

University of Missouri Center for Agroforestry

2004 Research Highlights

Research, Partnerships & Technology Transfer



*"We do not inherit this land
from our ancestors;
we borrow it
from our children."*

- Haida Indian saying



**Enhancing Land Stewardship, Farm Profitability,
Biodiversity and Wildlife Habitat through Agroforestry**

About the Center for Agroforestry



UMCA Key Accomplishments:

- Trains and supports an average of 12 Master's and 5 PhD students annually toward advanced degrees related to agroforestry, spanning 9 departments.
- Hosted a 3-day field tour of midwestern agroforestry practices, — drawing participants from 8 countries — in conjunction with the first World Congress of Agroforestry.
- Through one of the nation's most comprehensive research programs for water quality, determined that a filter strip 8 meters in width, comprised of native species, removes 75-80% of herbicide residuals from surface water runoff.
- Completed a DVD of the 5 agroforestry practices, featuring successful examples of Midwestern landowners engaging in agroforestry for profit.
- Hosted and coordinated the Missouri Chestnut Roast, drawing a crowd of more than 3,000 guests to the 2nd annual event in 2004.
- The Center continues to support one of the nation's premier flood tolerance research efforts, utilizing a 12-channel outdoor flood laboratory at the Horticulture and Agroforestry Research Center.
- During the past year, UMCA researchers published more than 60 articles in proceedings, refereed journals and the popular press.

What is Agroforestry?

Agroforestry is new market opportunities. Sustainable agriculture. Land stewardship. Habitat for wildlife. Improved water quality. Diversified farm income.

Agroforestry practices help landowners to diversify products, markets, and farm income; improve soil and water quality; and reduce erosion, non-point source pollution and damage due to flooding. The integrated practices of agroforestry enhance land and aquatic habitats for fish and wildlife and improve biodiversity while sustaining land resources for generations to come.

The University of Missouri Center for Agroforestry (UMCA), established in 1998, is one of the world's leading centers contributing to the science underlying agroforestry. Interdisciplinary collaboration is one of the outstanding hallmarks of the Center. Research on the benefits of agroforestry is supported from a broad spectrum of disciplines: forestry, fisheries and wildlife, entomology, plant pathology, agronomy, animal science, horticulture, soils, atmospheric science, agricultural economics and rural sociology. Linked with the Center's solid science and research programs are several key collaborations and partnerships with landowners, natural resource professionals, federal and state agencies and non-profit organizations. Through these critical relationships, UMCA and its partners are producing an expanding list of positive outcomes for landowners, the natural environment and society as a whole.

UMCA Goals:

- To generate income and develop new market opportunities for farm and forest landowners
- To protect the environment by reducing non-point source pollution
- To create and improve natural habitats for wildlife
- To mitigate against the impacts of periodic flooding

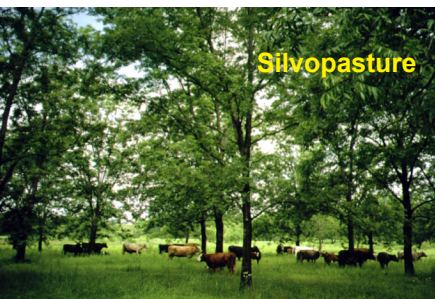


The Five Practices of

Agroforestry

Alley Cropping

Alley Cropping is planting rows of trees at wide spacings with a companion crop grown 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 crops may also be incorporated for extra income, including sunflowers or medicinal herbs planted in between rows of nut trees alternated with nursery stock trees.



wind erosion, and increase bee pollination and pesticide effectiveness. Livestock windbreaks help reduce animal stress and mortality, reduce feed consumption, and help reduce visual impacts and odors. Windbreaks may also provide excellent wildlife habitat, especially for quail and deer.

Silvopasture

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

Forest Farming

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

See successful examples of the 5 practices of agroforestry from the DVD "Agroforestry Practices," available from the Center for Agroforestry.

