption of these agroforestry practices. Several workshops and demonstration presentations on forest farming and mushroom cultivation were offered during 2018 to interested producers and

natural resource professional at locations around the state including Perryville, Kansas City, at MU extension events and at field days at MU agricultural experiment stations including the Wurdack Research Center, Southwest Center and at HARC. Intensive mushroom growing workshops covering growing techniques, enterprise budgeting and marketing strategies were presented to interested producers at The Great Plains Growers Conference, January 10-12, 2018 in St. Joseph, MO and at the Mid-Mo Expo, February 25, 2018 in Columbia, MO. During November 2018, four full-day agroforestry training workshops were offered to NRCS field staff and other natural resource professions in each of the four NRCS program regions around the state. Workshops were presented in Monroe City, Cape Girardeau, Springfield and Richmond, Missouri as part of a 3-year capacity-building project "Agroforestry and Specialty Crop Development for Resource Stewardship, Livelihoods and Vibrant Communities across Missouri" made possible under a grant from the NRCS-CTA-EQIP program. The project aims to:

- Increase the knowledge and technical assistance capacity of NRCS staff and other natural resource professionals on agroforestry and sustainable land use practices;
- Educate producers, land managers and other members of the Missouri's rural agricultural population, including low resource and historically underserved segments, on economic opportunities and environmentally sustainable production techniques for specialty crops, including organic production approaches;
- Increase awareness among farmers, land-managers, conservation organizations, other segments of the Missouri's rural agricultural community as well as the general citizenry, of NRCS and Farm Bill activities for resource conservation and sustainable land use practices.

Cliff McGee and Cheryl Recker from the MU Horticulture and Agroforestry Research Center (HARC), along with UMCA MS student Sam Sergent, participated in the annual Santa Fe Trail Days parade in New Franklin.

A silvopasture producer field day titled "Managing Natural Shade for Profitable Beef Production" was held at the "Mingo Farm" in St. James, MO on October 10, 2018. Attending producer families learned about how producer Brian Tomazi is managing shade for the benefit of his operation by creating small silvopasture zones of thinned trees in selected areas on the edge of pastures. There are also areas with dispersed residual trees and shrubs that were left in place when an abandoned and overgrown pasture was rehabilitated. Attendees were able to observe first hand and hear from Mr. Tomazi how he established silvopastures and how one can use natural shade on a farm to reduce heat stress, enhance animal welfare and economic returns in cow calf operations.

Agroforestry tours and field days

The Horticulture and Agroforestry Research Center (HARC) in New Franklin, Missouri is a central resource for the Center for Agroforestry research and outreach efforts. UMCA staff in conjunction with the HARC staff regularly provide in-depth tours at HARC for visitors from near and far. Notable visitors during 2018 included Congresswoman Vicky Hartzler, U.S. Senator Roy blunt's staffer Hannah Larrick, Missouri Walnut Council, and Missouri Farmers Care, 4H and FFA student groups, and visiting scholars from around the US and the world.

The Agroforestry Field Day titled "*Entrepreneurship with Native Plants and Specialty Crops*" was held on Saturday, April 7, 2018 at the Doug Allen project site in Gravois Mills, MO. While the day began with some unseasonably cold temperatures, the bonfire, chef prepared meal and great line up of speakers and entrepreneurs made for an excellent experience for all. Despite the cool weather, the event had a very good turnout of over 65 people.

Agroforestry in Action Webinar Series

The Center for Agroforestry hosts the Agroforestry in Action Webinar Series, a monthly webinar series offering presentations by leading researchers and practitioners in the field of agroforestry. The series invites speakers from both the USA and from around the globe to provide presentations and showcase recent and compelling work in agroforestry research and practice. Among the highlights from 2018 were presentations by Dr. James Roshetko of the World Agroforestry Centre (ICRAF) titled "Agroforestry & Forestry in Sulawesi: Linking Knowledge with Action" (February) and by Dr. James Fike of Virginia Tech on "Silvopasture Research and Outreach in Virginia" (March). For more information on the Agroforestry in Action Webinar Series and to view recorded versions of past presentations, please click on the webinar tab on the UMCA website: http://centerforagroforestry.org/

From left to right: Hannah Hemmelgarn (UMCA Education Program Coordinator), Carrie Hargrove (CCUA Director of Urban Farming, Columbia), Bryan Rogers (Manager of Advancement at Gateway Greening, St. Louis), Adam Saunders (CCUA Development Director, Columbia) met with Bill Ruppert of Missouri Grow Native!, and others at the St. Louis Science Center's GROW gallery.

OUTREACH

Participation in Agroforestry networks and Coordinating Bodies

UMCA outreach staff participate in a range regional and national agroforestry coordinating bodies to build the agroforestry knowledge infrastructure and advance coordination and policy development. UMCA faculty and staff serve on the Board of Directors of the Association for Temperate Agroforestry (AFTA), are actively involved in the planning of the biennial North American Agroforestry Conference (16th NAAC is scheduled for June 24-27, 2019 in Corvallis, OR.) and are founding members of the Mid-America Agroforestry Working Group. UMCA's interim director Dr. Michael Gold recently participated in a multi-day Agroforestry Economics workshop in Washington, DC, that brought together agroforestry thought leaders representing agencies, universities and NGOs from around the country. UMCA outreach staff are currently working on catalyzing regional learning networks for silvopasture and forest farming comprised of interested producers, researchers and practitioners around the lower Midwest and Ozark regions.

