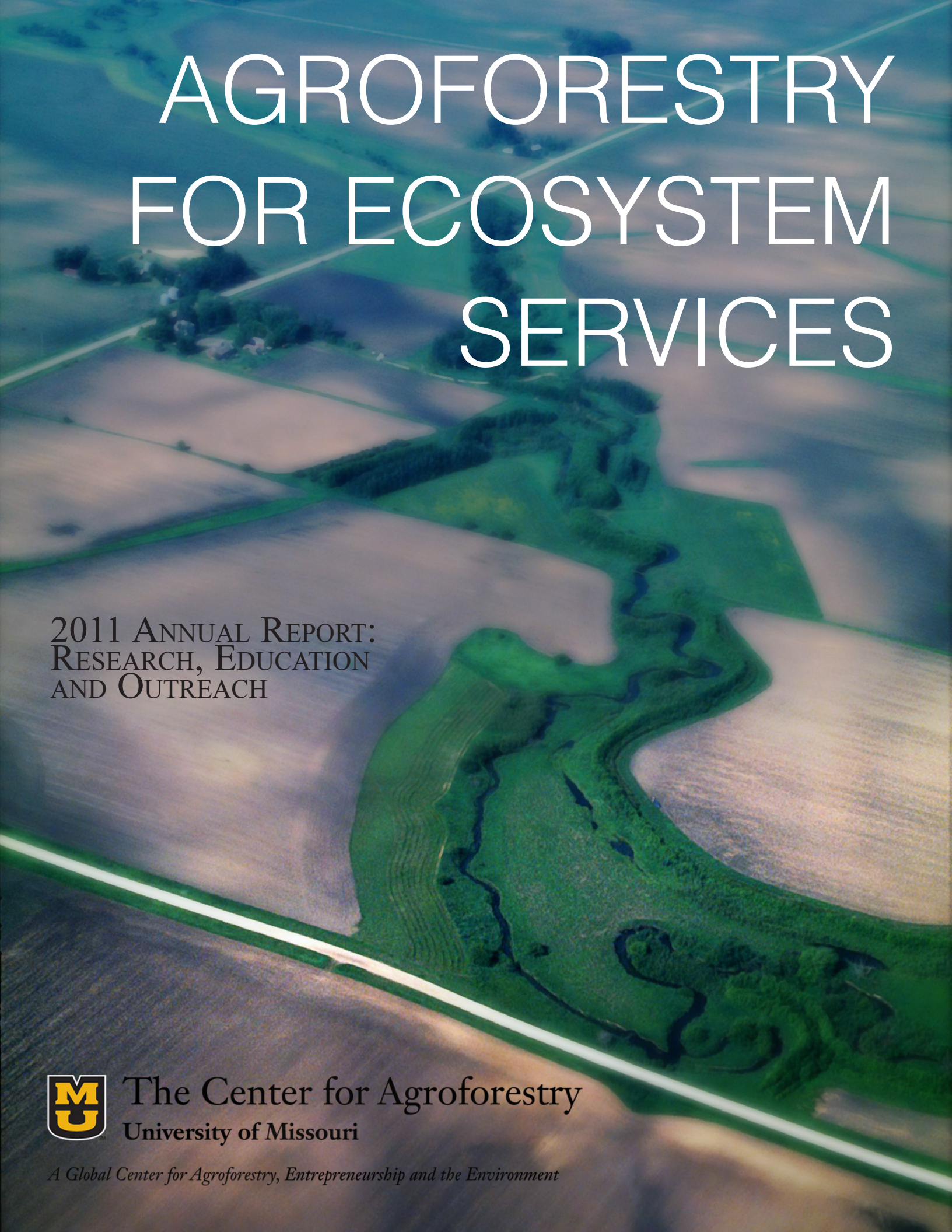

# AGROFORESTRY FOR ECOSYSTEM SERVICES

## 2011 Annual Report: Research, Education and Outreach


The Center for Agroforestry
University of Missouri


*A Global Center for Agroforestry, Entrepreneurship and the Environment*

# ABOUT THE CENTER

The Center for Agroforestry at the University of Missouri

*A Global Center for Agroforestry, Entrepreneurship and the Environment*

AGROFORESTRY PROVIDES new market opportunities, a number of ecosystem services, and is a form of sustainable agriculture and land stewardship.

In simple terms, agroforestry is intensive land-use management combining trees and/or shrubs with crops and/or livestock.

The Center for Agroforestry at the University of Missouri (UMCA), established in 1998, is an interdisciplinary research, teaching and outreach program that draws on the expertise of University faculty in natural resources, agriculture, plant and social sciences. The Center coordinates agroforestry activities locally, nationally, and globally by working closely with numerous collaborators.

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

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

2011 was a busy year including many major developments at The Center for Agroforestry. In 2011, UMCA:

- Hosted the Second Annual Agroforestry Symposium "Meeting Renewable Energy Goals: Role of Bioenergy Crops"
- Began teaching the graduate courses in the new Online Agroforestry MS degree program; first graduate students enrolled in the program
- Agroforestry was featured in the Crop Science Society of America's news magazine.

EDITED BY

*Mike Gold, Ina Cernusca and Cade Cleavelin*
*The Center for Agroforestry at MU*

ON THE COVER

*Tom Schultz (2001) | A wide angle view of several miles of buffers in Story County, IA*
*Department of Natural Resources Ecology and Management (NREM), Iowa State University*

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# DIRECTOR'S MESSAGE

Dr. Shibu Jose, Ph.D.,
H.E. Garrett Endowed Professor and Director

The Center for Agroforestry has long been a leader in developing agroforestry practices for the temperate zone worldwide, with wide ranging impacts based on our research, education and outreach programs. We're proud to say the Center has completed yet another successful year!

The annual report highlights a few of the research and outreach accomplishments of our faculty, staff and students. It was particularly rewarding to see faculty and staff come together to compete for a record number of external grants, winning many of them from local, state, national and international funding agencies.

Some of the accomplishments we are proud of in 2011 include:

- Initiation of a number of new critical agroforestry projects. Examples include the Doug Allen Research and Education Site in Laurie, MO, which showcases alley cropping, forest farming, wildlife habitat management, and prairie and forest restoration and the MU HARC farm that now includes an operational-scale silvopasture demonstration.
- Implementing a statewide network of edge-of-field water quality monitoring on farms as part of the Mississippi River Basin Initiative in collaboration with USDA NRCS, MO DNR and private landowners. Monitoring will continue for five years and potentially for nine years.
- Leading and co-leading several research and outreach projects with regional, national and international scope. Examples include a hardwood germplasm project funded by NSF and a US-Pakistan joint phytochemical project funded by the Higher Education Commission of Pakistan.
- Publishing new outreach material and updating several existing ones. New publications on elderberry and burgundy truffle mushrooms have become widely popular.
- Launching of the much anticipated online master's degree program with an emphasis in agroforestry. The program is admitting a steady stream of new graduate students with expectations of over a dozen students enrolled within the next year.

It would be remiss if I did not bring up the fiscal challenges the Center faced during the reporting year. This was the second year the Center operated without the "earmark" funding. While grants and contracts received from competitive as well as non-competitive sources helped us fulfill our mission, it was the determination and dedication of our faculty, staff, and collaborators that propelled us forward.

The unparalleled support we enjoyed from our friends and well-wishers kept us mindful of our mission to support the long-term future of rural and urban working farms and forests by achieving economic, environmental and social sustainability.

This annual report outlines the many ways by which we accomplished our mission in 2011. However, you will also notice that the seeds have already been sown for an exciting future. We appreciate your continued support of our program and look forward to another productive year in 2012.

– SHIBU JOSE, Ph.D., H.E. Garrett Endowed Professor and Director,
The Center for Agroforestry at the University of Missouri

# THE FIVE PRACTICES OF AGROFORESTRY

## forest farming

In forest farming, high-value specialty crops are grown under the protection of a forest canopy modified to provide the correct shade level. Crops like ginseng, truffles, shiitake mushrooms and decorative ferns are sold for medicinal, culinary and ornamental uses. Forest farming provides short-term income while high-quality trees are grown for wood products. Wildlife may find ideal habitat in a forest farming setting.

## silvo-pasture

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.

## 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 wheat, corn, soybeans or hay planted in between rows of black walnut or pecan trees. Non-traditional or value-added specialty crops also may be incorporated for extra income. 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 trees, shrubs, forbs and grasses, including native plants. They enhance filtration of nutrients from surface run-off and shallow ground water. 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.

## wind breaks

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.

Over the past decade, The Center for Agroforestry has been primarily supported by USDA-ARS grant programs, funding more than 60 individual projects. The Center continues to develop the scientific basis for designing and prescribing agroforestry practices within a "systems context," which allows technology to be used most effectively. To achieve this goal, research efforts have been organized into research "clusters" to enhance creativity and productivity among a range of investigators from many disciplines.

# RESEARCH CLUSTERS

## SPECIALTY CROPS
Features research on northern pecan, eastern black walnut and Chinese chestnut, including field studies, financial, market and consumer research and outreach. UMCA supports the nation's most comprehensive research programs for developing the eastern black walnut and Chinese chestnut as nut crops for agroforestry practices. Additional specialty crop foci include gourmet mushrooms, pawpaw, elderberry and pine straw.

## MEDICINALS/PHYTOCHEMISTRY
Ongoing studies include those on redcedar phytochemicals and elderberry in conjunction with MU's Center for Botanical Interaction Studies.

## ENVIRONMENTAL SERVICES
The objective is to quantify environmental benefits of agroforestry buffers on non-point source pollutants including antibiotics. Includes paired upland watershed study and work on riparian forest buffers in collaboration with Iowa State University scientists. In addition, researchers are working to see if vegetative environmental buffers can help to reduce odor from large farming operations.

## BIOMASS/BIOFUELS
The focus is to quantify and enhance growth in poplar and willow clones, sweet sorghum, switch grass and other species for biomass production. Studies include replicated trials along a latitudinal gradient from Columbia, Mo., to Booneville, Arkansas. Interest in large-scale biomass plantings in the MS/MO floodplain corridor are being supported by research into the flood tolerance of these same species in the Center's outdoor flood tolerance lab at the MU Horticulture and Agroforestry Research Center.

## EDUCATION
Historically, the Center has funded an average of 20 graduate students per year on various projects. Current funding levels have resulted in a decline in current graduate enrollment. Graduate student interest in enrollment in the Center's new and unique online graduate degree program and graduate certificate in agroforestry is growing rapidly.

## WILDLIFE INTEGRATION
Studies have looked at bottomland hardwood restoration and management, quantifying effects of bottomland agroforestry practices on wildlife species. Additional work involves assessment of wildlife benefits associated with upland agroforestry practices.

## SILVOPASTURE
Research studies include response of cattle, forage and trees in silvopastures with planted trees; extending the grazing season with early- and late-season forages; effects of integrating forages and rotational livestock grazing into managed white oak stands to determine impacts on tree growth, regeneration, forage quality and animal weight gain and health on north-facing slopes in the Ozarks; and establishment of drought-tolerant shortleaf pine and warm-season grasses on south-facing slopes in the Ozarks. Features replicated trials ranging from New Franklin, Mo., to Booneville, Ark.

## TREE/CROP INTERACTIONS
Impacts all biophysical research clusters, with a focus on above- and below-ground interactions between trees and crops; also includes insect predator/prey dynamics.

## SOCIO/ECONOMIC/MARKETING
The cluster's integrated approach works to understand the social and economic dimensions of a given enterprise, including institutions, networks, markets, non-market valuation and technology. Research activities provide an understanding of factors that facilitate or constrain involvement in agroforestry.

## OUTREACH
Efforts are centered around active training programs for resource professionals and landowners, with a focus on the application of ongoing agroforestry research and landowner demonstrations complemented by socio/economic/marketing studies.

# PARTNERSHIPS

The Center for Agroforestry at the University of Missouri partners with universities, natural resource entities, agricultural organizations and landowners across the Midwest and the nation to foster an integrated approach to farming across diverse landscapes.

## MU COLLABORATIONS

University of Missouri Extension
College of Agriculture, Food and Natural Resources
Partnerships with faculty in 15 departments: Animal Sciences; Horticulture; Forestry; Agricultural Economics; Rural Sociology; Entomology; Agronomy; Chemistry; Plant Pathology; Fisheries and Wildlife; Parks, Recreation and Tourism; Biological Engineering; Veterinary Pathobiology; MU Life Science Center; and Soil, Environmental and Atmospheric Sciences
University of Missouri National Center for Soybean Biotechnology
University of Missouri Center for Sustainable Energy
University of Missouri Agricultural Experiment Station Outlying Properties: Horticulture and Agroforestry Research Center, New Franklin, Mo.; Wurdack Farm, Cook Station, Mo.; The Southwest Center, Mt. Vernon, Mo.; Greenley Memorial Research Center, Novelty, Mo.; South Farms, Columbia, Mo.; Delta Research Center, Portageville, Mo.; Bradford Research and Extension Center, Columbia, Mo.; and Thompson Farm, Spickard, Mo.