Friends and Partnerships

From the Director



Harold E. "Gene" Garrett,
Director,
Center for Agroforestry

Dear Friends of UMCA,

We are so pleased to share with you our 2004 review of research and other current endeavors underway within the Center for Agroforestry. We are excited about our accomplishments but our excitement is tempered with the reality that there is yet much that we need to learn and do to create viable opportunities for landowners interested in applying agroforestry

technology to the greatest advantage.

We are slowly but surely piecing together the building blocks for the successful application of the five agroforestry practices (alley cropping, forested riparian buffers, silvopasture, forest farming and windbreaks). It is our Center's goal to develop these practices to maximize profitability while providing protection for our precious natural resources.

The spirit of teamwork and collaboration is one of the Center's most outstanding attributes, as demonstrated in the depth of our research projects and initiatives. From opening consumer markets for Missouri agricultural products and reducing nonpoint source pollution to protecting waterfowl habitat and developing new farm crops, UMCA is at the forefront of meeting the needs of landowners and natural resource professionals as we work to keep the family farm alive, the surrounding communities viable, and the environment in which we all live, healthy.

At the Center for Agroforestry, we work with the landowner and professional in seeking relevant solutions to problems relating to the management of our natural resources and in developing technology that satisfies the needs of the adopter. We truly believe that land is a community to which we all belong and that good stewardship must be the focus of all that we do. We continue in our endeavor to serve you, the users of the technology we develop, and we thank you for sharing our philosophy on the value of good land stewardship.

Gene

The University of Missouri Center for Agroforestry partners with universities, natural resource entities and agricultural organizations across the Midwest and the nation to preserve and strengthen the family farm and our nation's diverse landscapes.

Internal Collaborations

University of Missouri Extension

College of Agriculture, Food and Natural Resources:

Partnerships with 10 departments: Animal Science, Horticulture, Forestry, Agricultural Economics, Rural Sociology, Entomology, Agronomy, Plant Pathology, Fisheries and Wildlife and Soils, Environment and Atmospheric Science.

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 Research Center, Novelty, Mo.

External University Partnerships

The Agroecology Issue Team, Iowa State University

Federal and State Agency Partnerships

- The United States Department of Agriculture NRCS/USFS National Agroforestry Center, Lincoln, Neb.
- USDA ARS Dale Bumpers Small Farm Research Center, Booneville, Ark.
- USDA ARS Cropping Systems and Water Quality Research, Columbia, Mo.
- USDA Forest Service Central Hardwoods Research Unit, Columbia, Mo.
- Missouri Department of Conservation
- Missouri Department of Natural Resources
- Missouri Department of Agriculture

Private Lands and Research Initiatives

Missouri Department of Agriculture:

Partnership for Sustainable Agriculture Demonstration Awards. Together with the Missouri Department of Agriculture, the Center supports three value-added grants for landowners engaging agroforestry practices for additional income.

USDA Forest Service State and Private Forestry Division:

Collaborated to produce a Special Forest Product Production and Marketing Workshop to identify additional income sources for forest and landowners.

A Team Effort

U.S. Department Of Energy:

Received Ameriflux site grant for carbon sequestration research.

USDA ARS National Germplasm Resources

Laboratory: Received awards to support ongoing research in the genetic improvement of eastern black walnut.

Mid-America Regional Council, Kansas City, Mo.:

Together with the National Agroforestry Center, UMCA is using agroforestry technologies as “Green Infrastructure” to address storm water issues in urban areas and at the urban-rural interface.

Professional Associations:

- Western Chestnut Growers Association
- Northern Nut Growers Association
- Missouri Northern Pecan Growers, LLC
- Missouri Farmers Union
- Association for Temperate Agroforestry
- The Walnut Council (Missouri Chapter)
- Missouri Nutgrowers Association
- Missouri Christmas Tree Producers Association
- Missouri Forest Products Association
- Missouri Consulting Foresters Association
- Missouri Tree Farm Association
- Mid-Missouri Tourism Council
- Missouri Farm Bureau

UMCA Faculty and Staff:

Harold E. "Gene" Garrett, Ph.D.

Director

Michael Gold, Ph.D.