Participation in conference and events

Throughout the year, the UMCA Outreach team participates in a wide range of agricultural and natural resources related events and conferences both in Missouri, across the region as well as major national events. Participating as both presenters in technical sessions and panel discussions and as

Center for Agroforestry, MU School of Natural Resources, CAFNR International Programs and the Interdisciplinary Plant Group (IPB) welcomed leaders from UNIMINUTO's Agricultural colleges. Left to right: Jessica Morales Perdomo, Director of the School of Applied Natural Sciences; Joe Polacco, Emeritus Professor of Biochemistry; Nubia Carolina Higuera Mora, professor and leader of AgroEcology Research group at UNIMINUTO; Gregory Ormsby Mori, UMCA Outreach Coordinator.

exhibitors, UMCA faculty and staff share new research findings and information on the benefits of agroforestry to thousands of producers, natural resource professionals and decision makers.

International Engagement

UMCA faculty and staff regularly collaborate with international partners and engage in a range of international activities. UMCA's Outreach Coordinator Gregory Ormsby Mori participated as a speaker at the 4th European Agroforestry Conference held in June, 2018 in Nijmegen, Holland offering two presentations: "Specialty Crop Development for Temperate Agroforestry Systems in the Midwest USA" and "Advancing Agroforestry Policy Development in the USA". During the course of 2018, Mr. Ormsby Mori made several trips to the South American country of Colombia for activities including:

- Participating in a multi-disciplinary MU mission to explore opportunities for collaboration with UNIMINUTO, a Colombian university with extensive distance and virtual learning targeting underserved populations;
- As an invited keynote speaker for the 3rd International Sustainable Grazing Conference, held in June 7-9, 2018 in Florencia Colombia, making a presentation titled: "Advances in silvopasture research and promotion in North America";
- Collaborating with UNIMINUTO agroecology faculty to plan and present an intensive training on agroforestry for ex-combatants and a short course on sustainable development and sustainable agriculture for UNIMINUTO students that was offered in December, 2018.

During the fall of 2018, UMCA hosted a Borlaug Fellow from Liberia, Charles King, interim director of the Tree Crops Unit for the Ministry of Agriculture, Liberia, who researched agroforestry topics under the mentorship of Drs. Michael Gold and Francisco Aguilar. Mr. King has a particular interest in cocoa agroforestry systems, as after rubber, cocoa is the second most significant tree crop in Liberia. UMCA Education and Outreach Coordinator Mr. Gregory Ormsby Mori accompanied Mr. King on a tour of agroforestry and cocoa sites in Costa Rica, including visits to Earth University and The Tropical Agricultural Research and Higher Education Center (CATIE), home to a major cocoa germplasm collection and long-term research plots on cocoa and coffee agroforestry systems.

Dr. Chung-Ho Lin observes the large biodiversity of insects and plant habitat in Indonesia.

In the summer of 2018 two groups of UMCA professors visited Indonesia to review their students' research sites and explore possible collaboration opportunities between UMCA, Center for International Forestry Research (CIFOR) and several Indonesian universities. Drs. Zhen Cai, Francisco Aguilar and Chung-Ho Lin began their visit at the CIFOR headquarters in Bogor where their CIFOR Fellowship Master Students Amanda Dwikarina, Dienda Hendrawan, and Dorin Kusumawardani gave presentations on their research projects. The MU faculty then gave presentations about the Center of Agroforestry, School of Natural Resources, and the University of Missouri.

Dr. Lin later visited the Bogor Agricultural University (IPB) and presented seminars at the Department of Biology and Department of Agronomy and Horticulture. He also gave several research seminars at Atma Jaya University, Jakarta, and at the University of Udayana, Bali. As a result of his visit, several Material Transfer Agreements (MTA) and Memoranda of Understandings (MOU) were developed and subsequently approved between the University of Missouri CAFNR and relevant Indonesian institutes to foster future collaboration on natural products and bioremediation research. Drs. Zhen Cai and Francisco Aguilar visited Ainun Seruni's (2018 agroforestry MS graduate) study site in the Gunung Kidul District in Yogyakarta along with collaborators from the World Agroforestry Center (ICRAF) Drs. James Roshetko, Aulia Perdana, and Gerhard Manurung. For the remainder of the trip, Drs. Cai and Aguilar visited Kapuas Hulu District in West Kalimantan, study site of Dorin Kusumawardani, current UMCA MS student, and Bantaeng District in Central Sulawesi, study site of Dienda Hendrawan, current UMCA MS student, to meet with farmers, local government agents, and visit local smallholder farms.

Drs. Ben Knapp and Ranjith Udawatta visited

In boat, back to front: Dr. Zhen Cai, Dr. Francisco Aguilar, Dorin Kusumawardani, with Community Forest Group of Bumi Lestari explore peat swamp forest area designed for ecotourism in Penepian Raya Village, Kapuas Hulu Regency, West Kalimanta. The group also monitored natural bee habitat which produces products from this village.

Indonesia in July. They also gave presentations on their research at CIFOR headquarters along with their current MS student, Muhamad Nugraha, and 2018 UMCA MS graduate, Kania Rahayu. Dr. Udawatta then traveled to Kania's research sites.