## EXTERNAL UNIVERSITY COLLABORATIONS

The Agroecology Issue Team, Iowa State University
Chetopa Experiment Station, Kansas State University
Environmental Science, Lincoln University
Mid-America Agroforestry Working Group (MAAWG)
Dept. of Biology, St. Louis University
Dept. of Biological Sciences, University of Notre Dame

## FEDERAL AND STATE AGENCY PARTNERSHIPS

Federal Collaborations
USDA Agricultural Research Service - Dale Bumpers Small Farms Research Center, Booneville, Ark.
USDA Forest Service - Central Hardwoods Research Unit, Columbia, Mo.
National Agroforestry Center, Lincoln, Neb.
USDA Natural Resource Conservation Service
USDA Agricultural Research Service - Cropping Systems and Water Quality Research, Columbia, Mo.
USDA Forest Service - Hardwood Tree Improvement and Regeneration Center, West Lafayette, Ind.
State Collaborations
Missouri Department of Conservation
Missouri Department of Natural Resources
Missouri Department of Agriculture
Missouri Natural Resources Conservation Service
Missouri RC & Ds

## PROFESSIONAL ASSOCIATIONS AND BUSINESSES

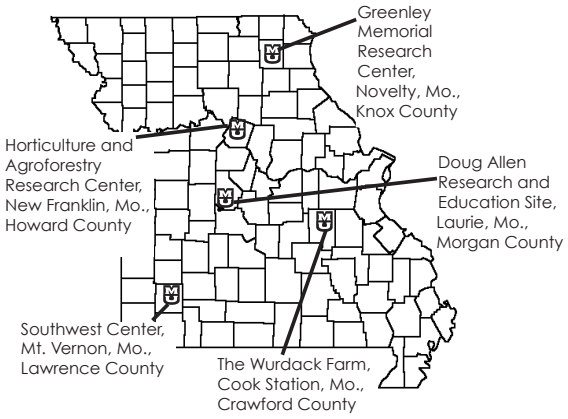
Association for Temperate Agroforestry
Forrest Keeling Nursery
Hammons Products Company
Missouri Northern Pecan Growers, LLC
Missouri Forest Products Association
Missouri Nut Growers Association
Missouri Walnut Council
Chestnut Growers of America
Missouri Farm Bureau
Missouri Farmers Union
Missouri Tree Farm Association
Missouri Christmas Tree Producers Association
Missouri Consulting Foresters Association
Midwest Elderberry Association

## DONORS AND FRIENDS

Doug Allen
Friend of the Center; has made a planned gift of 535 acres and corresponding resources for the establishment of the Doug Allen Research and Education Site, Laurie, Mo.

## INTERNATIONAL COLLABORATIONS

National Sun Yat-sen University, Kaohsiung, Taiwan
Quaid-i-Azam University, Islamabad
Uppsala University, Sweden
Abomi Calavi University, Benin, West Africa




**THE CENTER FOR AGROFORESTRY** conducts both basic and applied research on five farm sites that are part of the University of Missouri Agricultural Experiment Station, representing the economic and ecological diversity of the state. Additional research farm sites are incorporated on a regular basis as the Center expands the depth and breadth of its program.

*Special recognition is extended to the Dale Bumpers Small Farms Research Center, Booneville, Ark., whose financial, scientific and collegial support have provided the impetus for the global advancement of agroforestry.*

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# MISSISSIPPI RIVER BASIN INITIATIVE

UMCA instrumented 10 watersheds in north east and north central Missouri as part of the Mississippi River Basin Healthy Watersheds Initiative (MRBI) established by the Natural Resources Conservation Service (NRCS). Through this new initiative, NRCS and its partners will help producers in selected watersheds in the Mississippi River Basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity. It is anticipated that these conservation practices will help reduce Nonpoint Source Pollution from agricultural watersheds in the MRBI areas and eventually help reduce the Hypoxia in the Gulf of Mexico. Evaluation of watershed models is expected to examine effects of conservation practices on large geographic regions and develop water quality improvement guidelines.

## MITIGATING EROSION AND NON-POINT SOURCE POLLUTION IN THE MISSISSIPPI RIVER BASIN

The Gulf of Mexico (GoM) is the third largest drainage basin in the world, the ninth largest water body in the world, and an international maritime ecosystem. According to the International Monetary Fund (IMF 2007), this region ranks seventh in the global economy in terms of the combined gross domestic production of the five bordering states (FL, AL, MS, LA, and TX). Major economic drivers in the region are fishing, shrimp, oyster, tourism, recreation, oil, and gas. Many of these industries depend on the water quality of the GoM. It is believed that production and health of the region contributes not only to the local and regional economy but also to national and global economy.

Hypoxia in the GoM is the primary factor affecting the region's health, water quality, and gross production. Hypoxia can be defined as a "dead zone" where dissolved oxygen concentration drops to a level that does not support aquatic life. Excess nutrients increase algal growth, and their subsequent death and decomposition causes depletion of oxygen in the water. There is a strong consensus that the cause of the Gulf's hypoxic zone is attributed to nutrients coming from the watershed of the Mississippi River Basin. The Mississippi River, stretching from northern Minnesota to the GoM, carries an average 436,000 tons of sediment each day. About 40% of world's corn and over 40% of world's soybean are produced in the Mississippi River Basin. Throughout this region plant nutrients are typically supplied by commercial and animal manure fertilizers that affect local water quality and eventually flow downstream to impact hypoxia in the GoM (Figure 1).

Although nitrogen (N) and phosphorus (P) are macronutrients essential for plant growth, excess nutrients, sediments, herbicide and pathogens derived from field runoff are among the leading causes of impaired streams. A seven-year study showed that approximately 1.21 lb/ac (1.29 kg/ha) P and 14.29 lb/ac (16 kg/ha) N are annually


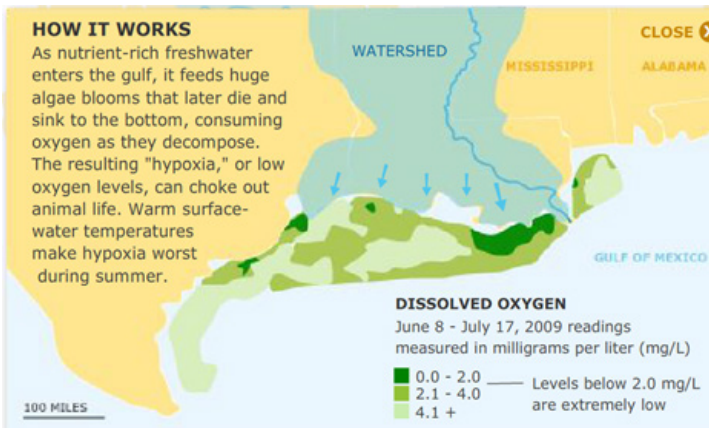


**Figure 1. The Mississippi River Watershed and the hypoxic zone in the Gulf of Mexico**

**Source: http://www.mnn.com/earth-matters/translating-uncle-sam/stories/what-is-the-gulf-of-mexico-dead-zone**

lost from corn-soybean rotations (Udawatta et al., 2004, 2006). N and P occur in four inorganic forms in streams and rivers: nitrate, nitrite, ammonium and orthophosphate. In addition, sediment and organic matter bound N and P also enter water bodies. Many of these nutrients enter the river from non-point sources like runoff, which are much more difficult and complex to control and monitor than point sources of pollution.

Taken together, these non-point source pollutants are detrimental to aquatic life, promote algal growth and adversely impact recreational use and aesthetics. Recent estimates suggest that 43% of the N and 27% of the P flux to the Gulf originate in Mississippi River Basin and come primarily from agricultural runoff (Aulenbach et al., 2007).

Nutrient discharges from sewage treatment plants and from urban runoff have also been identified as important, but are smaller contributors accounting for ~10 % of the nutrients that contribute to Gulf hypoxia. The five largest "hypoxic zones" in the Gulf of Mexico have occurred within the past decade. The average size of the hypoxic zone in the northern Gulf of Mexico from 2004-2008 was ~17,000 km$^2$, the size of Lake Ontario. However, the size of the zone depends on the volume of fresh water discharged into the GoM with larger zones occurring in wet years and smaller zones in drought years. Since the health and water quality of the region is vital for the local, regional, national, and global economy, it has become imperative to reduce excess nutrient loading into the GoM.

The National Academy of Sciences (NAS) – National Research Council released a report (2002) entitled: "Riparian Areas: Functions & Strategies for Management". In that report the committee recommended … "Restoration of riparian functions along America's water bodies should be a national goal. Over the last several decades, federal and state programs have increasingly focused on the need for maintaining or improving water quality, ensuring the sustainability of fish and wildlife species, protecting wetlands, and reducing the impacts of flood events. Because riparian areas perform a disproportionate number of biological and physical functions on a unit area basis, their restoration can have a major influence on achieving the goals of the Clean Water Act, the Endangered Species Act, and flood damage control programs."

An additional recommendation from the 2002 NAS report was: … "Although many riparian areas can be restored and managed to provide many of their natural functions, they are not immune to the effects of poor management in adjacent uplands. Upslope management can significantly alter the magnitude and timing of overland flow, the production of sediment, and the quality of water arriving at a downslope riparian area, thereby influencing the capability of riparian areas to fully function. Therefore, upslope practices contributing to riparian degradation must be addressed if riparian areas are to be improved. In other words, riparian area management must be a component of good watershed management."

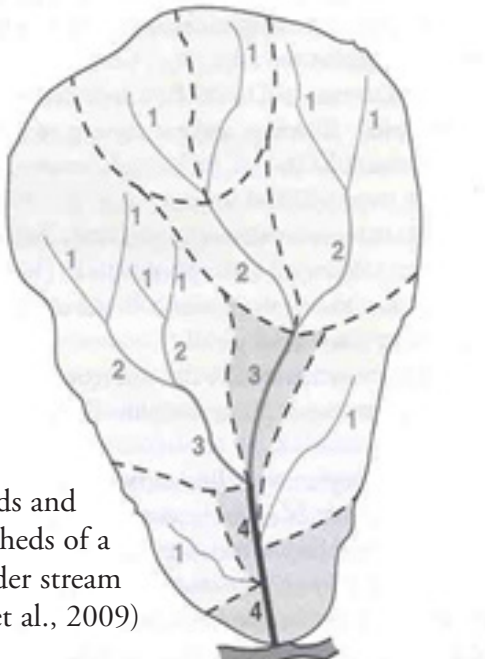


Figure 2. Watersheds and subwatersheds of a fourth order stream (Schultz et al., 2009)

In terms of non-point source pollution prevention, riparian and upland buffers have a number of important functions including: 1) Filtering and retaining sediment; 2) Trapping, storing and transforming chemical inputs from uplands; 3) Trapping phosphorus attached to soil sediment; 4) Trapping and transforming nitrogen and pesticides (atrazine, etc.). In addition, nutrient management, crop rotation, land use practices, and other conservations methods also help reduce nutrient losses from watersheds. For example, cover crops can have a significant effect as ~50% of the N and P loss occur during crop free periods (Udawatta et al., 2004, 2006).

Riparian and upland buffers have the largest influence on water quality along 1st - 3rd order streams (smallest size) as over 90% of stream lengths in a watershed are 1st - 3rd order.

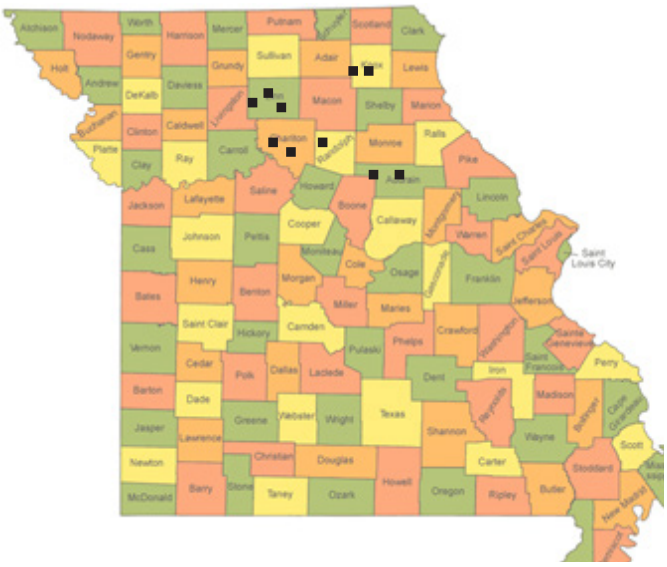

**Figure 3. Approximate location of study watersheds in Missouri as of 2011 (editor's note: additional sites will be added in 2013).**

This is the zone of erosion and sediment and solute production and most of this production passes through the buffer (riparian) community (Figure 2). Therefore, uninterrupted and wide riparian buffers along the streams can effectively reduce sediment and nutrient losses.

In 2000, the USEPA Science Advisory Board developed an Action Plan to reduce both N and P loads by 45% aiming to reduce the hypoxic zone to 5,000 km$^2$ by 2015 (U.S. EPA Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Progress toward this goal has been limited for several reasons including lack of clear authority to undertake implementation and lack of funding to support control activities. Nonetheless, a number of control methods have been identified, particularly for nutrients coming from agricultural fields. Finding cost-efficient solutions for reducing nonpoint source pollution, such as nutrient reductions from agricultural fields, have been viewed as one of the most challenging problems to solve. The specific practices implemented in a watershed will depend on the location of the field within the watershed as well as the hydrology and land use at other locations in the watershed (including agricultural conservation practices); additionally, reduced nutrient export at the edge of agricultural fields are not the endpoint of interest, rather, reduced nutrient loading into the Gulf is the goal.