Associate Director

Larry Godsey

Research Associate / Economist

Mark Coggeshall

Tree Improvement Specialist /

Research Analyst

Julie Rhoads

Technical Training Specialist /

Events Coordinator

Dusty Walter Technology Transfer /

Research Specialist

William Reid, Ph.D.

Adjunct Associate Professor

Ken Hunt, Ph.D.

Post-Doctoral Fellow

Bonnie Beckett

Sr. Administrative Assistant

Rachel McCoy

Sr. Information Specialist

Ina Cernusca

Research Associate

Associate Staff:

Ray Glendening - Farm Manger, HARC

Kenny Bader - Forestry

Wayne Bishop - Forestry/Wildlife

Nancy Bishop - HARC

Jimmy Houx - Agronomy

Terry Woods - Entomology

Melissa Niedermann - Agronomy

Aaron Brown - Wildlife

John Thompson - Agronomy

Randy Thiessen - Horticulture

Jimmy Houx - Agronomy

Associate Faculty, Staff and Collaborators:

Faculty

Steve Anderson, Ph.D. - Soils, Environmental and Atmospheric Sciences

Johann Bruhn, Ph.D. - Plant Pathology

Bruce Cutter, Ph.D. - Forestry

John Dwyer, Ph.D. - Forestry

Milon George, Ph.D. - Forestry

Richard Guyette, Ph.D. - Forestry

Mickey Heitmeyer, Ph.D. - Fisheries & Wildlife

Rob Kallenbach, Ph.D. - Agronomy

Monty Kerley, Ph.D. - Animal Science

William Kurtz, Ph.D. - Natural Resources

David Larsen, Ph.D. - Forestry

Marc Linit, Ph.D. - Entomology

Bob McGraw, Ph.D. - Agronomy

Jeanne Mihail, Ph.D. - Plant Pathology

Rose-Marie Muzika, Ph.D. - Forestry

Steve Pallardy, Ph.D. - Forestry

Bob Pierce, Ph.D. - Fisheries & Wildlife

Sandy Rikoon, Ph.D. - Rural Sociology

Chris Starbuck, Ph.D. - Horticulture

Corinne Valdivia, Ph.D. - Agricultural Economics

Michele Warmund, Ph.D. - Horticulture

Post-Doctoral Fellows:

Chung-Ho Lin, Ph.D. - Forestry

Terrell Stamps, Ph.D. - Entomology

Ranjith Udawatta, Ph.D. - Forestry

Collaborators:

Gary Bentrup - USFS/NAC

David Brauer, Ph.D. - ARS/USDA

Joe Colletti, Ph.D. - ISU Forestry

Dan Dey, Ph.D. - USFS

Michael Dosskey, Ph.D. - USFS/NAC

John Kabrick, Ph.D. - USFS

Rob Myers, Ph.D. - Jefferson Institute

Richard Schultz, Ph.D. - ISU Forestry

Michele Schoeneberger, Ph.D. - USFS/NAC

Jerry Van Sambeek, Ph.D. - USFS

Doug Wallace - NRCS State Forester

Gary Wells - NRCS/NAC

Technology Transfer and Outreach

A primary goal of the Center for Agroforestry is to educate and inform landowners and natural resource professionals about new research in agroforestry, and to demonstrate how this can be applied successfully to their operations. The UMCA Technology Transfer team works side-by-side with landowners, resource professionals and extension agents from across the state, and the Midwest, through on-site consultations, educational workshops and informational exhibits.

During 2004, the UMCA Technology Transfer team participated in 47 agricultural and natural-resources related conferences and events, serving as featured speakers at 10 events. From the National Small Farms Trade Show to the Western Chestnut Growers Convention, to the Missouri Governor's Conference on Agriculture and the Tri-State Forest Stewardship Conference, the team reached thousands of land and forest owners with new research findings and information on the benefits of agroforestry.

Technology Transfer Highlights, 2004:

The First World Congress of Agroforestry drew nearly 500 agroforestry experts, researchers and innovators from 80 countries to Orlando, FL., in June, and offered the Center the opportunity to speak on the impacts of agroforestry to a diverse, international audience. The Center also served on the two-year global organizing



committee for this groundbreaking event.