Dr. Knapp traveled to an East Kalimantan location (where Muhamad Nugraha is employed) which consists of several forest areas, a forest nursery, and laboratory facilities. Dr. Knapp was able to visit inventory plots selected by Muhamad Nugraha that represented different levels of forest health; meet with the company's R & D team; and discuss Muhamad Nugraha's MS research project.

Dr. Zhen Cai, Dienda Hendrawan, and Dr. Francisco Aguilar with smallholder farmers in Campaga Village, Central Sulawesi.

MU/UMCA OUTLYING FARMS & CENTERS

Horticulture and Agroforestry Research Center (HARC)

HARC is one of the University of Missouri's Agricultural Research Centers, a network of sites across the state hosting state-of-the-art programs that bring Missouri agricultural land and forest owners' new information for reaching maximum income potential and environmental benefits on a variety of land types and ecoregions.

Located at New Franklin, Mo., and set in the beautiful, rolling Missouri River hills, HARC is the primary research site for the Center for Agroforestry at the University of Missouri. HARC sits at the interface of the loess hills and Missouri River bottom and provides a scenic, historic and scientific setting for development of horticultural- and agroforestry-related studies. This 665-acre farm includes several experimental fruit and nut orchards; forest farming, riparian buffer, silvopasture, alley cropping, and windbreak demonstrations as well as forage shade trials; flood tolerance trials; biofuel trials; pinestraw production trials; greenhouses; five lakes and ponds and one of Missouri's oldest brick homes, the fully restored 1819 Thomas Hickman House. Tours and educational events are hosted regularly including the annual Missouri Chestnut Roast.

Interdisciplinary cooperation allows researchers from multiple disciplines, including tree breeding and improvement, entomology, plant pathology, horticulture, agronomy, animal science and agroforestry, to combine research efforts to address an array of economic and environmental issues. Specialty crops featured include major germplasm collections of northern pecan, eastern black walnut, and Chinese chestnut, along with research on elderberry, pawpaw, pine straw, grapes, and gourmet mushrooms. In addition HARC features an innovative, outdoor 24-channel flood tolerance research laboratory and bioremediation, non-point source pollution and shade tolerance studies.

Southwest Research Center

Established in 1959, this Center addresses the main agricultural concerns of area industries including dairy, beef, forage and specialty crop production. Horticultural research, including black walnut, pecan, pawpaw, persimmon, chestnut, elderberries and grapes provides information on viable production alternatives for both commercial producers and home gardeners interested in small fruits and vegetables. Forage grass breeding conducted at the Southwest Center has been instrumental in the development of three new "endophyte-free" tall fescue varieties – "Missouri 96," "Mozark" and "Martin" – as well as an orchardgrass variety, "Justus." Small grains

UMCA staff Hannah Hemmelgarn, left, and Gregory Ormsby Mori, right, give several mushroom demonstrations throughout the year.

Sam Sergent, UMCA MS student, conducts research on elderberry flowers and elderberry variation across selected cultivars. Elderberries are grown at HARC and the Southwest Research Center.

research focuses on variety testing and development, proper fertilization practices and harvest management alternatives.

Greenley Research Center

The major objective of the center is to evaluate efficient, profitable crop production in northern Missouri while emphasizing soil conservation, water quality and energy efficiency. Researchers study the benefits of reduced tillage, alternative cropping practices, the effects of new technology and products, variety testing, soil fertility and beef cattle backgrounding. Studies on water quality and the environmental impact of crop production are being implemented. UMCA has maintained a long-term (28 year) paired-watershed agroforestry research study located at Greenley that has generated a wealth of scientific information about the value of upland agroforestry buffers in claypan agricultural soils. Ongoing performance testing of corn, soybean, sunflowers, biomass and winter wheat yields results to aid Missouri producers.

Bradford Research Center

As a research laboratory and outdoor classroom, Bradford's faculty and students investigate wastewater management, entomology, pest and weed control, specialty crops, organic transition techniques, agroforestry, permaculture and engage the community through workshops, field days, and partners with University organizations to improve MU's sustainability.

Doug Allen Research & Education Site

The Doug Allen Research and Education Site contains 521 predominantly hilly and wooded acres in the Ozark region near Laurie, Mo., and contains many desirable tree species, including black and white oak, shagbark hickory, northern red oak, white ash, river birch and eastern red cedar. Approximately 83 acres of the site are bottomland fields and have been converted to warm season prairie grasses. Portions of the property feature soil well-suited to growing the Missouri native shortleaf pine - a species the Center has invested fifteen years of research into as a potential source of short and long-term income for landowners.

2018 Doug Allen Property Field Day. Lunch included locally harvested nettles, golden glow plant, wild leeks (ramps), pawpaw fruit, black walnuts and pecans. Prepared by Ben Hamrah of Peachtree Catering.

Wurdack Research Center

Nestled along the Meramec River near Cook Station in the northeast Ozarks, the Hugo Wurdack Research Center conducts demonstrations and research in silvopasture and wildlife management practices that are economically viable, environmentally sound and sociologically acceptable for the Ozark Region of Missouri. Wurdack is operated using Best Management Practices and provides educational information on a wide range of agricultural, natural resource and scientific topics to area beef and forage producers, soil and water district members, students from elementary and secondary schools, and other interested groups. Farm activities emphasize management practices that promote sustainable agricultural production while protecting the natural environment and the quality of life for citizens of Missouri's Ozark region.

GRANTS 2018

AGROFORESTRY

Gold, M., PI, USDA ARS (2016-2021) Agroforestry for Small Farm Sustainability, $2,969,000 (to date).