To help solve these water quality problems, the Natural Resources Conservation Service (NRCS) has developed the Mississippi River Basin Healthy Watershed Initiative (MRBI). On March 2, 2010 the Chief of the NRCS announced the availability of financial assistance (Federal Register Vol. 75, No. 40) for the MRBI. MRBI is implemented by NRCS through the Cooperative Conservation Partnership Initiative (CCPI), the Wetlands Reserve Enhancement Program (WREP), Conservation Innovation Grants (CIG), and other programs. Under MRBI-CCPI, NRCS enters into multi-year agreements with eligible

**Figure 4. Instrumentation of a watershed.**

partner organizations. The program identified 41, 8-digit hydrological units as designated areas within 12 states. The purpose of the notice was to solicit proposals from potential partners to enter into partnership agreements with NRCS, agricultural producers, and landowners of the future availability of program funds through approved partnership projects. The focus of the program is to reduce N and P loadings to the Gulf from agricultural watersheds through adoption of multiple conservation practices in agricultural watersheds in the Mississippi-Missouri Watershed Basins. NRCS has approved a number of core and support conservation practices, which are recognized methods of avoiding, trapping, and controlling pollutants (www.nrcs.usda.gov/programs/mrbi/mrbi.html). The MRBI initiative is adopting a three-tiered monitoring and evaluation approach designed to assess environmental outcomes at the field, 12-digit, and 8-digit watershed scales.

The objectives of the MRBI are:

1. Avoid, control and/or trap nutrient runoff
2. Maintain agricultural productivity
3. Improve wildlife habitat
4. Protect restore and enhance wetlands
5. Partnership efforts

The Center for Agroforestry at the University of Missouri has been awarded MRBI funding and currently monitors 10 tier one watersheds in north-east and north-central Missouri and will be expanding to several more in the near future (Figure 3). The tier one approach monitors water quality and evaluates effects of conservation practices, systems and activities implemented through the project on a field or edge-of-field scale. The study design includes control watersheds, treatment watersheds, and paired watershed approach. These watersheds are instrumented with metal approach sections, H-flumes (3-ft), bubbler flow-measuring devices, water sampling units (Teledyne ISCO, Lincoln, NE), sampler housings, solar panels, and deep cycle batteries as described by Udawatta et al. (2011). ISCO flow measuring devices record flow rate, water level, sampling time and signal the water samplers to collect water samples. These data will be downloaded to a laptop computer. Runoff samples are collected after each measurable runoff event and water samples are analyzed for sediment, total P (TP), dissolved P, total N (TN), and nitrate-N using standard methods (Udawatta et al., 2011).

MRBI monitoring is unusually challenging for a number of reasons. First, numerous conservation options are potentially appropriate for any given agricultural field and several options can be used jointly. The options we assess include terraces, nutrient management, crop rotation, tillage, grass waterways, and cover crops. Certain watersheds had several of these practices combined. The evaluation considers previous land use and the current land use with conservation practices to understand environmental benefits and how these adoptions help reduce hypoxia in the GoM. We will use watershed simulation models integrated into GIS data layers to examine the effects of these practices on larger geographic regions and to evaluate long-term benefits on larger watersheds.

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Riparian forest and upland buffers are an important agroforestry practice that protects water quality by slowing surface runoff, reducing sediment transport, improving infiltration, trapping, transforming and removing non point source pollutants, stabilizing streambanks, increasing diverse food and cover for upland wildlife, improving aquatic habitats for fish and other organisms and enhancing opportunities to generate farm income through products harvested from the buffer. Vegetative environmental buffers are being tested for their efficacy in reducing odor from confined feeding animal operations.

# ECOSYSTEM SERVICES

## AGROFORESTRY BUFFERS IN GRAZING SYSTEMS IMPROVE SOIL QUALITY AND CARBON SEQUESTRATION

(Udawatta, Kremer, Anderson)

Agroforestry buffers in managed intensive grazing systems improve soil quality and carbon sequestration. Many marginal forest lands in Missouri would be good candidates for silvopasture; a four county survey revealed that 68% of woodlands are grazed. These areas could be intensively managed for additional income through use of improved pasture and livestock production.

However, silvopasture has not been fully embraced by landowners. It is essential that the economic benefits and environmental services be demonstrated with scientifically proven procedures.

A two-year study of agroforestry buffers in managed intensive grazing systems compared with row crop and undisturbed forests, demonstrated that establishment of agroforestry buffers improves soil quality and carbon sequestration in less than 10 years. The soil quality indicators were consistent during the two measurement years with significantly higher values in permanent vegetation areas compared to row crop areas. Three indices that were compared indicated that the agroforestry buffer treatment had the highest soil quality index in each comparison while the row crop treatment had the lowest index. Results of the study reveal that establishment of agroforestry and grass buffers in grazed pasture can enhance soil quality and thus help maintain ecosystem sustainability. The study has made a significant contribution to the literature which lacked documentation on soil quality improvement in grazed pastures.

## MODELING THE ENVIRONMENTAL BENEFITS OF GRASS AND AGROFORESTRY BUFFERS

(Udawatta, Anderson, Baffaut)

Watershed models have become useful and necessary to evaluate impact of conservation management practices on non-point source pollution (NPSP).

In situ studies at the watershed scale have inherent problems including high costs due to their large scale and complex nature, private land ownership , and extended length of time to achieve concrete results. Alternatively, models provide a convenient, efficient, and economically feasible method to evaluate nutrient loading mechanisms under various management systems provided sufficient measured data are available at the small watershed scale.

**APEX Model**: This study investigated long-term benefits of upland agroforestry and grass buffers using the Agricultural Policy Environmental eXtender (APEX) model. The model demonstrated reductions of 28-30% sediment, 11-13% total nitrogen, and 22-26% total phosphorous. The study also examined optimum width and placement options for buffers in crop watersheds in order to provide guidelines for adoption of this technology to larger watersheds. Findings of the simulation and other studies on this watershed prove that

agroforestry buffers improve environmental quality with no significant effect on crop yield while minimizing the percentage of land taken out of production.

**Fuzzy Logic with Genetic Algorithm Simulations:** This project developed a simple tool using fuzzy logic with a genetic algorithm for runoff predictions in watersheds, which can incorporate human expert knowledge and experience in the absence of measured data. The developed fuzzy logic model predicts surface runoff based on measured rainfall. This type of tool can be utilized for estimation of total maximum daily loads (TMDL) of pollutants from watersheds to water bodies for water quality monitoring and regulatory purposes. The fuzzy logic model can also be adopted to predict other pollutant loadings. Fine-tuned APEX and fuzzy logic models can be used to develop guidelines for buffer placement and determine effects on TMDLs to reduce impacts on water bodies in Missouri and other regions.

## VETERINARY ANTIBIOTIC EFFECTS ON THE ENVIRONMENT

(Goyne, Anderson, Lin, Lerch)

Widespread use of veterinary antibiotics (VA) in poultry and large animal production is used to maintain livestock health and treat infected organisms. Widespread VA use has created a new environmental challenge that must be addressed. Livestock treated with antibiotics can excrete up to 80% of antibiotics administered, thus significant concentrations of antibiotics are found in manure which is typically disposed of via land application. Recent studies have documented the presence of VA in surface waters of Missouri and other states in the U.S. Consequences associated with antibiotics in surface waters are unknown, and it may be difficult to elucidate the consequences of widespread VA use before detrimental impacts have occurred. A recent study 1) measured changes in VA concentration after leaching through repacked columns containing agroforestry buffer, grass buffer and cropland soil; 2) measured VA transport breakthrough in repacked soil columns; and 3) estimated parameters from transport models for agroforestry buffer soil as compared to grass buffer and cropland soils. Findings suggest that the agroforestry buffer soil has a larger capacity to retain the VA sulfamethazine (SMZ) than the cropland soil, and manure-derived dissolved organic matter has little effect on SMZ sorption or leaching. Overall, the study facilitates our understanding of SMZ transport in the environment and supports the use of vegetative buffers to mitigate VA from agroecosystems.

## EVALUATING UPTAKE AND RETENTION OF VETERINARY ANTIBIOTICS BY VEGETATIVE BUFFER SOILS

(Goyne Anderson, Lin, Lerch, Udawatta)

Previous research conducted by a team from The Center for Agroforestry at MU and Associate faculty has demonstrated the utility of vegetative buffers (tree/grass and grass buffers) for reducing transport of pesticides and enhancing pesticide degradation. Building upon this prior research, the utility for vegetative buffers to reduce veterinary antibiotic (VA) loss from agroecosystems was investigated. A series of laboratory, growth chamber and field studies has documented that vegetative buffer strips can reduce loss of VA from agricultural fields due to enhanced antibiotic uptake onto soils planted to vegetative buffers. Further, greater dissipation of pollutants occurred in the root zone of plant species used to create buffers. Cumulatively, this research demonstrates that vegetative buffer strips are an effective and economical means to prevent antibiotics found in animal manures from entering waterways of Missouri and, subsequently, helps to maintain the quality of life and health of Missouri's residents.

## MICROBIAL COMMUNITY CHARACTERISTICS IN VEGETATIVE BUFFER AND CROPLAND SOILS

(Unger, Goyne, Kremer)

Recently, UMCA Associate Faculty have been exploring the use of agroforestry and grass buffers to mitigate the spread of antibiotics in the environment. A complimentary, and essential, aspect that requires investigation is the effect of infiltrating antibiotics on soil microbial communities within the rooting zone of plants. Root exudates from tree and grass buffers are expected to mitigate the effect of the antibiotics in terms of microbial biomass; however, shifts in microbial community characteristics are still expected as the more sensitive species are lost. Differences in soil microbial community structure for agroforestry buffers, grass buffers and crop systems were observed. In general, agroforestry and grass buffers support greater overall microbial biomass as well as greater bacterial and fungal populations than crop systems. In terms of soil microbial community function, the soil microbial communities of these buffer strips and crop system seem robust to the effects of lincomycin and oxytetracycline antibiotics at test concentrations. After initial brief inhibition, microbial community function rebounded and showed full recovery within 63 days of application. Moreover, these results show that test antibiotics do not negatively impact buffer functions. In addition, collaboration with the USDA-ARS lab in Maricopa, AZ, revealed that antibiotic resistance did not develop over the course of our investigation. These results may be related to the high clay content of soils in these systems; thus, future research efforts will include investigations on other soils to determine if our results are more widely applicable.

## EFFECTS OF AGRICULTURAL LAND MANAGEMENT PRACTICES ON SOIL ORGANIC MATTER

(Goyne, Motavalli, Kremer)

Soil organic matter (SOM) is the largest manageable pool of carbon on Earth, and it is essential for maintaining crop productivity, soil quality, and mitigating pollutant transport through soil. Thoroughly understanding the influence of various management techniques, such as agroforestry practices, on carbon pools, quantity, and chemistry is essential for understanding the role land management can play in carbon sequestration and pollutant transport. The goals of this work are to compare: (1) Soil organic carbon (SOC) and total nitrogen (TN) on a concentration, soil volume and soil mass basis in claypan soils planted to different conservation management practices and as a function of landscape position; (2) soil quality in no-till, grass vegetative filter strips (VFS) and agroforestry VFS across four landscape positions ten years after the VFS were planted in a maize-soybean rotation; and (3) indicators of SOM quality from three conservation management practices (i.e., no-till, grass VFS and agroforestry VFS) and four landscape positions in a claypan agroecosystem. Our research on soil organic matter content and chemistry suggest that vegetative buffers significantly increase soil carbon concentrations in surface soils relative to no-till managed cropland. Carbon fractions in vegetative buffer soils are also changing relative to the cropland soil, and we have developed a new technique to rapidly assess changes in soil carbon fractions in soil. Overall, improvements in soil quality and soil organic matter quality are induced by the presence of perennial vegetation present within the vegetative filter strips. These results are important to citizens of Missouri as they illustrate improved ecosystem services in agroecosystems where vegetative filter strips are established. Subsequently, improved ecosystem services will enhance the quality of life for Missouri's citizens via sequestration and stabilization of carbon in soils and improved soil and water quality.

## LAND USE EFFECTS OF GREENHOUSE GAS PRODUCTION IN MISSOURI RIVER FLOODPLAIN SOILS

(Motavalli, Udawatta)

The Missouri Floodplain is a highly productive region for agriculture and other land uses, but it is subject to frequent flood events. Little information is available about the effects of flooding and land management on greenhouse gas (GHG) production. This project seeks to get more accurate estimates of these emissions through a better understanding of the spatial variation in emissions and development of improved protocols for gas sampling. This information will enable the future development of best management practices that will result in lower GHG emissions. GHG emissions are an important concern for their effects on climate change. However, little information is available on these types of emissions in the floodplain. Therefore, large-scale estimates of GHG production may be inaccurate. In addition, each of the greenhouse gases may have different conditions that promote their loss. Understanding these conditions is necessary for improved land management. Losses of nitrous oxide also repre-

sent a possible decrease in efficiency in nitrogen fertilizer use, which may result in lower crop production. The objectives of this study are to evaluate and spatially characterize soil greenhouse gas emission responses to differences in physical and chemical soil properties and nutrient management among three management treatments: agroforestry, row crop agriculture, and riparian forest. The study fills a gap in the literature on greenhouse gas production from the agriculturally important Missouri River floodplain region. It also shows the relationship of greenhouse gas emissions in agroforestry practices to other production systems.