"Today, agroforestry is truly a science-based technology that offers both poor and wealthy nations many opportunities, including the reduction of poverty and providing ecosystem services. The World Congress of Agroforestry demonstrated to me that agroforestry has finally come of age." - Gene Garrett, UMCA Director

Prior to the World Congress event, the Center hosted a pre-congress **tour of Midwestern agroforestry practices**, drawing 23 guests from 8 different countries, including India, Australia and Germany, to experience some of the



region's best agroforestry examples. Tour stops in Iowa included

the Iowa State University windbreak practice demonstration area, near Ogden; the Bear Creek Riparian Buffer Demonstration area located near Story City; and Ben's Black Walnut Orchards and processing facility at Centerville. In Missouri, tour stops included the Deer Ridge, Henry Sever, and Ross Jones Farm alley cropping demonstrations near Novelty; University of Missouri Greenley Memorial Research Center, also near Novelty; and Shepherd Farms located in Clifton Hill.

As a co-sponsor of the first joint



meeting of the **Northern Nut Growers Association/North American Fruit Explorers**, the Center for Agroforestry coordinated and led field tours of the HARC farm, the Forrest Keeling Nursery, Elsberry, Mo., and Stark Bro's Nursery, Louisiana, Mo. More than 200 attendees from every corner of the nation came to Columbia, Mo., for the workshops and field tours promoting fruit and nut crops as a viable option for landowners.

Through collaboration with the National Farmers Union, the Missouri and Kansas Farmers Unions and the USDA Southwest Missouri RC & D, the Center co-sponsored an **agroforestry field day** on Oct. 30th at the University's

Southwest Research Center, Mt. Vernon, Mo. More than 40 landowners attended the event that highlighted trees as a sustainable economic resource. Workshop topics included integrating forestry management on the farm; nuts as a growing market; lease hunting as an additional income source; non-timber products and



Skip Mourglia, USDA NRCS Forester, explains establishment of a fast-growing windbreak at an agroforestry field day.

marketing and managing a woodlot. Discussion areas focused on helping farmers turn their woodlots into sustainable, productive acres.

Tours of research plots and private woodlots allowed participants to see first-hand how to manage their woodlots. The group first toured a low-maintenance, fast-establishing windbreak designed to provide wind protection for cattle in less than 10 years. The next tour stop featured the Southwest Research Center nut orchards, which include 800 grafted trees. Participants examined nut



harvesting equipment and compared improved varieties of walnuts, pecans, hickories and paw paws. The final tour featured a walk through a forest on the Baugh family farm to discuss which management activities should be implemented for optimal profit and sustainability.

Approximately 75 land and forest owners, mushroom producers and mushroom hobbyists attended the **Specialty Mushroom Workshop** on Dec. 3 and 4th in Columbia, Mo., hosted by the Center for Agroforestry.



Participants at the Specialty Mushroom Workshop learn cultivation and marketing tips.



Discussion topics included truffle, shiitake, stropharia and oyster mushroom cultivation, marketing strategies, winter production and log preparation. Tours of the mushroom research area at the Horticulture and Agroforestry Research Center in New Franklin, Mo., and a specially prepared gourmet wine and food tasting were also featured. Mushroom cultivation is a profitable component of the agroforestry practice of forest farming, and one element of the Center's research programs toward identifying profitable options for land and forest owners.

Believing the adoption of agroforestry practices is best accomplished through learning by example, a new focus on agroforestry demonstrations in communities near the University of Missouri's outlying research farms has been established, with events planned for 2005 to offer land and forest owners hands-on experiences with the benefits derived from agroforestry.

In 2004, the Center **completed a DVD** integrating the four previously produced videos on the agroforestry practices of alley cropping, windbreaks, riparian forest buffers and silvopasture with the fifth practice, forest farming. The new section shows examples of successful forest farming operations, including shiitake mushrooms, pine straw, woodland wildflowers, medicinal plants and high value wood blanks, along with tips for marketing forest farming products.