BIOFUEL/BIOMASS

Thomas, A.L., PI, USDA National Laboratory for Agriculture and the Environment (2015 - 2019) Carbon and Nutrient Dynamics of a Bioenergy Agroforestry System, $32,570.

EDUCATION

Gold, M., PI, USDA NCR SARE PDP (2017-2019) Missouri Agroforestry Summer Institutes: High School Educator Training for Curriculum Delivery. $70,334.

Gold, M. I; Co-PIs: Cai, Ormsby-Mori, Hemmelgarn. MO NRCS Training and Demonstration Grant. (2018 – 2021) Agroforestry and Specialty Crop Development for Resource Stewardship, Livelihoods and Vibrant Communities across Missouri. $97,319.

Li, C., PI; Co-PI: Hemmelgarn, Prairie Fork Conservation Area (2018-2019) Engaging and Empowering Urban Youth through Schoolyard Habitat Restoration and Conservation Education- An Innovative Middle School Program $9,800.

Li, C., PI; Co-PI: Hemmelgarn. Prairie Fork Conservation Area. (2018 – 2019) Natural Resources Career Academy: A Summer Residential and Experiential Course for Missouri High School Students. $14,500.

ENVIRONMENTAL SERVICES

Bardhan, S., HBCU Capacity Building Grant, USDA (2018 – 2021) Variability of Soil Greenhouse Gas Emissions and Soil Microbial Diversity and Function in Conventional and Alternate Land Use Systems in Floodplain Soils, $293,500

Bardhan, S., MU CAFNR International Program (2018 – 2019) Approaching Microbial Community Divergence as Diagnostic Tool for Early Warning of Climate Change, $2500

Drobnis, E. PI; Co-PIs C.-H. Lin, S.C. Nagel. MU School of Medicine (2019-2020). $25,000.

Fidalgo, M., PI; Lin, C.-H., Nagel, S., Co-PIs, USGA (2016-2018) Total Endocrine Disrupter Chemical (EDCs) Concentration in Natural Waters. $44,000.

Fidalgo, M., PI; Lin, C.-H., Mayhan, B., Trauth, K., Co-PIs, EPA Region 7 Grant (2017-2019) Pesticide Landscape-Based Monitoring Method Development and Strategy. $40,666.

Inniss, E. PI; Co-PI: Lin, C-H. MDNR. Technology Assistance to Missouri Utilities to Meet DBPs Standards. $72,081.

Jose, S., PI, USDA NRCS (2013-2018) cyber-linked watersheds, $160,000

Lim, T., PI; Lin, C.-H., Wan, C., Co-PIs, MU Research Board (2016-2018) Degradation of Veterinary Antibiotics via Anaerobic Digestion. $49,000.

Lin, C.-H., PI, MO Dept. of Agriculture (2016-2018) Identify Novel Uses of Black Walnut and Its Byproducts. $29,500.

Lin, C.-H., Co-PI, MU Research Board (2016-2018) Degradation of Antibiotics from Concentrate Animal Feeding Operations Wastewater by Heterogeneous Fenton Reaction. $36,936.

Lin, C.-H., EPA (2016-2019) Pesticide Sensor Development and Landscape-Based Sampling Strategy Supporting Implementation of Wetland Water Quality Standards. $406,661.

Lin, C.-H., PI, MU Office of Academic Affairs, Research and Economic Development, FastTrack Pitch Competition Award (2018-2019) A novel Continuous Flow System for Blood Type Conversion.$50,000

Nelson, K., Motavalli, P., Thompson, A., Udawatta, R., Lory, J. Missouri Fertilizer and Ag Lime Board. (2016-2019) Impact of Cover Crops on Nutrient Loss in a Terraced Fields. $87,000.

Thomas, A.L. USDA National Laboratory for Agriculture and the Environment, Ames, IA (2015-2018) Carbon and Nutrient Dynamics of a Bioenergy Agroforestry System. $32,570.

Udawatta, R., Anderson, S. SNR Mini-Grant Program (2017-2018) Micro-tomographic Evaluation of Geometrical Soil Pore Parameters and Water Transport to Quantify Environmental Services of Conservation Practices. $5,000.

Udawatta, R, PI; Jose, S., Co-PI, USDA NRCS (2015-2022) Mississippi River Basin Healthy Watershed Initiative (MRBI) Edge of Field Monitoring-Ora Morris, Livingston County $147,298.

Udawatta, R., PI; Jose, S., Co-PI, USDA NRCS (2016-2019) Monitoring and Modelling of Mississippi River Basin Healthy Watershed Initiative (MRBI) Edge of Field Monitoring and Environmental benefit evaluation $169,846.

Udawatta, R.P. and S. Jose. USDA-NRCS & MDNR. (2017-2022) Mississippi River Basin Healthy Watershed Initiative Edge of Field Monitoring-Alita Johnson Revocable Trust, Audrain County. $119,615

Udawatta, R.P.; Co-PIs: Sougata Bardhan, S., Cai, Z., Cartwright, L. (MO NRCS), Ambrose, B. (landowner). NRCS, MO-CIG (2018 – 2021) Ecosystem Services of Cover Crops, Riparian Buffers, and Crop Rotation with Biochar on Eroded Midwest Corn/Soybean Landscapes, $75,000.