## MICROBIAL COMMUNITY DIVERSITY AND COMPOSITION ACROSS A GRADIENT OF SOIL ACIDITY IN SPRUCE-FIR FORESTS OF THE SOUTHERN APPALACHIAN MOUNTAINS

(Bardhan, Jose, Jenkins, Webster, Udawatta, Stehn)

Although efforts have been made to reduce air pollution, many regions of the eastern United States and Europe still face serious environmental problems resulting from industrial activities and combustion of fossil fuels. Though the Clean Air Act (1970) and subsequent amendments (1990) have resulted in decreased levels of acid deposition, the lasting impact of acidification on soil and surface waters is still hotly debated. Acid deposition changes soil chemistry and pH and reduces available plant nutrition. This study investigated the influence of soil acidity and associated changes in soil conditions on soil microbial populations and microbial activity. Soil microbial diversity and activity can often provide a better indication of the soil physical and chemical environment than simple physico-chemical analysis. This study compared the microbial diversity in the soils of high elevation spruce-fir forests in Great Smoky Mountains National Park. Although wet acid deposition ranged from low (6-14 kg/ha), medium (15-23 kg/ha), high (24-32 kg/ha), and very high (33-41 kg/ha), microbial diversity and community structure among the different levels were not markedly different. Identification of bacterial species that normally thrive in severely acidic environments are a strong indication that in spite of the reduction of acid deposition, high elevation forests in the northeast and eastern United States continue to be influenced by legacy effects and feedback cycles.

## ODOR ABATEMENT AND CONFINED ANIMAL FEEDING OPERATIONS

(Lin, Walter, Garrett)

Use of vegetative environmental buffers (VEBs) for odor abatement is recent and the science in support of using windbreaks as VEBs is limited. The purpose of this project was to develop a VEB design that has the highest probability for maximizing odor abatement. UMCA scientists used the existing scientific literature and UMCA knowledge of windbreak technology for crop protection. A three-row windbreak configuration was implemented parallel to and along all four sides of a confined animal feeding operation facility. Air sampling was performed to monitor the effects of the VEB on odor abatement. Using baseline data collected before the VEB took effect, 2-D simulations demonstrated that the surface concentration maximum to the Northeast of the facility was reduced by approximately 27% when a VEB is fully developed around the facility. The simulation also showed decreasing odor concentrations with increasing distance from the facility. The results of the 3-D simulations showed that when a VEB is fully established around the facility, the upper air concentration maximum over the facility becomes more concentrated and vertical dispersion in general increases around the facility. Results also suggest that the concentration of the odor generating volatile organic compounds diminish rapidly with distance from the emission source.

*Photo: Windbreak for odor abatement*

## QUANTIFYING FLOODPLAIN STREAM BANK EROSION
(Hubbart)

Stream bank erosion can contribute as much as 80% of suspended sediments to streams, particularly in urbanized watersheds. Excessive sediment in watercourses has been recognized as impairing water quality, jeopardizing aquatic biota, and is a key transport agent for nutrients and pathogens. Information pertaining to the quality of stream bank erosion, deposition rates, and contributions to in-stream suspended sediment loading will provide the basis for sound, science-based decision making relative to land use practices, water quality, and natural resource sustainability in dynamic urbanizing lands. Bank erosion and deposition rates were quantified using the erosion pin method comparing a remnant bottomland hardwood forest (BHF) to an adjacent agricultural site (AG). Results show that the erosion rate at the BHF site was 10 times less than the AG site. Forested sites were favorable for stream bank stabilization. The result was due, in part, to woody vegetation root systems in forested area and enhanced soil aggregation and increased soil critical shear strength. Winter resulted in the largest bank erosion rate compared to the other three seasons. Summer season had the next largest erosion rate. Implications of this work include that stream banks are more vulnerable to erosion because of higher peak stream discharge and channelization (i.e., straightening). Forested riparian systems are more effective than grass for stream bank protection. It is recommended that practices should be implemented to protect stream banks against erosion during winter season, including planting woody vegetation on the stream bank.

## EFFECTIVENESS OF RIPARIAN FOREST BUFFERS IN HEADWATER WATERSHEDS
(Isenhart, Schultz – ISU Research)

The goal of the UMCA supported collaboration with Iowa State University (ISU) scientists in northwest Missouri is to determine if the density of natural forest buffers or constructed buffer ground cover is sufficient to slow and diffuse concentrated flow and/or if grass filters upslope of the narrow riparian forest buffers are necessary to assist in providing that function. Data collected in NE Missouri on bank erosion show a very strong seasonal influence with most of the erosion occurring during November to mid-March period and the rest of the year showing significantly reduced rates. Measurements will continue for two more years to complement the four years of data already collected and provide a better picture of the relationship of weather, primarily precipitation, to bank erosion. Such a data set will be unique to the literature. A study is looking at the influence of buffers on bank erosion along the channel (it is assumed that vegetation will have different influence on bank erosion if the channel is incising rather than widening or stabilizing). Another study will re-survey soil physical characteristics 20 years after the establishment of riparian forest buffers on previously cultivated and grazed soils. A study conducted 8 years after the establishment showed significant improvement in soil structure and organic matter content and the present study will determine if further improvement occurred during the intervening years.

## LONG TERM IMPACT OF ALLEY CROPPING ON SOIL PROPERTIES AND MICROBIAL COMMUNITIES IN NORTH EASTERN MISSOURI
(Bardhan, Udawatta, Jose)

An alley cropping study was established in 1990 at the MU Ross Jones farm. Silver maples were grown in rows spaced 18 m apart with 1.5 m distance between each tree within the row. Intercropping was done with a corn–soybean rotation under no-till management as well as oats. A study was designed to evaluate any differences in the soil properties and microbial diversity between tree rows and intercropped areas. Soil samples were collected with a bulk density probe as well as for measuring soil C, N, textural class and soil microbial community diversity. Laboratory analysis for soil and microbial community diversity for this study has been completed.

The Ross Jones alley cropping study demonstrated that the close proximity of tree roots within the alley cropping area resulted in intermingling of microbial communities and no distinct difference in diversity was observed. Soil bulk density, C and N concentrations were similar between the different transects while minor differences were observed between alleys and tree rows. Microbial diversity in alley cropping areas most likely was influenced not only by the maize-soybean rotation, but also by the tree rows contributing both above and belowground litter for the past 21 years.

# SILVOPASTURE

Silvopastoral management creates an environment where trees, forage and livestock work together and can be developed to their full economic potential. Numerous greenhouse, field and pasture studies show silvopastures can be productive complements to traditional rotationally grazed pastures. But there is limited research on how silvopastures fit into a "system." Converting entire pasture systems to silvopasture is unlikely on a wide scale. UMCA silvopasture research seeks to develop silvopasture systems landowners can implement and profitably use to produce livestock products and high quality tree or forest products simultaneously.

(Dwyer, Walter)

Research conducted on the impact of management intensive grazing in highly regulated forests and underplanted white oak seedlings reveal three key areas that might hinder adoption and promotion of managed hardwood silvopasture systems: the impact of hardwood silvopasture on log quality, the growth rate of the residual trees, and the impact on white oak regeneration.

Results show no significant differences in epicormic response of overstory trees (log quality) between the thinned treatments and unthinned control. Growth comparisons 6 years pre- and 6 years post-treatment for white and black oaks showed that the mean percentage change in growth rate in response to treatments was significantly greater for white than black oaks.

For white oak, all thinned treatments, including silvopasture, resulted in changes in residual growth responses of greater than 100%. Mean growth responses of both black and white oaks in silvopasture treatments were significantly improved over the control. The silvopasture practice did not negatively impact white oak seedling survival. However, total volumetric growth of seedlings in the silvopasture treatment was significantly lower than in the "thin only" treatment.

Based on original mean tree diameters, a model was developed to express overstory growth and to project the forest management required to maintain adequate available light to support understory forage growth. The model indicates that the proper residual tree density is 162 trees/ha.

Second year survival data on pine seedlings planted at the MU Southwest Center silvopasture research project reveal a drastic reduction in survival between the 1st year and the 2nd year. Some mortality can be explained by the record drought that the Springfield, MO area suffered during the summer of 2011.

In the spring of 2011 the herbicide Pendimethalin (Prowl) was aerially applied to the fescue as a pre-emergent to control crabgrass as well as other plants. The label warns against spraying over trees with leaves and buds exposed as this may cause plant injury. Finally, in all three blocks tree survival was highest in the BNE (endophyte-free fescue) treatment.

*Photo: Cattle grazing in a hardwood silvopasture research site at MU Wurdack Farm.*

# SPOTLIGHT: ELDERBERRY

## FIRST INTERNATIONAL SYMPOSIUM ON ELDERBERRIES TO BE HELD IN COLUMBIA, MO, JUNE 2013

The elderberry (*Sambucus canadensis*), a native Missouri shrub, is an emerging and promising specialty crop in Missouri, North America, and internationally. Both the fruit and flowers are used in wines, jellies, food colorants, and, increasingly, in medicinal and nutraceutical products.

Fueled by 14 years of research and grower initiatives, Missouri is emerging as the national leader in elderberry development and production. Over the past 3 years Missouri has established the largest acreage of improved elderberry in the US. A recent major NIH grant to MU is funding research into elderberry's medicinal characteristics.

Photo: Ripe elderberries (*Sambucus canadensis*)

Researchers worldwide are studying the horticultural, biochemical, and medicinal attributes of elderberry, but there is a lack of collaboration. Our objective is to fast-track the growth of Missouri's elderberry industry by organizing and hosting the First International Elderberry Symposium, linked with a concurrent elderberry producer workshop in Columbia, MO, June 9-14.

Web:
*http://muconf.missouri.edu/elderberrysymposium*

The Symposium is being organized under the auspices of the International Society for Horticultural Science and will bring the world's elderberry experts to Missouri. This international Symposium and producer workshop will place Missouri at the forefront of elderberry research and development, and will profoundly influence the competitiveness of the Missouri elderberry industry.

The impact of the first-ever International Elderberry Symposium and the associated workshop will be immense. The gathering of diverse international elderberry researchers for the first time, along with the dissemination of the latest elderberry research across the entire spectrum of the species will be unprecedented. The Symposium will also serve as a tremendous boost to the stature and awareness of elderberry, not only in Missouri, but also nationally and internationally.

We are confident that this international gathering will firmly establish Missouri as the epicenter of elderberry research and development, and will solidify elderberry as a viable food and medicinal crop worthy of world-class attention. The impact on individual scientists, including those in Missouri, will also be profound as new collaborations and partnerships are developed.

Publication of the first all-elderberry volume of *Acta Horticulturae*, containing 50 or more peer-reviewed research papers, will form the cornerstone of elderberry research and advancement for decades to come, and will serve as a springboard for additional international research, collaborations, and conferences. The exposure of Missouri producers to this extraordinary gathering of international researchers, along with their assimilation into the international elderberry community will excite and inspire them to continue and expand their production and market development.

We believe that yet another significant impact of this event will be a direct increase in Missouri's competitive advantage as it becomes even more well known as the leader in the U.S. elderberry industry.

## RESEARCH ON MRSA-FIGHTING COMPOUND MAKES WAVES

Research started years ago at The Center for Agroforestry has found a compound in the needles of the Eastern Red Cedar (ERC) tree that can kill the staph "superbug" MRSA. Now, news outlets around the region and country are hearing about this groundbreaking research.

Most people would never suspect a "trash tree," one often removed by farmers due to its ability to destroy farmland, could be the key to fighting a deadly bacterium. Now, University of Missouri researchers have found an antibiotic in the ERC that is effective against methicillin-resistant Staphylococcus aureus (MRSA).

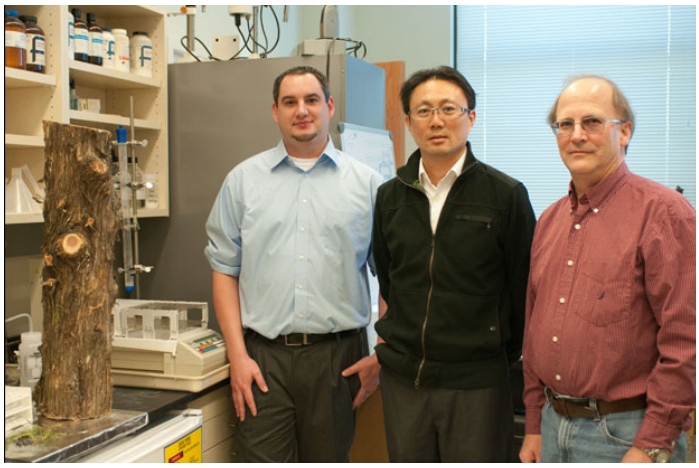

*Photo by Keith Montgomery, CAFNR Communications*

The MU research team includes (in photo, left to right) Brian Thompson, Bond Life Sciences Center; Chung- Ho Lin, The Center for Agroforestry; and George Stewart, pathobiology.

"I wanted to find a use for a tree species that is considered a nuisance," said Lin, research assistant professor, UMCA. "This discovery could help people fight the bacteria as well as give farmers another market."