UMCA Co-Sponsors Agroforestry Grants

The Center is demonstrating its commitment to assisting landowners with the establishment of agroforestry practices by partnering with the Missouri Department of Agriculture's (MDA) Sustainable Agriculture Demonstration Awards program.

In 2004, UMCA sponsored three of the program's grants to focus on sustainable projects that involve agroforestry. One project is highlighted below in an excerpt from the MDA's "Small Farms, Big Ideas" series:

Grant helps landowner replace tornado-damaged trees with cedar and pine windbreak



Monet, Mo. - Last year a tornado destroyed the house, barns and almost every tree on Robert and Cheryl Karr's property. Now, a year later, thanks to a grant from the Missouri Department of Agriculture, 90 young trees form a new windbreak to replace cedars destroyed by the storm. The Karr's lost 28 large oak trees from their yard, as well as the cedar trees that once provided cattle a windbreak in the winter and shade in the summer.

Through the producer grant co-sponsored by the Center for Agroforestry, the Karr's planted approximately 90 cedar and pine trees in an L-shaped windbreak. "We try to manage our farm as good stewards," Robert says. "You have to conserve the soil, keep the trees healthy, take good care of the animals. You have to watch over the whole complex thing."

The Missouri Chestnut Roast



Connecting Missouri Families to the Land

The Missouri Chestnut Roast, held annually in October, is quickly becoming one of Mid-Missouri's premier family-oriented events. The event is an outstanding opportunity to introduce families and landowners to the broad range of possibilities and benefits agroforestry practices can provide. Hundreds of visitors each year enjoy their first sample of sweet, Missouri-grown roasted chestnuts, along with a variety of products featuring locally-grown black walnuts and pecans, recipes and nutritional information to peak their interest in purchasing nut products.

Highlights, Missouri Chestnut Roast:

- More than 3,000 in attendance at the second annual Chestnut Roast
- Guided tours of 660-acre Horticulture and Agroforestry Research Center featuring diverse agroforestry practices
- Educational booths from Missouri value-added agriculture vendors and University agricultural and environmental research programs
- Showcase for Missouri's outstanding agricultural products, including wines; jams and jellies; pecan, walnut and chestnut products; locally-produced honey; cheeses and meats
- Children's Tent, farm display, family activities and live music
- Cooking demonstrations by local gourmet chefs featuring Missouri chestnuts
- Guided tours of the Hickman House, a historic 1819 Georgian cottage and one of the oldest brick homes still standing in the state
- Demonstrations of new research on profitable specialty products produced through agroforestry, including pine straw, woody florals and chestnuts
- Free fresh-roasted chestnuts, and samples and displays of Missouri pecans and black walnuts
- Beautiful Missouri River Hills scenery and artist exhibits depicting the unique landscapes

Fresh roasted chestnuts.



Chestnut cooking demonstration.



Right: Midwestern chestnut vendors sell a variety of fresh products to visitors.



Left: A Missouri value-added food vendor offers free samples of sauces and jellies made with local black walnuts, pecans and chestnuts.



Success Stories



Forest Farming: Ozark Forest Mushrooms, Timber, Mo.

One of the state's most significant demonstrations of a successful forest farming practice is Dan Hellmuth and Nicola Macpherson's Ozark Forest Mushrooms, Timber, Mo. The entrepreneurial couple established the specialty mushroom operation in 1990 on what was then a timber operation, and coordinate every step of the value-added process, from the inoculated log to packaged, consumer-friendly products. Under the guidelines of the Stewardship Incentive Program, administered by the Missouri Department of Conservation (MDC), Hellmuth and Macpherson harvest a renewable supply of mushroom bed logs while simultaneously maintaining their forested acres in a healthy ecological state — and what began 14 years ago with only 100 oak logs in production has grown to include 12,000 shiitake logs in production.

A new greenhouse with a wood furnace for burning spent/culled shiitake logs has recently been completed for researching mushroom cultivation during the cold season and sustainable usage of wood resources.