OUTREACH

Funkenbusch, K., PI; Co-PI.: Gold, M.A., et al. USDA 2501 OAO (2017-2018). Missouri Outreach and Assistance for Socially Disadvantaged and Veteran Farmers and Ranchers. $199,982

Jose, S. Co-PI, USDA NIFA (2015-2018) Armed to Farm: Soldiering the Success of Military Veterans in New Poultry, Livestock and Agroforestry Enterprises, $500,000.

Jose, S., Co-PI, USDA-AFRI (2015-2020) Armed to Farm: Veteran Labeled Marketing, Education and Research Strategies to Soldier Success for Military Veteran Farmers. $499,978.

GRANTS 2018

SOCIOECONOMICS/ MARKETING/ ENTREPRENEURIAL

Gold, M., Cai, Z., Mori, G.O. and Hemmelgarn H. MO NRCS. (2018-2021) Agroforestry and Specialty Crop Development for Resource Stewardship, Livelihoods and Vibrant Communities across Missouri. $97,319.

Lin, C.-H. PI. Tiger Energy (2016-2019) $200,000.

SPECIALTY CROPS

Cai, Z., PI: Co-PIs: Thomas, A.L., Byers, P.L., and Gold, M.A. Missouri Department of Agriculture, Specialty Crop Block Grant Program (2018) Establishing Missouri's Pawpaw Industry: Horticulture, Market Research, and Outreach. $29,751.

Hwang, C.-F. and A.L. Thomas. USDA-NIFA-Capacity Building Grants for Non-Land Grant Colleges of Agriculture (2018) Building Research and Education Capacities to Strengthen the Black Walnut Breeding Program. $297,847.

Lin, C.-H., PI, SNR Mini-Grant (2018-2019) Identify Novel Uses of Black Walnut and Its Byproducts through Global Metabolomics Profiling and High-throughput Screening. $5,000

Lin, C.-H., Cai, Z., & Gold, M. (2018-2020) Explore the Economic Opportunities and Health Benefits of the Elderberry in Missouri. $29,500.

Nelson, K., Motavalli, P., Thompson, A., Udawatta, R., Lory, J., Co-PIs. MO Fertilizer and Ag Lime Board (2016-2019) Impact of Cover Crops on Nutrient Loss in a Terraced Field. $87,000.

PUBLICATIONS 2018

ABSTRACTS

Alagele, S., S.H. Anderson, R.P. Udawatta. 2018. Agroforestry, Grass, Biomass Crop, and Row-Crop Management Effects on Soil Water Dynamics for Claypan Landscapes. Abstracts 2018-2019. Soils Across Latitudes, 2018-2019 International Soils Meeting, San Diego, CA January 6-9, 2019.

Alagele, S.M., S.H. Anderson, R.P. Udawatta, and S. Jose. 2018. Agroforestry, grass, biomass crop, and row-crop management effects on soil water dynamics for claypan landscapes. Pp 212-216 In N. Ferreiro-Dominguez and M.R. Mosquera-Losada (Eds.) Agroforestry as Sustainable Landuse, 4th European Agroforestry Conference, 28-30 May 2018. Nijmegen, The Netherlands.

Appenteng, M.K., R. Krueger, M.C. Johnson, H. Ingold, R. Bell, A. Thomas, and C.M. Greenlief. 2018 (in press). Cyanogenic Glycoside Analysis in American Elderberry: Method Development and Validation. 2018 Midwest Regional Meeting, American Chemical Society. Chemical Abstracts.

Bolster, C.H., T.L. Veith, C. Baffaut, N.O. Nelson, D.L Osmond, M.L. Cabrera, P.J.A. Kleinman, J. Ramirez-Avila, A.N. Sharpley, R.P Udawatta, G. Pierzynski, D. Sweeney. 2018. Development of a New Database Containing Event-Based P Loadings from Agricultural Fields. Abstracts ASA.

Bruner, P., A.L. Thomas, and C.M. Greenlief. 2018 (in press). Which is Better; Frozen Storage or Heat Drying?: Effect of Storage Method on the Compounds in American Elderberry (*Sambucus nigra* subsp. *canadensis*). 2018 Midwest Regional Meeting, American Chemical Society. Chemical Abstracts.

Byers, P.L., A.L. Thomas, and E. Nichols. 2018. Blackberries: A Model for Integrating Research with Outreach and Education to Farmers and the Public. Proceedings of the 30th International Horticultural Congress S12:OS1-2.

Cai, Z., Gold, M., and Brannan, R. 2018. An exploratory analysis of US consumer preferences for North American pawpaw. American Society for Horticultural Science. July 31- August 3. Washington, DC.

Ho, T.. C-H. Lin and F. Fritschi. 2018. A Plant Growth Inhibitor N-trans-cinnamoyltyramine in Rice and Its Synthesis. Conference Proceedings for the 8th World Congress of Allelopathy. https://wca2017.sciencesconf.org/data/pages/book_wca2017_en.pdf

McGowan, K.G., P.L. Byers, S. Jose, M. Gold, and A.L. Thomas. 2018. Flower Production and Effect of Flower Harvest on Berry Yields within Six American Elderberry Genotypes. Proceedings of the 30th International Horticultural Congress S12:PS1-1.

Rankoth, L.M., R.P. Udawatta, C.J. Gantzer, R.L. Wright and S. Jose. 2018. Cover crop effects on soil water dynamics and plant water uptake of corn. Abstracts 2018-2019. Soils Across Latitudes, 2018-2019 International Soils Meeting, San Diego, CA January 6-9, 2019. 5585 Guilford Road, Madison, Wisconsin 53711-1086.