MRSA is an evolving bacterium resistant to most medications. For most people, the infection is isolated to the skin. However, it can spread to vital organs causing toxic shock syndrome and pneumonia. The incidence of disease caused by MRSA bacteria is increasing worldwide. In 2005, more than 94,000 people developed life-threatening MRSA infections in the U.S., according to a CDC report. Nearly 19,000 people died during hospital stays related to these infections.

A resilient tree with either needles or narrow leaves, ERC survives in even the poorest soils. Once used widely by Native Americans, ERC berries today are a desirable food for birds. Unfortunately, birds spread the seeds widely and it is invasive on farm, forest and pasture land; farmers actively destroy the trees. ERC trees contain chemicals that burn readily and were blamed for the rapid spread of Oklahoma and Texas wildfires in 2005 and 2006. ERC's range extends from Kansas to the eastern U.S. An estimated 500 million trees grow in Missouri.

A study to determine uses for ERC trees was conducted a decade ago by another team of researchers from UMCA, led by forestry research professor and Center Associate Director Mike Gold. The study demonstrated ERC trees have a wide array of economic uses with an estimated national market value exceeding $60 million. Their findings uncovered intriguing studies that led to the current work on the medical uses of ERC.

Lin, Stewart and Thompson identified, isolated and tested 17 bioactive compounds and have plans to analyze more. The team tested the compound's effectiveness against many versions of MRSA in a test tube with promising initial results.

In addition, researchers found that some chemical compounds in the tree are able to fight and kill skin cancer cells present in mice. It might also be effective as a topical acne treatment. Stewart said the compounds are years away from commercial use, as they must go through clinical trials. The team's research was presented recently at the International Conference on Gram-Positive Pathogens.

Articles on this research have appeared in the Columbia Daily Tribune, Science Daily, The St. Louis Post-Dispatch, and Medical News Today.

*The MU News Bureau/CAFNR Communications contributed to this article.*

## BIOMASS

Agroforestry offers a potential way to integrate perennial woody bioenergy crops with traditional agricultural crops to satisfy energy demands without sacrificing food production. Windbreaks, alley cropping and riparian buffer strips are ideally suited for biomass production in agroforestry settings. In addition to satisfying domestic energy demands, these systems could also potentially enhance water quality, sequester carbon, improve aesthetics, and provide critical wildlife habitat. Potential sources of biofuel feedstock include a wide range of plant species and production systems. Systems that have garnered particular attention include perennial switchgrass, short rotation woody crops (willow and poplar spp.), and annual crops (corn, soybean and sweet sorghum). Although corn and soybean are the crops of choice in Missouri and Arkansas and are an important source for bioethanol and biodiesel production, alternative crops such as switchgrass, sweet sorghum and short rotation woody trees provide the opportunity to diversify the farm's income while providing enhanced ecosystem services.

### BIOFUEL FEEDSTOCK PRODUCTION IN CENTRAL MISSOURI AND ARKANSAS
(Fritschi)

This study compares annual crop, perennial grass, and short-rotation woody crop production systems for biofuel feedstock production across a latitudinal gradient from Central Missouri to Central Arkansas. Drought conditions in 2011 resulted in poor survival of willow at all three locations. Cottonwood tree growth, survival and biomass yield were better than that for willow at all locations. Corn and soybean plots at Booneville and Southwest Center failed to yield and had poor yields at HARC. Sorghum survival and yields at the MU Southwest Center and HARC were good, proving sorghum's ability to withstand severe drought and maintain yield under adverse growing conditions. Besides monitoring plant growth, soil analyses are being conducted at all three locations.

### BIOENERGY PLANTATIONS AT HARC
(Dwyer)

An operational scale bioenergy plantation was established at HARC to educate private landowners on how to manage and economically produce green energy from biomass. Phase one involved the establishment of a 9-acre plantation designed to evaluate the survival, production, and installation costs of various cottonwood clones, two proprietary willow clones and nursery-run silver maple. Specific objectives of the project are to:

1) determine the plantation yields by species,

2) determine the economics of growing short rotation woody biomass, and

3) develop a strategy for growing biomass profitably for landowners.

The plantation was installed in May of 2011. In February of 2012 the plantation will be cut to facilitate the development of coppice sprouting. First year survival was 69% and 92% respectively for the two willow clones. Silver maple survival was 98%, and cottonwood survival ranged from 5% to 80% for the 13 clones in the project. Survival in 2011 was impacted by drought and invasion of giant ragweed in the plantation. The total cost to establish the 9-acre plantation was $27,524. With the Biomass Crop Assistance Program in place paying a rental rate of $40/acre for 5 years, and a 75% establishment cost share, the net present value would be approximately $900/acre with an IRR of 25-30%.

## Socio-Economic and Policy Analysis Projects (Aguilar)

A Study of Missouri Private Forest Landowners' Willingness to Participate in a Biomass Crop Assistance Program

Model Development and Predictor Tools Using FIA and State Forest Resource Assessments in Support of Wood for Energy Program

Charging into Blend Wall: Conjoint Analysis of Consumer Willingness to Pay for Ethanol Blend Fuels

A Feasibility Analysis of Harvesting and Using Wood as a Feedstock for Ethanol and Other Energy Sources While Sustaining the Forest Resource

Assessment of Opportunities and Long-term Impacts on Forest Resources of Co-combustion of Woody Biomass With Coal for Electricity Generation in the U.S

Assessing the Environmental Sustainability and Capacity of Forest-Based Biofuel Feedstocks within the Lake States Region

## UMCA DIRECTOR HELPS TO PLANT SEEDS FOR AN ADVANCED BIOFUEL ECONOMY

*This article is adapted from the original piece by Megan Cassidy that was published in the July 28th issue of the Columbia Missourian*

UMCA director Dr. Shibu Jose is part of a growing contingent of researchers who are working to establish a biofuel economy based in the floodplains of the Mississippi and Missouri Rivers. Dr. Jose and his team authored a proposal that would involve converting less than one percent of the 116 million acres of the floodplain area to biomass crops.

*Photo: Dr. Shibu Jose at a HARC demonstration.*

This would create a "corridor of sustainable biomass and advanced biofuel production." The proposed crops include seven types of grasses and trees: Cottonwood/Poplar and Willow (trees), Switchgrass and Miscanthus (grasses), Energy Cane and Sweet Sorghum and Biomass Sorghum. These biomass crops are viable alternatives to corn and soybean crops that are currently cultivated in marginal areas, which are prone to failure due to flooding or soil erosion, and must be replanted yearly.

With the exception of sorghum, all of the crops listed above are perennials, which do not require annual planting. Jose and his team of researchers and industrial partners are also sensitive to the food vs. fuel debate. That's why they are targeting land that would be high risk or unproductive for corn and soybeans. They also believe that the lower-input perennial production systems that they propose will help reduce nutrient and sediment loading to the streams and rivers thereby easing up the hypoxia "dead zone" in the Gulf of Mexico.

The immediate goal is to unite the various players in the biomass and biofuel industry behind the common goal of creating a financially stable biomass and biofuel production system for the U.S. More than 50 partners from every area of the industry supply chain have agreed to back the effort.

"The technology to produce advanced biofuels is rapidly evolving; however, the development of a sustainable feedstock system has not been on pace with the technology development," Dr. Jose said.

"The biomass crops that we have identified include both woody and herbaceous species that are both flood and drought tolerant," he added. "Many of them also require less chemical input, can hold the soil in place and provide habitat for wildlife while providing an income for landowners."

Rather than building a basic supply chain, Dr. Jose said the teams have added bankers, transportation experts and equipment manufacturers to the mix. "There is no existing model that brings every player together like this in the region," he said.

He says if all goes as planned in the next five to 10 years, the Mississippi and Missouri river corridor could see:

- 1 million acres of biofuel crops
- The creation of dozens of advanced rural bio-refineries (ARBRs) in the region, creating jobs and economic benefits in a ten state region
- A healthy, advanced biofuel industry producing 20 to 30 percent of the national goal of 21 billion gallons a year

Dr. Jose's team has been awarded a grant from the Mizzou Advantage program. They are also applying for several federal grants worth millions of dollars, but the programs are highly competitive.

"We've decided as an institution to move forward with the consortium," he said.

# SPECIALTY CROPS

UMCA's specialty crops cluster features research on pecan, black walnut, chestnut, elderberry and pawpaw, including field studies, market and consumer research, financial decision modeling and outreach. The Center supports the nation's most comprehensive research program for developing eastern black walnut and one of only two national programs to develop Chinese chestnut as specialty crops for use in agroforestry practices. For new orchards to succeed, reliable cultivar information and proven orchard management techniques are essential. Research supports the production, availability and distribution of quality, proven, nursery stock, decreasing grower risk of failure while increasing their production efficiency and profitability.

## BLACK WALNUT
(Coggeshall)

Eastern Black walnut (EBW) (*Juglans nigra*) is very well adapted to Missouri's harsh climate and offers long-term income potential to a variety of farmers and landowners statewide. Yet, unlike research to improve the quality of EBW timber as a fine hardwood, EBW nut production has not been pro-actively studied or developed until recently.

### Walnut rootstock evaluations
To gain greater insight into the effect of rootstock origins on cultivar performance, scions of the cultivar 'Sparrow' were grafted onto seedlings representing 11 open pollinated families in the HARC greenhouses in spring 2010. An 8.5 acre grafted orchard was established at HARC in the spring of 2011, and a replicate planting (9 acres) was planted on lands owned by Hammons Products Company near Stockton, MO in the fall 2011. This new study includes more than 500 trees with Sparrow scions grafted to 12 different seedling rootstocks. These orchards will facilitate future economic analyses and enable researchers to overlay additional (e.g. fertilization) treatments in a systematic arrangement to elucidate the benefits of specific cultural practices over time.

Thousand Cankers Disease (TCD) poses a serious threat to the EBW resource. A series of multi-year greenhouse inoculation trials conducted at Colorado State University (CSU) focused on host responses in terms of black walnut susceptibility/tolerance. Significant (and stable) levels of genetic variation in canker development caused by *Geosmithia morbida* – the fungus that causes TCD - have been detected. For 12 EBW cultivars, canker development ranged from 30 to 283 $mm^2$ after 8 weeks, depending upon clone. Inferences from these data are limited as these trials were conducted in a greenhouse in the absence of the walnut twig beetle, which vectors the disease. In collaboration with Hammons Products Company in Stockton, MO a total of 33 seedlots from 11 states were sown in the fall of 2010 and the resulting seedlings are to be outplanted in Tennessee and Pennsylvania in the spring 2012. These "common garden" plantings will help us to determine if TCD susceptibility is a function of geographic (or seedlot) origin. Ten accessions in the UMCA EBW collection that serve as the parents of our largest control-pollinated families will be grafted in 2012 for use in future TCD field screening trials in Knoxville, TN in 2013. All such plantings will enable us to further quantify both the levels and patters of susceptibility of black walnut to TCD.

### Applied EBW breeding program
EBW possesses significant levels of genetic variation for an array of commercially important nut traits, as well as timber characteristics, which can be readily exploited using traditional plant breeding techniques. Based on annual nut production and phenology data from 2007 to 2011, a total of 15 control-pollinated trees have been selected for grafting in spring 2012. These 15 second generation selections represent the "best" individuals derived from the breeding program to date. Grafts will be outplanted in spring 2013 at three locations.

## CHESTNUT (Hunt, Warmund)

### Chinese chestnut cultivar performance in Missouri
Based on fifteen years of field research, Chinese Chestnut is an orchard crop with proven potential for Missouri and surrounding states. Successful development of the chestnut industry will be based, in part, on reliable cultivar performance data. Long term evaluations under local conditions helped determine cultivars with potential commercial success in nut production and nut quality. Based on the long term evaluation, the short list of recommended list of cultivars was updated in 2011 and the existing Agroforestry in Action Guide "Growing Chinese Chestnuts in Missouri" was revised accordingly. Information obtained from this study is being utilized as the basis for current cultivar recommendations and orchard management strategies in Missouri and adjacent areas of the US Midwest.

### Control of Asian chestnut gall wasp
The Asian chestnut gall wasp (*Dryocosumus kuriphilus*) is a major threat to commercial chestnut growers as it greatly reduces yield and can eventually kill young trees. This insect can have a devastating impact on chestnut nut production in Missouri. Therefore, the development of control strategies is very important. Two studies were conducted in this area:

1. Development of procedures to disinfect scion wood. This is essential in preventing gall wasp from entering the State and limiting its spread into

uninfected areas. Hot water immersion and radio frequency heating are being tested to determine if chestnut scion wood can be disinfected by either of these methods.

2. Cellular characterization of galls induced by the Asian chestnut gall wasp. This research provides a better understanding of the insect-induced damage. Anatomical features of galls are currently being investigated. Scanning electron microscopy and transmission electron microscopy are being used to identify larva and to characterize cellular changes induced by larvae.

## BURGUNDY BLACK TRUFFLE

(Bruhn, Mihail)

Missouri is in a position to benefit from research conducted locally and in Europe enabling local cultivation of the exquisite and very high value Burgundy black truffle in oak and/or hazel orchards.