It's hard work that doesn't stop," Macpherson said, "but when I walk into a restaurant and see my mushrooms on the menu, or walk into a supermarket and see our products on the shelf, that gives me huge pleasure and makes all the work worthwhile."



Alley Cropping: Shepherd Farms, Clifton Hill, Mo.

Drive through the farmland of northeast Missouri and you may encounter one of the state's more exotic examples of diversification. You may also want to stop and have a sample.

Dan Shepherd of Shepherd Farms, Clifton Hill, Mo., raises buffalo for processing into lean, high-quality meats and jerky, in addition to his pecan and bluegrass hay alley cropping practice. Shepherd Farms is also a nationwide leader in production, wholesale and retail distribution of Eastern Gamagrass seed. The farm has its own pecan cracking facility and a large country store, stocked with fresh pecans, snack mixes featuring the sweet nuts and a variety of buffalo products. Due to its broad mix of integrated farming practices and agritourism elements, Shepherd Farms is a popular group tour destination and offers an educational experience showcasing the benefits of agroforestry and farm diversity.

"Alley cropping is ideal for achieving both our production and conservation benefits," said Shepherd. "We earn an annual income off the ground, while the trees are being established. We also enjoy an abundance of wildlife in the habitat created by alley cropping. While the crops are growing we see deer, turkey and quail utilizing this ground and the trees."



Value Added Forestry: Oak Leaf Wood 'N Supplies, Moweaqua, Ill.

Paul Easley of Moweaqua, Ill., knows there is money to be made in sawing and selling wood that to others, is waste. Wood byproducts, including those usually left in the woods following Timber Stand Improvement (TSI) or those discarded from urban tree removal, can become blanks for gun stock, bowls, writing pens or other craft wood projects that do not require the typical boards sold by larger mills.

Easley has established a successful business during the past 18 years, utilizing a portable sawmill and a dehumidification dry kiln. His retail store, Oak Leaf Wood 'N Supplies, sells retail hardwoods, imported lumber, hand tools, and woodworking supplies to customers across the U.S. and overseas. In addition, he markets the value-added wood products that are sawed, dried, planed and shaped on-site — including cabinet and furniture-grade lumber, carving stock and mantles.

"We believed there had to be a wiser use for the trees that needed removed than trash wood or firewood," said Easley.

"Do the job with a smile on your face and be enthusiastic about your product. Do that, and talk with your customer, you can succeed. We're living proof."

The Horticulture and Agroforestry Research Center

The Horticulture and Agroforestry Research Center (HARC), located at New Franklin, Mo., is the primary research site for UMCA. This 660-acre farm opened in 1953, incorporated a major agroforestry dimension in 1993, and includes several experimental fruit and nut orchards; forest farming, riparian buffer and silvopasture demonstrations; forage shade trials; greenhouses; a flood tolerance laboratory; five lakes and ponds and one of Missouri's oldest brick homes, the 1819 Thomas Hickman House.

The farm, set in the beautiful, rolling Missouri River hills, is also the U.S. National Arboretum Midwest Plant Research and Education Test Site. Tours and educational events are hosted regularly.

Through an interdisciplinary approach, UMCA leads the nation in key research areas:

The farm is the site of the nation's most comprehensive programs for developing the eastern black walnut and Chinese chestnut into profitable orchard crops.

Extensive bioremediation, non-point source pollution and shade and flood tolerance studies.

A research project for producing gourmet mushrooms, including morel and the European black truffle, has been developed.

Examples of Current HARC projects:

Pitch x Loblolly Pine and Black Walnut Winter Forage Alley Cropping Study:

This is the oldest agroforestry study on the farm and serves several purposes, including exploring the effects of row spacing on tree growth and tree/forage interactions in an alley cropping practice. Pitch pine / loblolly pine hybrids and black walnut planted in single, double

and triple rows are grown to examine the effects of row configuration on these species.



Riparian Buffer Biofilter Livestock Trial:

Assesses the value of riparian buffers in filtering nitrates and phosphates out of runoff from adjacent livestock grazing.