Rankoth, L.M., R.P. Udawatta, C.J. Gantzer, S. Jose and S.H. Anderson. 2018. Cover crops on soil water dynamics of claypan soils with corn-soybean rotation. Abstracts 2018-2019. Soils Across Latitudes, 2018-2019 International Soils Meeting, San Diego, CA January 6-9, 2019. 5585 Guilford Road, Madison, Wisconsin 53711-1086.

Udawatta, R.P. 2018. Agroforestry practices for water quality and quantity benefits. Pp 269-273. In N. Ferreiro-Dominguez and M.R. Mosquera-Losada (Eds.) Agroforestry as Sustainable Landuse 4th European Agroforestry Conference, Agroforestry as Sustainable Land Use. 28-30 May 2018. Nijmegen, The Netherlands.

BOOKS & BOOK CHAPTERS

Anderson, S.H. and R.P. Udawatta. 2019. Agroforestry: A System for Improving Soil Health. In: M.R. Mosquera-Losada and R. Prabhu (eds.) Agroforestry for Sustainable Agriculture. Burleigh Dodds Science Publishing, Cambridge, UK. In Press

Gold, M. 2019. Agroforestry for the Cultivation of Nuts. In: M.R. Mosquera-Losada and R. Prabhu (eds.) Agroforestry for Sustainable Agriculture. Burleigh Dodds Science Publishing, Cambridge, UK. In Press

PUBLICATIONS 2018

BOOKS & BOOK CHAPTERS

Jose, S., Gold, M.A.; Garrett, H.E. (2018) Temperate Agroforestry in the United States: Current Trends and Future Directions. Chapter 3. In: Temperate Agroforestry Systems 2nd Edition. A.M. Gordon (Editor), S.M. Newman (Editor), B. Coleman (Editor). CABI. (H ISBN 9781780644851)

Van Sambeek, J. 2019. Agroforestry for Hardwood/Timber. In M.R. Mosquera-Losada and R. Prabhu (eds.) Agroforestry for Sustainable Agriculture. Burleigh Dodds Science Publishing, Cambridge, UK. In Press

JOURNAL ARTICLES

Alagele, S.M., S.H. Anderson, and R.P. Udawatta. 2018. Biomass and buffer management practice effects on soil hydraulic properties compared to grain crops for claypan landscapes. Agroforestry Systems. Doi.org/10.1007/s10457-018-0255-1

Aguilar, F. X., Obeng, E. A., and Cai, Z. 2018. Water quality improvements elicit consistent willingness-to-pay for the enhancement of forested watershed ecosystem services. Ecosystem Services, 30: 158-171.

Body, M.J.A., M.S. Zinkgraf, T.G. Whitham, C-H. Lin, R.A. Richardson, H.M. Appel, and J.C. Schultz. 2018. Heritable phytohormone profiles of poplar genotypes vary in resistance to a galling aphid. Molecular Plant-Microbe Interactions. https://doi.org/10.1094/MPMI-11-18-0301-R

Byers, P.L., A.L. Thomas, and E. Nichols. 2019 (in press). Blackberries: A model for integrating research with outreach and education to farmers and the public. Acta Horticulturae.

Cai, Z., Gold, M., and Brannan, R. 2018. An exploratory analysis of US consumer preferences for North American pawpaw. In Press. Agroforestry Systems. DOI: 10.1007/s10457-018-0296-5

Cercioglu, M., S.H. Anderson, R.P. Udawatta, and S.I. Haruna. 2018. Effects of cover crop and biofuel crop management on computed tomography-measured pore parameters. Geoderma. 319:80-88.

Dai, J., D.C. Vu, S. Nagel, C-H. Lin and M. Fidalgo. 2018. Colloidal crystal templated molecular imprinted polymer for the detection of 2-butoxyethanol in water contaminated by hydraulic fracturing. Microchimica Acta 185:32 doi: 10.1007/s00604-017-2590-8

Davis, A.N., G. Carlo, Z. Gulseven, F. Palermo, C-H. Lin, S.C. Nagel, D.C. Vu, P.H. Vo, T.L. Ho, and J.A. McElroy. 2018. Exposure to environmental toxicants and young children's cognitive and social development. Reviews on Environmental Health (In Press)

Kadhem, A., Xiang, S., Nagel, S., Lin, C.H., and Fidalgo. M.M. 2018. Photonic molecular imprinted polymer film for the detection of testosterone in aqueous samples. Polymers https://doi.org/10.3390/polym10040349

Kassotis, C.D., D.C. Vu, P.H. Vo, C-H. Lin, J.N. Cornelius-Green, S. Patton and S. C. Nagel. 2018. Endocrine disrupting activities and organic contaminants associated with oil and gas operations in Wyoming groundwater. Archives of Environmental Contamination and Toxicology 75:247-258 https://doi.org/10.1007/s00244-018-0521-2

Hemmelgarn, H.L, M.A. Gold, A.L. Ball and H.E. Stelzer. 2018. Agroforestry education for high school agriculture science: An evaluation of novel content adoption following educator professional development programs. Agroforestry Systems. https://doi.org/10.1007/s10457-018-0278-7

Ho, K-V., Z. Lei , L.W. Sumner , M.V. Coggeshall, H-Y. Hsieh, G.C. Stewart and C-H. Lin. 2018. Identifying antibacterial compounds in black walnuts (*Juglans nigra*) using a metabolomics approach. Metabolites 8, 58; doi: 10.3390/metabo8040058.