Our detection and isolation into pure culture of nitrogen-fixing bacteria resident within Burgundy truffle fungi sheds fresh light on an essential and manageable element of truffle biology. This kind of enhanced understanding of truffle biology will not only contribute to more efficient truffle cultivation, but also establishes truffle cultivation as a sustainable agroforestry practice that also serves to improve soil quality. Recent developments are leading to the ability to take the inoculation process from the greenhouse to the field, enabling the infection of pre-existing trees as well as seedlings. This will permit us to field-inoculate seedlings produced using a modification of Forrest Keeling Nursery's RPM® process. Our research has shown that the containers and substrates used in the RPM® process are incompatible with greenhouse truffle fungus infection, even though RPM® seedlings develop more highly branched lateral root systems which may translate into a higher density of truffle production in the field. We will continue experimenting with a process for inoculating seedlings at the time of planting, using several materials as carriers for truffle spores and selected beneficial bacterial strains (e.g., vermiculite, calcined clay, and biochar derived from white oak sawdust and ground milfoil weed). Locally grown truffles will draw attention to both traditional and novel products of local agriculture, horticulture and agroforestry, encouraging the further imaginative establishment of local sustainable agriculture and food manufacture.

## PINE STRAW

(Starbuck)

Results of research at HARC indicate that production of pine straw mulch may be an enterprise permitting utilization of marginal land to generate income in Mid-Missouri. Pine straw, based on the naturally shed needles of pine trees, is the most commonly used mulch in the southeastern U.S. A pine straw plantation can be harvested multiple times during the life of a pine plantation, providing supplemental income over a 20 or 30 year period with relatively low input. While Mid-Missouri has no native pines, research at HARC has shown that certain genetic selections of loblolly pine and hybrids between pitch and loblolly pine are cold hardy and have needles suitable for baling. Since pines can be grown on flat, sloping and/or infertile ground, availability of hardy loblolly and pitch x loblolly pines will allow Missouri landowners to plant a crop on less productive ground that will reduce soil erosion from wind and water while generating a steady income stream.

## ALTERNATIVE NATIVE WOODY FRUIT/NUT CROPS AT SOUTHWEST CENTER

(Thomas)

The native tree and shrub crops pawpaw (*Asimina triloba*), persimmon (*Diospyros virginiana*), elderberry (*Sambucus canadensis*), hickories (*Carya spp.*), and Ozark chinkapin (*Castanea ozarkensis*) are of great interest to a variety of farmers. These crops are all perfectly adapted to Missouri's climate and soils, yet all have been seriously neglected in terms of horticultural research. Several of these species (namely elderberry, pawpaw, and persimmon) are also known for traditional and contemporary medicinal use, yet very little is known scientifically about the physiological aspects of various medicinal compounds within the plants themselves. Of these species, elderberry has the greatest potential to develop into a major crop in the near future. Elderberry is an attractive shrub with countless uses and benefits in agroforestry and horticulture, including feeding and protecting wildlife, soil and streambank stabilization, and use of both flowers and fruit for jams, jellies, syrups, natural food colorants, juice concentrates, wines, dietary supplements, and medicinal uses. All of these aspects of elderberry can be further developed with a combination of basic and applied research. Two new elderberry cultivars adapted to the Midwest were released in 2010 / 2011: 'Wyldewood', a tall, vigorous elderberry plant that consistently produces high yields, is efficient to harvest, and produces fruit well-suited for processing; and 'Bob Gordon', a productive cultivar adapted to the agronomic conditions in the Midwestern U.S. that has outperformed the standard 'Adams II' and other genotypes in multiple studies. A $7.7 million grant proposal was awarded from the U.S. National Institutes of Health to study the medicinal aspects of elderberry in great detail.

# TREE/CROP INTERACTIONS

This UMCA cluster studies the complex interactions between trees and crops that are inherent to agroforestry. In any system, trees and crops may compete for light, water and nutrients or have complementary relationships. The goal is to successfully manage these interactions. For example, scientific theory suggests a more diverse plant community supports a more diverse insect community, with the side benefit of reducing pest insects. The UMCA Tree/Crop Interactions project team is examining various aspects of the impact of alley cropping on crop yield and predator/prey pest dynamics.

## THE EFFECTS OF GRASS SODS (LIVING MULCHES) ON TREE GROWTH

(Van Sambeek, Navarette-Tindall)

A study was conducted to examine the effects of grass sods used as living mulches when establishing black walnut, northern red oak and pitch x loblolly pine. The study compared the competitive nature of forage grasses grown with trees and evaluated possible interactions between soil moisture, soil nutrients and fertilization.

*Photo: tall fescue in black walnut and red oak at HARC*

In the Spring of 2011, the plots of the original study were reconfigured to begin quantifying how grass sods suppress growth and how much area under the tree crown must be free of grass to allow acceptable sapling growth. Black walnut, northern red oak, and pitch x loblolly pine were used in combination with ground covers under six treatments. Results indicate that tree growth rates during the 2011 drought were about half that of the 2009 and 2010 growth rates for walnut, oak, and hybrid pine.

In plots with grass sods there is a negative trend on the diameter growth rate of walnut and oak (but not pine). In these plots growth rate was lower than in plots where half or all of the grass sod had been killed. Likewise, there is a positive trend wherein fertilization increases the growth rate of walnut and oak, but not pines. Finally, it was noted that removing half of the grass (living mulch) on sites with slopes appears to be as effective as removing all the grass where soil erosion is likely to be a problem.

## POTENTIAL TO PRODUCE BIOMASS IN ALLEY CROPPING

(Van Sambeek, Jose, Wallace, Garrett)

During the 2010 and 2011 growing season, several warm season grasses – Little and Big Blue Stem and Switchgrass – selected for shade tolerance in the Shade Tolerance Screening Laboratory, were established in an open field and an adjoining alley-cropping practice (alleys 20, 40, and 60 feet wide) at HARC.

*Photo: 40 feet of alley cropping with switch-grass at HARC*

Light sensors measured the amount of light received by five rows of plants within each alley. Above ground forage biomass was harvested after a hard killing frost in fall 2011 to determine their bioenergy potential. Results show that as alley width decreased, yields decreased in response to reduced daily light and increased tree-root competition. 'Alamo' and 'Kanlow', both stiff-stemmed grasses, were the top yielding switchgrass cultivars in all treatments.

The UMCA socio/economic/marketing cluster looks at human and economic dimensions of agroforestry including individual attitudes, knowledge, incentives and social-economic-resource characteristics; the role of institutions in constraining or facilitating agroforestry; specialty crop financial decision models; knowledge of markets for new products; the role of agroforestry in agritourism; and networks that facilitate access to information about agroforestry practices.

# MARKETS & SOCIOECONOMICS

## POLICY AND ENVIRONMENTAL IMPLICATIONS OF THE BARRIERS TO AGROFORESTRY ADOPTION

(Valdivia, Barbieri, Godsey)

New research has been focused on identifying the barriers preventing agroforestry adoption. Based on results from a four county survey conducted in mid-Missouri, the most influential barriers limiting implementation of agroforestry on the farm were identified. These most influential barriers were: 1) the costs of establishing or managing trees, 2) the time required to manage, and 3) the lack of tree management experience.

All barriers were grouped into two main factors: Transaction Costs, related to information access and perceived establishment costs; and Profitability Concerns, associated with perceptions of the effects of agroforestry on farm profitability and agricultural production. Three types of landowners were also identified: environmentalists, agriculturalists, and disengaged, who differ in their perceptions of these barriers. While environmentalists were more concerned about establishment costs, agriculturalists were concerned about both costs and profitability. Environmentalists were more multifunctional, involved in the farming (e.g., agroforestry adoption) and services (e.g., recreational activities) functions. The disengaged appeared to have no concerns, had less land available for adopting practices, and perceived lower environmental concerns and benefits of planting trees.

The socio-economic characteristics of environmentalists and agriculturalists in terms of farm size and acres farmed, portfolio diversity, overall awareness of environmental problems, and their horizontal and vertical social networks, suggest that policies fostering agroforestry adoption should target both groups in the short term. It is also necessary to recognize differences between types of landowners in outreach efforts. For example, although environmentalists and agriculturalist landowners are well networked and share values related to the benefits of trees and their concerns about conservation, it is imperative to recognize that more landowners in the agriculturalist cluster are actively farming as compared to their counterpart. The results of this study have policy implications for the practice of agroforestry. Incentive structures and information are powerful motivators for changing practices. Incentives not only refer to economic, but also other motivations, such as preferences and values. According to the findings, access to information and cost share programs would reduce the barriers to adoption of practices that incorporate trees on the landscape, by reducing transaction costs of establishing the practice. Incentives need to include reduction of costs and increased profitability to be appealing to those more engaged in farming (the agriculturalists).

A "new generation" of incentive programs is needed in the USA that allows landowners to pursue alternative market opportunities when establishing agroforestry practices. Policies that support establishment, and encourage landowners to generate income from the trees, shrubs, or alternative crops, as incentive payments are reduced accordingly, can address the profitability concerns that matter to agriculturalists. Increased attractiveness to landowners seeking to earn on-farm income are programs that reduce up front establishment costs, provide income while alternative crops come into production, and reduce long-term costs to the federal government.

## PERCEPTION OF RECREATIONAL BENEFITS AND AGROFORESTRY ATTRIBUTES

(Barbieri, Valdivia)

Agriculture serves multiple functions to society, including the provision of a landscape valued for its aesthetics and recreational opportunities. Agroforestry is multifunctional as it offers a wide range of biophysical, economic and social benefits to farmers and overall society. Although agroforestry has been associated with the recreational function on a farm, there is lack of knowledge about consumers' perceptions of the recreational value of agroforestry landscapes. A study conducted on a panel of residents from Missouri, Pennsylvania and Texas examined the perceived

functions and benefits of agroforestry landscapes; identified visual components of agroforestry landscapes that are more appealing to the public; and contrasted different perceptions of the recreational value of agroforestry landscapes between different consumer segments. Preliminary analysis suggests that farm animals and planted trees or shrubs (examined as agroforestry indicators) were the most preferred agricultural landscape components that respondents would like to see when visiting a farm for recreation. These results suggest an additional value of agroforestry for those landowners willing to offer agritourism. Respondents perceive that farms adopting agroforestry produce both eco-physical and socio-economic benefits. To capture the public's positive perceptions of agroforestry and grow their customer base, agritourism enterprises must promote these benefits in their advertising and promotion efforts. Perceived benefits and landscape preferences differed between genders and across respondents with different agritourism experiences.

## ELDERBERRY MARKET STUDY
(Cernusca, Gold, Godsey)

Elderberry is an underutilized native perennial crop with a multitude of benefits for human nutrition and health (both the fruit and flowers are used in food products as wines, jellies, syrups, food colorants and, increasingly, in medicinal products). In addition, when planted in rows for alley cropping or riparian buffers, elderberry generates a number of environmental benefits (e.g., helps control soil erosion and restore ecological functions with respect to nutrient cycling, hydrology and water management as well as landscape biodiversity). Importantly, elderberry is emerging as an important specialty crop for Missouri, North America, and internationally. A recent national market study identified elderberry as a small, vertically integrated industry with high growth prospects, represented by a few players who primarily sell to early adopter customers and focus their efforts on creating consumer awareness for both the product and the industry. Like many small farmers, elderberry growers and producers struggle with multiple challenges. They have to compete in a financial and policy environment that does not afford the same opportunities available to corporate farms in conventional agricultural markets. Because of the newness of this industry, there is no detailed financial information concerning the elderberry industry. Banks are therefore reluctant to provide loans to prospective elderberry producers. It is also difficult to attract any other investors since it is not known if elderberry industry returns are attractive or if they expected to remain profitable. Challenges also exist on the marketing side. They include establishing a presence on the Internet and getting into the distribution system. Moreover, detailed information about growing elderberry has been lacking and until recently, growers were mostly "on their own" when facing an array or production and marketing issues. For example, without dedicated equipment for mechanical harvesting (yet to be developed), the harvest process is very labor intensive. Growers also have to manage poorly understood pests and diseases, along with non-labeled pesticides and unknown fertilizer application rates.

On a more positive note, demand trends are favorable. Elderberry's unique properties (e.g., health benefits, flavor and taste, history and tradition, ties to folklore) attract customers. Prices are good across the value chain.

Industry competition is minimal at present, with individual firms creating their own market niches and cooperating with one another. Firms must establish consumer perceptions of product quality, service superiority, and advantageous relationships with customers to develop a competitive advantage. In sum, the industry is growing very fast. All market participants currently benefits from the efforts of the industries major players.

## AGROFORESTRY ECONOMICS RESEARCH
(Godsey)

One of the keys to promoting agroforestry adoption is to have positive and realistic economic examples from early adopters. However, with the majority of agroforestry practices, the actual application of the practice is as unique as the landowner that adopts it. Therefore, economic data for agroforestry must be collected and analyzed in two distinct ways. First, case studies must be documented and analyzed that show successful applications of agroforestry practices that provide financial and environmental benefits. Data collected for case studies in 2011 included examples of silvopasture, alley cropping, and vegetative environmental buffers. Future case studies that are being documented include alley cropping with almonds and black-eyed peas in California, alley cropping with hazelnuts in Wisconsin, and silvopasture with loblolly pine in Missouri. The case studies provided information on factors that impacted the adoption decision as well as

information on costs, revenues, labor and risks. Second, data collected from the economic case studies will be used to build financial decision support models to analyze the financial performance of agroforestry practices under various management assumptions. Cost, revenue and labor data will be used to construct a mathematical model that will show the relationship between management decisions and financial performance for each economic enterprise.

Several financial decision support models were developed this year, including the Elderberry Financial Decision Support Tool and the Loblolly Pine Decision Support Tool. These tools enable landowners to make management decisions and identify the impacts of those decisions on the financial performance of the practice. The newest tool, available online at http://www.center-foragroforestry.org/profit/elderberryfinance.php, is the Elderberry Financial Decision Support Tool, an Excel (©Microsoft Corporation)-based model that allows the user to select multiple options from a list of the most common establishment, management, harvesting and marketing techniques to determine the methods that will generate the best economic returns.

**ELDERBERRY MARKETING – CONSUMER PREFERENCES**
(Aguilar, Cernusca)

An online survey gathered information from 1,043 households from the United States on their preferences for elderberry juice and jelly products. Results reveal that roughly one-third of the individuals surveyed were familiar with elderberry. Of those individuals who had heard of elderberry, 60% had sampled an elderberry product and 80% of those individuals who had sampled also purchased elderberry products. The elderberry products most commonly purchased were elderberry juice, jelly, and wine products. These products were most often purchased in grocery stores, farmers markets and health food stores.

The study employed a conjoint analysis to determine the importance of product attributes in determining overall consumer utility of elderberry juice and jelly products. Elderberry products were examined based on four attributes including price, health claims, and origin of production and fruit type. The surveys were divided into two separate versions, the first focusing on jelly products and the second on juice products. Elderberry Jelly: Consumers prefer products that are made locally and contain beneficial health claims. When controlling for all other variables, products made locally were 3.6 times more likely to be purchased than products there were imported. Similarly, products with health claims were two times more likely to be selected than products without health claims.

Elderberry Juice: Similar to elderberry jelly, the results of the elderberry juice conjoint analysis indicate a preference for products made locally and that contain health benefit claims. Products that were made locally were 3.3 times more likely to be purchased than those that had been imported, when controlling for all other variables. Products with health claims were 2.1 times more likely to be purchased than products without health claims, when controlling for all other variables. (Above findings based on M.S. Thesis of P. Mohebalian.)


*Photo: Elderberry wine bottled at Kansas winery Wyldewood Cellars*

## ONLINE M.S. IN AGROFORESTRY OFFICIALLY LAUNCHES AT MU

The Center for Agroforestry at the University of Missouri's new online degree program was launched in 2011. Presently, there are no comparable comprehensive graduate programs in agroforestry elsewhere in the U.S. Online courses and degree programs enable working professionals and other non-traditional learners to realize their aspirations for advanced training, and breach the traditional barrier for those disadvantaged by limited time or distance. Agroforestry has been gaining recognition across the U.S., Canada and throughout the world, and the need for trained professionals in agroforestry has been expanding.

While gaining attention, widespread agroforestry illiteracy remains and the need for a cadre of well-trained professionals is essential to support its continued growth. Short courses and workshops are helpful, but professionals and landowners alike across the U.S., Canada and overseas are seeking more comprehensive graduate degree or certificate programs. The new online agroforestry degree program will help fill that void.

The M.S. with an emphasis in Agroforestry curriculum is a 30-credit non-thesis degree through the Department of Forestry at MU. Additionally, a 12-credit Graduate Certificate in Agroforestry, based on four core courses, has also been approved.

The M.S. in agroforestry is a flexible degree designed to meet the advanced educational goals of a wide range of students. The program was developed to provide advanced study and experience in agroforestry and related fields that are unavailable at other colleges and universities in the U.S. or abroad.

This online Master's in Agroforestry degree program is designed for professionals working in natural resources around the globe who already have an undergraduate degree. In addition, the online Master's is open to all individuals holding accredited B.S. or B.A. degrees who wish to expand their breadth and depth of knowledge in the field of agroforestry.

The 12-credit certificate is intended for current students interested in supplementing their degree in a related field and for Peace Corps volunteers and military personnel who work in countries where agroforestry is integral. Similar to the full online Master's, the certificate is open to all individuals holding accredited B.S. or B.A. degrees who wish to expand their breadth and depth of knowledge in the field of agroforestry.

### COURSE LIST FOR 2013:

- AGROFORESTRY THEORY, PRACTICE AND ADOPTION
  FOREST 4385/7385 – Michael Gold
- ECOLOGICAL PRINCIPLES OF AGROFORESTRY
  FOREST 8385 – Shibu Jose
- AGROFORESTRY ECONOMICS AND POLICY
  FOREST 4387/7387 – Larry Godsey
- AGROFORESTRY FOR WATERSHED RESTORATION
  ENVSCI 4396/7396 – Ranjith Udawatta
- WATERSHED MANAGEMENT AND WATER QUALITY
  FOREST 4390/7390 – Jason Hubbart
- SOIL FERTILITY AND NUTRITION
  SOIL 4113/7113 – Peter Motavalli
- INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS
  NATR 4325/7325 – Hong He
- NATURAL RESOURCE POLICY AND ADMINISTRATION
  NATR 4353/7353 – Francisco Aguilar
- TOPICS: ADVANCED FOREST BIOMETRICS
  FOREST 8401 – Dave Larsen

Find out more information about admission and degree requirements at:

http://online.missouri.edu/degreeprograms/agroforestry/index.aspx

# OUTREACH

The Center's outreach activities introduce the benefits of agroforestry practices, and the products and environmental benefits created through their use, to agricultural and forest landowners, natural resource professionals and consumers. The results of a multi-faceted, long-term sustained commitment of knowledge creation, information sharing and transfer include: greater adoption of agroforestry practices, establishment of new specialty crops and associated value-added industries, increased consumer demand for specialty crops, reduced non-point source pollution, increased habitat and wildlife biodiversity, and increased opportunities for agritourism and economic development in rural areas.

## 2ND ANNUAL AGROFORESTRY SYMPOSIUM - JAN 12, 2011

The 2nd Annual Agroforestry Symposium brought a group of National Bioenergy Experts to Columbia. About 140 attendees were able to learn more about "Meeting Renewable Energy Goals: Role of Bioenergy Crops." Speakers came from across the country to convene at the University of Missouri and discuss how bioenergy crops will fit into our nation's energy goals. In addition to those attending the symposium on campus, many others were able to listen via an online, live stream of the event. Fifty-one locations across the country and world tuned in. Approximately 40 posters also were available for attendees to view, to learn more about The Center's research in a wide-range of fields, including bioenergy.

## MISSOURI NATURAL RESOURCES CONFERENCE

UMCA was well represented at the conference on Feb. 2-4, 2011 at the Lake Ozark, Mo. Dr. Ranjith Udawatta organized and moderated the workshop "Agroforestry Entrepreneurship and Environmental Benefits". Presenters included Drs. Udawatta, Shibu Jose, Wendi Rogers, and Larry Godsey. UMCA collaborators presented six papers and displayed nine posters.

## NORTH AMERICAN AGROFORESTRY CONFERENCE (NAAC)

Eleven members of The Center for Agroforestry's faculty and staff attended the 12th NAAC conference in Athens, GA. The conference, sponsored by the Association for Temperate Agroforestry (AFTA), ran from June 4-9 and was held at the University of Georgia. Members of The Center for Agroforestry presented 16 talks and Posters during the 12th NAAC.

## ANNUAL TRI-SOCIETIES CONFERENCE

Dr. Shibu Jose, and co-author Dr. Ranjith Udawatta gave an invited talk on "Agroforestry's Role In Greenhouse Gas Mitigation in the United States" in a symposium organized by the Canadian Society of Soil Science at the ASA, CSSA, SSSA International Annual Meeting in San Antonio, TX in October. Dr. Udawatta presented several talks at the ASA, CSSA, SSSA Tri-Socities conference.

## CHESTNUT GROWERS OF AMERICA (CGA) ANNUAL MEETING

The CGA annual meeting was held on June 25th at the Elsberry Plant Materials Center. Dr. Ken Hunt, Dr. Larry Godsey and Ina Cernusca presented results of their research on chestnut yields and orchard management, low cost harvest equipment for chestnuts, and a survey of chestnut markets.

## THE NORTHEASTERN SILVOPASTURE CONFERENCE

The MU Center for Agroforestry was invited to present at the Northeastern Silvopasture Conference held in Watkins Glen, NY on November 7th and 8th, 2011. Dr. Dusty Walter, Dr. Larry Godsey and Dr. Gene Garrett from UMCA covered the broad topic of silvopasture design, implementation, economic potential, and environmental impacts. There were approximately 110 participants and a majority of those were farmers wanting solutions to creating more productive grazing systems. The conference was a huge success and reinforced that there is real potential, and need, for the silvopasture practice.

## THE SOCIETY OF AMERICAN FORESTERS ANNUAL CONVENTION

Dr. Shibu Jose was the track chair for agroforestry sessions at the Society of American Foresters Annual Convention in Hawaii in November 2011. As track chair, he was instrumental in organizing four different agroforestry sessions: two focused on temperate agroforestry and two on tropical agroforestry. He also gave an invited talk on "Agroforestry Systems for climate change mitigation, food security and rural prosperity." MU Forestry Professor Dr. Francisco Aguilar and four of his students/postdocs gave presentations at the convention.

Dr. Shibu Jose presented at the Missouri River Relief Big Muddy Speaker Series, Jan. 18, on "Biomass in the Missouri River Floodplain." in Rocheport, Mo.

Dr. Ken Hunt led the Nut Trees session during the Putting Small Acres to Work workshop held on Feb.12, 2011 in Quincy, Ill. He also presented on pecan cultivar nut yields at HARC at the Kansas Nut Growers Annual Meeting March 12, Parsons, Kan. He performed a demonstration on grafting pawpaws at the Hands-on fruit care workshop series, University of Missouri Extension, March 18, Columbia, Mo.

Dr. Larry Godsey presented on "Forest Tax and Estate Planning" at the Tri State Forestry on the Grow Conference, March 11, Idabel, Oklahoma. He also presented the elderberry financial decision support tool that he developed for elderberry farmers at the Elderberry Workshop on June 2011, Hartsburg, MO.

Dr. Mark Coggeshall presented: "TCD screening strategies: The search for resistance in black walnut" at the Thousand Cankers Disease Workshop on March 31 organized by Purdue University. He also presented on the black walnut breeding program at the University of Missouri Center for Agroforestry at the Michigan Nut Growers Association Spring Meeting, April 9, East Lansing, Mich.

The following presentations were given by UMCA faculty at the National Walnut Council 7th Research Symposium which was held July 31st - August 3rd in Madison, Wisconsin: Dr. Shibu Jose: "Integrating Walnut into Agroforestry Practices"; Dr. Mark Coggeshall: "Breeding Black Walnuts in the Age of Genomics.

## ADDITIONAL OUTREACH ACTIVITIES

Part of the chestnut harvest was used for the UMCA Chestnut Roasting Booth at various local events. UMCA faculty and staff members roasted chestnuts at Clover's Natural Market's 46th Anniversary Party, The Columbia Center for Urban Agriculture's Harvest Hootenanny, Forrest Keeling Nursery's Great River Road Chestnut Roast, Columbia Farmers Market, MU Farmers Market, and at the Urban Chestnut Brewing Company in St. Louis, Missouri.

UMCA's Dr. Dusty Walter and MU Forestry's Dr. Hank Stelzer operated and discussed the advantages of a portable sawmill during a FFA field day at CAFNR's Bradford Research and Extension Center, at the MU Southwest Research Center Field Day, MU Wurdack Farm field day and the Annual South Farm Showcase.

**THE ALLEN RESEARCH AND EDUCATION PROJECT (AREP)**, located just outside of Laurie, Mo., is a busy place. This spring was no exception. With assistance from the local Master Naturalists Chapter, controlled burning took place the first week of April. Fields of native warm-season grasses and forbs must continually be managed to control tall fescue and other undesirable cool season grasses. These native grasses and forbs provide excellent habitat for habitat sensitive wildlife, such as bobwhite quail. Approximately a quarter of the open field areas, ~20 acres, were burned this year. An additional bonus for work on AREP is being watched over by eagles. A nesting pair is ever vigilant this time of year.

Two shiitake inoculation days were conducted by Dr. Johann Bruhn at AREP in the Spring of 2011. The logs were placed under trees on the property in a forest farming demonstration. These logs should produce a few mushrooms this autumn and come into full production in the Spring of 2012.

The University of Missouri Center for Agroforestry published a new Agroforestry in Action guide "Burgundy Black Truffle Cultivation in an Agroforestry Practice." It highlights information about the Burgundy truffle (*Tuber aestivum Vitt., syn.T. uncinatum Ch.*) and the Perigord black truffle (*T. melanosporum Vitt.*), which have been determined to be the two best candidate species for truffle cultivation in the south-central U.S. A PDF of the guide can be found at:

*http://www.centerforagroforestry.org/pubs/Trufficulture2011.pdf*

*Perigord black truffle*

## INTERNATIONAL FORESTRY EDUCATION GRANT APPROVED

A new grant "Internationalization of Forestry Education, Research and Extension: U.S. Costa Rica Cooperation," was approved by the USDA NIFA International Science and Education Competitive Grants Program. Dr. Francisco Aguilar of the MU Forestry Department is the lead PI for the project. Co-PIs include: Drs. Muzika, Larsen and Stelzer (Forestry), Drs. Gold and Jose (UMCA/Forestry), Dr. Allen (Ag. Journalism), Dr. Gilles (Rural Sociology), and Dr. Navarrete-Tindall (Lincoln University).