Lei, Z., C. Kranawetter, B. Sumner, D. Huhman, D.J. Wherritt, A.L. Thomas, C. Rohla, and L.W. Sumner. 2018. Metabolomics of two pecan varieties provides insights into scab resistance. Metabolites 8(4):56. doi: 10.3390/metabo8040056.

Ma, B., Cai, Z., Zheng, J., and Wen Y. 2019. Conservation, ecotourism, poverty, and income inequality: A case study of the nature reserves in Qinling, China. World Development. 115:236-244.

https://doi.org/10.1016/j.worlddev.2018.11.017

McGowan, K.G., P.L. Byers, S. Jose, M. Gold, and A.L. Thomas. 2019 (in press). Flower production and effect of flower harvest on berry yields within six American elderberry genotypes. Acta Horticulturae.

Senaviratne, G.M.M.A., C. Baffaut, J.A. Lory, R.P. Udawatta, N.O. Nelson, J.R. Williams, and S.H. Anderson. 2018. Improved APEX model simulation of buffer water quality benefits at field scale. Trans American Society of Agricultural and Biological Engineers 61:603-616.

Senaviratne, G.M.M.M.A., C. Baffaut, J.A. Lory, R.P. Udawatta, N.O. Nelson, and A.B. Bhandari. 2018. Evaluation of four parameterization strategies for the APEX model. American Society of Agricultural and Biological Engineers. 61:1603-1617. doi:10.13031/trans.12656

Serra-Clusellas, A., L. De Angelis, C_H. Lin, P. Vo, M. Bayat, L. Sumner, Z. Lei, N. Braga, L.R. Pizzio, J.D. Stripeikis, J.A. Rengifo-Herrera and M.M. Fidalgo. 2018. Abatement of 2,4-D Herbicide from water by hydrogen peroxide solar photolysis and solar photo-Fenton-like process with Fe(III) Water Research 144:572-580 doi: 10.1007/s00604-017-2590-8

Taleghani, A.H., T.T. Lim and C-H. Lin. 2018. Degradation of veterinary antibiotics in swine manure via anaerobic digestion. American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting. 1801460. (doi:10.13031/aim.201801460)

Vu, D.C., P.H. Vo, M.V. Coggeshall and C-H. Lin. 2018. Identification and characterization of phenolic compounds in black walnut kernels. Journal of Agricultural Food and Chemistry. 66 (17):4503-4511; DOI:10.1021/acs.jafc.8b01181

Vu, D.C., T.L. Ho, P.H. Vo, G. Carlo, J.A. McElroy, A.N. Davis, S.C. Nagel and C-H. Lin. 2018. Determination of volatile organic compounds in child care centers by thermal desorption gas chromatography-mass spectrometry Analytical Method 10: 730-742; DOI: 10.1039/C7AY02570J

VeVerka, J.S., R.P. Udawatta, and R.J. Kremer. 2018. Soil health indicator responses on Missouri claypan soils affected by landscape position, depth, and management practices. Journal of Soil Water Conservation. In Press

Vu, D.C., P.H. Vo, M.V. Coggeshall and C-H. Lin. 2018. Identification and characterization of phenolic compounds in black walnut kernels. Journal of Agricultural Food and Chemistry. 66 (17):4503-4511; DOI:10.1021/acs.jafc.8b01181

Weerasekara, CS, NR Kitchen, S Jose, PP Motavalli, S Bardhan, RB Mitchell. 2018. Yield of Lignocellulosic Warm-Season Grasses Affected by Nitrogen and Harvest Management. Agronomy Journal. 110(3), 890-899

OTHER/Popular Press

Bardhan, S. 2018. Where do agricultural greenhouse gases come from, and what can be done to reduce them? Sustainable Secure Food Blog, URL: https://sustainable-secure-food-blog.com/2018/06/22/where-do-agricultural-greenhouse-gases-come-from-and-what-can-be-done-to-reduce-them/

Bentrup, G., Cernusca, M.M., Gold, M.A. (2018) Supporting U.S. agricultural landscapes under changing conditions with agroforestry: An annotated bibliography. Bibliographies and Literature of Agriculture 137. Washington, DC: U.S. Department of Agriculture Forest Service. 63 p

Cai, Z. 2018. Pawpaw (Asimina triloba): Market and Consumer Preferences. 2018. Annual Grafting Meeting. Missouri Nut Growers Association. May 5. Fayette, MO.

Dold, C., A.L. Thomas, T.J. Sauer, A. Ashworth, D. Philipp, and T.C. Adams. 2018. Carbon Budget Calculation for Silvopastoral Systems. The Temperate Agroforester 24(1). Association for Temperate Agroforestry.

Fitzgerald, A. 2018. Black walnuts contain heart healty nutrients that can stave off obesity and cardiovascular disease. MU News Bureau, Dec. 10, 2018. (Chung-Ho Lin research)

Frey, G.E., …., Gold, M.A., Godsey, L.D., et al. (2018) Chapter 6. In: Economics of Non-timber Forest Products. In: Chamberlain, J.L., Patel-Weynand, T., Emery, M., comps., eds. Assessment of Non-Timber Forest Products in the United States Under Changing Conditions. A technical synthesis report for the 2017 National Climate Assessment. US Department of Agriculture Forest Service, Washington, DC. pp. 119-149.