**Summary**: Building on needs and strengths of the University of Missouri (MU) Department of Forestry and Center for Agroforestry (UMCA), the project seeks to further the internationalization of the education, research and extension programs. International collaborators are EARTH University and the Tropical Agricultural and Higher Education Center (CATIE) in Costa Rica. Activities to enhance the global competence of students, faculty, other scientists and extension specialists include: (1) Undergraduate Summer Studies of Tropical Forest Resources and Communities; (2) a Tropical Forest Resource and Communities Immersion Trip; (3) an MU-CATIE Scientist Exchange Program; and (4) a Doctoral Student International Travel Allowance. To maximize benefits to Missouri's communities and businesses, project partners include colleagues at Lincoln University, an 1890 Land Grant University, and the Missouri Forest Products Association (MFPA). Project deliverables include the internationalization of the newly developed online M.S. degree in Agroforestry, partial funding for two Ph.D. students and new courses in extension and forest-based entrepreneurship. Dissemination efforts will include journal articles, a blog, webinars and the creation of an Online Library of International Forestry Education Knowledge. In the long term, the project aims to develop a globally recognized forest resource program that fully integrates education, research and extension activities; catalyzes the development of an international forest resource education network; establishes a global partnership in forest and agroforestry research; and spurs the creation of new forest based businesses in Missouri and Costa Rica.

## CENTER FOR AGROFORESTRY HOSTS NUFFIELD SCHOLAR

As part of his UK-based Nuffield Scholar program, Stephen Briggs contacted the Center early in 2011 with an interest in viewing research on temperate zone alley-cropping and discussing policy related to adopting agroforestry practices. Visiting Nuffield Scholar Stephen Briggs came to visit UMCA in June of 2011. In an open seminar, he discussed "Agroforestry in the EU and UK, a case study from Whitehall Farms, England." With Dr. Dusty Walter as his guide, Briggs visited with a number of Missouri landowners who have active agroforestry production operations. Dr. Gene Garrett gave Briggs a tour of the research at the MU Horticulture and Agroforestry Research Center, New Franklin, MO. Dr. Ranjith Udawatta gave him a tour of the paired watershed study at the Greenley Center to observe the research on utilizing contour buffer alley-cropping in terms of soil, water and nutrient movement. Stephen also attended the 12th North American Agroforestry Conference in Athens, GA.

## INVITATION BY IMAU

Dr. Ranjith Udawatta was invited by the Inner Mongolia Agricultural University (IMAU) in Peoples Republic of China to lecture on conservation agroforestry buffers. During his stay in China in July, he visited several agricultural, forestry, and replanting projects in the region. In the Dalou Research site in Zhungeer, he met with farmers and discussed multi- functional riparian buffer systems to protect water bodies and windbreaks to reduce water loss and wind erosion. The main concern was to conserve water for newly established agriculture, economic plants and forestry. Water and soil conservation districts, forestry department and private sector participation for replanting has been impressive.

## DR. BRUHN IN FRANCE

Research Associate Professor of Plant Science and UMCA, Dr. Johann Bruhn, participated in two Burgundy truffle meetings held in Nancy, France. At the annual *Tuber aestivum/uncinatum* European Scientific Group meeting, Dr. Bruhn presented his paper "Studies of Bacteria Isolated from *Tuber aestivum* (*syn. T. uncinatum*) Truffles and Mycorrhizas," co-authored by David Emerich (MU Biochemistry) and colleagues from Sweden and Italy. Dr. Bruhn also participated in the First European Week of the Burgundy Truffle. Dr. Bruhn was also inducted, along with Christina Wedén (Uppsala University) and Gerard Chevalier into the Gotlands Tryffel Akademi in Visby, Sweden.

# PUBLICATIONS 2011

## BOOK CHAPTERS

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Paudel, B.R., R.P. Udawatta, S.H. Anderson and R. Kremer. 2011. Assessment of soil quality for grazed pastures with agroforestry buffers and row crop systems. Agronomy Abstracts 2011. International Meetings of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, San Antonio, TX, 16-19 Oct. 2011.

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### THESES & DISSERTATIONS

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Mohebalian, P. Consumer preference for elderberry juice products. M.S. Thesis. University of Missouri, Columbia, MO.

Paudel, B.R. 2011. Soil quality as affected by agroforestry and grass buffers in grazed pasture and row crop systems. M.S. Thesis. University of Missouri, Columbia, MO.

Wagner, J.B. 2011. Suitability of cold-hardy loblolly and pitch x loblolly hybrid pines for commercial pine straw production in Missouri. M.S. thesis. University of Missouri, Columbia, MO.

Walter, W. 2011. Silvopasture's effect on growth and development of white and black oaks in an intensively managed upland central hardwood forest. Ph.D. dissertation. University of Missouri, Columbia, MO.

### CULTIVARS RELEASED

Byers, P.L. and A.L. Thomas. 2011. 'Bob Gordon' elderberry. Journal of the American Pomological Society 65(2):52-55.

### PATENT APPLICATIONS

Development of nanocarbon-based biocatalyst for remediation of atrazine.

Development of spore-based biocatalyst for remediation of pollutants and biofuel production.

Purification of anti-microbial and anti-inflammatory diterpenoids from Eastern red cedar (*Juniperus virginiana*).

Purification of the bioactive saponin Esculentoside D. from *Phytolacca latbenia*.

Use of tricyclic diternpenoids from Eastern redcedar (*Juniperus virginiana*) for preventing and ameliorating the development of melanin and hyperpigmentation.

### SPIN-OFF START-UP

Spogen Biotech Inc. — Bioremediation and Biofuel Production

### MEMORANDUM OF UNDERSTANDING

Dr. Bruhn has finalized an MOU linking The University of Missouri (specifically The Center for Agroforestry, the Department of Biochemistry and the Division of Plant Sciences) with Uppsala University in Uppsala, Sweden (the Division of Pharmacognosy and the Department of Medical Chemistry). This MOU is being initiated in recognition of the research collaboration on truffle biology and cultivation of Drs. Bruhn and Emerich at MU with Drs. Weden, Backlund and Alsmark at UU.

# GRANTS 2011

### AGROFORESTRY

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Jose, S. USDA ARS. An Analysis of Agroforestry's Physical, Biological , Ecological, Economic and Social Benefits. $3,350,000 2009-2012.

Jose, S. Missouri Department of Conservation. Tree improvement program. $30,000. 2011.

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Jose, S. MU College of Agriculture, Food and Natural Resources, Agroforestry Center Research and Outreach. $250,000. 2011

Muzika, R.M. Integrating disciplinary diversity in graduate student education to support forest resource management decisions. $245,000. USDA National Needs Program. 2010-2015.

# GRANTS 2011

Womack, K., S. Amelon and L. Godsey. Estimating the economic impact of White Nose Syndrome on bat populations in the Midwest. $60,000. US Forest Service. 2011-2012.

## BIOFUEL/BIOMASS

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## MEDICINALS

Yang, J. in cooperation with C.H. Lin. Analysis of antibiotics and personal care products using HPLC-MS/MS. $8,500. Lincoln University Cooperative Research and Extension Programs.

Yang, J. in cooperation with C.H. Lin. Analysis of TNT using high performance liquid chromatography. $2,000. Lincoln University Cooperative Research and Extension Programs. 2010-2011.

Lin, C.H., G. Stewart, X. Zou, B.Thompson, M. Gold, Thar Process Inc. Exploring the health benefits and economic opportunities of the bioactive compounds isolated from Eastern redcedar in Missouri. $49,746. Mizzou Advantage. 2011-2012.

Lubahn, D., et al. The MU Center for Botanical Interaction Studies. $7.6 million. National Institutes of Health. 2010 - 2015.

Folk, W., Lin C.H. et al. Use of botanicals in chronic pain research. $50,000. Mizzou Advantage. 2011-2012.

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Dwyer, J. and W.D. Walter. Wurdack Farm Advisory Board. $13,000. 2010-2011.

## SPECIALTY CROPS

Barrett, B.A. and W.T. Stamps. Chestnut weevil monitoring: Developing a comprehensive strategy for pest management. $22,420. Missouri Department of Agriculture Specialty Crops Block Grant. 2010-2012.

Bruhn, J.N., A. Henry, R. Kremer and C. Starbuck. Burgundy truffle cultivation in Missouri. $5,900. Mizzou Advantage. 2011

Bruhn, J.N., D.W. Emerich and M.K. Hendrickson. Burgundy truffle cultivation in Missouri. $6,300. Mizzou Advantage. 2011

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Coggeshall, M.W. Designated state forestry personnel representing Iowa, Indiana, Connecticut, Pennsylvania and Vermont. Restoration of at-risk forest tree species through germplasm conservation: Recovery and restoration disease resistant butternut (*Juglans cinerea*). $18,000. USDA Forest Service Northeastern Area State and Private Forestry Competitive Grant Initiative. 2009-2012.

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Gold, M.A., M.M. Cernusca, L.D. Godsey, F.X. Aguilar, E. Barham, A. Thomas, P. Byers, J. Brewer, T. Durham and P. Bay. Developing successful marketing strategies for elderberry growers and value added processors: A model for specialty crop development in the U.S. Midwest. $105,427. USDA NCR-SARE. 2010-2013.

Hellmuth, N.M., D. Hellmuth and J.N. Bruhn. Phase 1: Truffle orchard establishment – The burgundy truffle as a new sustainable agroforestry crop for Missouri. $6,000. NCR-SARE Farmer/Rancher Grant Program.

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Stamps, W.T. and B. Barrett. Biology and behavior of the black walnut curculio. $18,730. Missouri Department of Agriculture Specialty Crops Block Grant. 2011-2013.

Stamps, W.T. and M.J. Linit. Ecology and diversity of the insect community in alternative crops and nut trees. $70,000. Missouri Agriculture Experiment Station. 2006-2011.

Thomas, A.L., P. Byers, J. Avery, W. Reid and B. Martin. Advancement of American elderberry as a Missouri specialty crop by elucidating its pest and disease complex. $29,611. Missouri Department of Agriculture Specialty Crops Block Grant. 2010-2012.

Thomas, A.L., P. Byers, M. Gold, et al. Hosting the first international elderberry symposium (June 2013) to fast-track the growth of Missouri's elderberry industry. $30,000. Missouri Department of Agriculture Specialty Crops Block Grant. 2011-2013.

Thomas, A.L., P. Byers, M. Gold, et al. The organization and hosting of the first international elderberry research symposium in Missouri, June 2013. $25,000. USDA/NIFA/AFRI. 2011-2013.

Coggeshall, M.V. National Science Foundation. TRPGR: Comparative genomics of environmental stress responses in North American hardwoods. $357,028 (total NSF award $3.7 million) (co-PI) Pennsylvania State University, University of Missouri, University of Notre Dame, University of Tennessee, Michigan Technological University, Clemson University, University of West Alabama. 2010-2014.

Warmund, M. Disinfestation of Asian chestnut gall wasp larvae from chestnut scion wood to produce a clean source of nursery stock. $27,082. Missouri Department of Agriculture Specialty Crops Block Grant. 2011-2012.

Warmund, M. Elucidating the role of walnut curculio (*Conotrachelus retentus*) and bacterial isolates associated with black walnut kernel necrosis. $15,095. Missouri Department of Agriculture Specialty Crops Block Grant. 2010-2011.

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## TREE/CROP INTERACTIONS

Stamps, W.T. and L.D. Godsey. Economic and environmental benefits from multiuse agricultural landscapes to family farms: Biodiversity, pesticide reduction, and crop management in forage and oil seed crops alley cropped with black walnut. $35,300. USDA ARS. 2010-2011.

The University of Missouri Center for Agroforestry is dedicated to working with landowners, natural resource professionals and other stakeholders the world over to keep lands sustainable, both environmentally and economically. The Center supports comprehensive research on the many facets of agroforestry, including windbreaks, forest farming, silvopasture, riparian forest buffers and alley cropping.

We work hard to extend that knowledge to landowners, natural resource professionals and policy makers around the state, the region and the globe. Research collaborations with international institutions, attending and presenting at conferences globally and hosting visiting scholars from around the world help us all learn from each other.

The Center for Agroforestry at the University of Missouri – a global approach.


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The Center for Agroforestry
University of Missouri

*A Global Center for Agroforestry, Entrepreneurship and the Environment*

## 2011 UMCA Highlights

Awarded several grants totaling over $2 million

Published Agroforestry in Action Guide "Burgundy Black Truffle Cultivation in an Agroforestry Practice"

Released Elderberry Financial Decision Support Tool

Hosted 2nd Annual Research Symposium focused on Bioenergy Crops

Filed multiple patent applications and invention disclosures

Twelve members of The Center for Agroforestry's faculty and staff presented 16 different papers at the 12th North American Agroforestry Conference in Athens, GA.

Discovered by UMCA and MU scientists, a new elderberry cultivar, 'Bob Gordon', was officially released.

Hosted a large number of visiting scholars from home and abroad

Admitted first batch of students in the new online agroforestry M.S. degree program