Gold, M.A. and Z. Cai. 2018. 2018 Annual market survey: Reduced yields, grown demand and increased organic production. The Chestnut Grower 19 (3):1,4-5.

Gold, M.A., H.L Hemmelgarn, G.O. Mori (eds). 2018. Training Manual for Applied Agroforestry Practices – 2018 Edition. MU Center for Agroforestry. 385 p.

Gold, M.A. and H. Hemmelgarn (eds). 2018. Action in Agroforestry. UMCA monthly E-Newsletter. Vol.:1-12 http://www.centerforagroforestry.org/pubs/action/archive.php

Gold, M.A, H.E. Stelzer and H.L. Hemmelgarn (eds). 2018. Green Horizons. Newsletter of the MU Center for Agroforestry. Vol. 22, No. 1-3. 12 p.

Rice, S. 2018. Air quality measurement tool could be beneficial for children's health. MU News Bureau News Release. May 2, 2018. https://munews.missouri.edu/news-releases/2018/0502-air-quality-measurement-tool-could-be-beneficial-for-childrens-health/ (Chung-Ho Lin research)

Thesis/Dissertations

Salah Alagele: PhD student. Dissertation Title is "Effects of agroforestry buffers, grass buffers, biomass crops and grain crops on soil water use, soil hydraulic properties, and soil quality." Co-Advisor Ranjith Udawatta

Nasruddeen Al-Awwal: PhD student. Dissertation Title is "Development of a new sensor to measure dissolved nutrients in runoff waters." Committee member Ranjith Udawatta

Jamshid Ansari: PhD student. Dissertation Title is "Variability of soil greenhouse gas emissions and soil microbial diversity and function in conventional and alternate land use systems in floodplain soils." Committee member Ranjith Udawatta.

Haryo Ajie Dewanto, MS. Thesis title "Spatial Analysis to Establish Agroforestry Areas as Buffer Zones in Tropical Peatland Forest of Indonesia', Advisor, Hong He.

Novianus Efrat, MS. Thesis title "Identification of Health-Promoting Compounds from Switchgrass (Panicum virgatum L.) Using Global Metabolomics Platform". Advisor, Chung-Ho Lin

Meredith L. Evans, Online MS. Final Project Title "Developing an Equine Silvopasture Project: An On-Farm Case Study". Advisor, Michael Gold.

Ainun Seruni, MS. Final Project Title: "Economic And Social Resilience Of Smallholder Agro-Silvopastoral Farmer: A Case Study In Gunung Kidul District, Yogyakarta-Indonesia" Advisor, Francisco Aguilar.

Danh Vu, MS. Thesis Title is "Determination of Potential Health-promoting Compounds in Black Walnuts (Juglans nigra L.)". Advisor, Chung Ho Lin.

Timothy Watkins, Online MS. Final Project Title: "Developing an Agroforestry Plan for Kilimo Timilifu, Tanzania". Advisors, Shibu Jose/Michael Gold.

Connect with the Center

CENTERFORAGROFORESTRY.ORG

THE CENTER FOR AGROFORESTRY

@MUAGROFORESTRY

AGROFORESTRY ACADEMY
July 21 - 26, 2019 | Columbia, Missouri

What is the Agroforestry Academy?

A week-long training that includes integrated classroom workshops, multiple on-farm visits, hands-on demonstrations and content integration into practical on-farm agroforestry planning and design to advance adoption of agroforestry as a cornerstone of productive land use.

Tell me more

Agroforestry is a **land management approach** that provides opportunities to combine **productivity and profitability** with environmental stewardship, resulting in healthy and sustainable agricultural systems that can be passed on to future generations.

Who will Benefit?

◆ **Educators** (natural resource professionals, extension agents…)
◆ **Farmers**, including beginning and military veteran farmers.

Advanced training will be provided on the main temperate zone agroforestry practices integrated with options for bioenergy, marketing, economic, social dimensions, and environmental services.

Trainers

Experienced trainers will be drawn from the MU Center for Agroforestry, USDA National Agroforestry Center, Extension and NRCS agroforestry specialists, other selected experts from the US and Canada, farmer educators and agroforestry practitioners.

Resources

The Agroforestry Academy link on the Center's website contains the 2018 edition of the UMCA Training Manual and the Handbook for Agroforestry Planning and Design which will serve as the foundational tools for the Academy.

In addition, the Academy web pages (www.centerforagroforestry.org/academy/) contain a wealth of additional information and resources from past academies.

REGISTRATION

FULL REGISTRATION:

$1,000/person (includes lodging, food, local travel and all training materials)

Scholarships available for Veteran farmers

Please register by **May 24, 2019**

HOW TO REGISTER? Please submit application:

◆ Registration (name, organization, address, phone number and email), and
◆ Payment (total attending number, total payment) *make checks payable to the University of Missouri*

to **Caroline Todd**
Center for Agroforestry
203 ABNR - University of Missouri Columbia, MO 65211
Phone: 573-884-2874
Email: ToddCS@missouri.edu

Contact

For more information about scholarships and other details, contact:

Mike Gold: goldm@missouri.edu

Gregory Ormsby Mori
ormsbyg@missouri.edu

Hannah Hemmelgarn
hemmelgarnh@missouri.edu

Center for Agroforestry (UMCA)
www.centerforagroforestry.org/academy/