Aerial view, 660-acre Horticulture and Agroforestry Research Center



forage that offer potential for income and environmental benefits. This project seeks to identify poplar clones that are well-adapted to the climate of the lower Midwest floodplain and that produce substantial wood crops for fiber, chips or energy over short (4-5 year) rotations. The project also will provide estimates of total carbon sequestered by such plantations, data that will be useful in determining potential economic returns from carbon credit programs that may emerge. Cottonwood clones are being evaluated for their growth response and adaptability to

Missouri conditions.

The best cultivars will be used in agroforestry to produce biomass and for pulp and paper production.

Cherrybark Oak Spacing Study:

Cherrybark oak has market potential north of its native range, which extends south from the Missouri Bootheel and the USDA cold

hardiness Zone 6. Seedlings have been planted at different spacings to establish uniform shade conditions for field testing promising agroforestry forages from the forage shade study laboratory.

Silvopastoral Practice: Researchers are investigating the similarities and differences in cattle performance between traditional open grazing and silvopastoral grazing practices. Factors also being evaluated include the success of electric fences as deterrents to protect young trees from grazing damage, and how grazing and forage production affect tree growth.



Pitch x Loblolly Pine Progeny Testing:

Pitch/Loblolly hybrid pines offer a market to Missouri landowners for both wood and pine straw, a multi-million dollar landscaping mulch crop common in

the southern states.

Mushroom Trials for Forest Farming:

Researchers are evaluating European truffles, morels, shiitakes and other gourmet mushrooms for landowner production and profit.

Cottonwood Clonal Trial:

Landowners may see a need for production alternatives to row crops and

Pine-Straw: The purpose of this study is to evaluate pitch x loblolly hybrid pines (*Pinus rigida x taeda*) along with cold-tolerant selections of pure loblolly pine for their suitability for the production of pine straw mulch in Missouri.



Pine straw, the naturally shed needles of pine trees, is an excellent mulch material used extensively in the Southeastern

United States in landscape plantings. The purpose of hybridizing these two pine species was to create a pine with the cold hardiness of a pitch pine and the fast growth rate and long needles of a loblolly. Fifteen different genotypes of pure loblolly are also being evaluated for cold hardiness, growth rate, needle length and needle yield. Results to date indicate that some pitch x loblolly genotypes in the plantation are hardy, fast growing, long-needled pines, suitable for commercial pine straw production in Missouri. (See related article pg. 18).

Missouri Gravel Bed for Nursery Stock:

The Missouri Gravel Bed (MGB) is a method, developed at HARC, that allows planting of bare rooted nursery stock at any time of the year. Dormant, bare rooted trees and shrubs are set into a frequently irrigated mixture of pea gravel and sand. Plants can be removed from the gravel at any time during the summer and fall and field planted bare root, in full leaf with a survival rate equal to or greater than those expected for container-grown or balled and burlapped plants. The main objective of this project is to evaluate the potential of MGB to facilitate planting of trees and shrubs in agroforestry and landscape plantings. (See related article pg. 17.)

Pot-in-Pot Nursery Stock Trial: Pine trees planted for pine straw production generally take at least ten years to begin producing a commercial yield of pine straw mulch. The purpose of

this trial is to evaluate the potential for growing high value nursery stock between pines during plantation establishment using the Pot-in-Pot (PIP) production method. In PIP production, plastic "socket" pots are sunk in the ground and growing containers are nested in the sockets. Although the initial cost of establishing a PIP nursery is relatively high, the socket pots can be used for several successive crops of nursery stock. Also, PIP eliminates the costs associated with winter protection of containers using conventional container production methods. The long-term goals of this project are to estimate the profit potential for PIP production during pine plantation establishment and to evaluate a series of increasingly shade tolerant ornamental species for PIP production between the pines as the plantation matures.



Flood Tolerance: A Flood Tolerance Laboratory was constructed along Sulphur Creek in the Missouri River floodplain at HARC. This facility provides a unique field laboratory for studying the response of plant species to the periodic flooding common to mid-western floodplains. The laboratory has 12 channels, each approximately 20-ft wide by 600-ft long.

Each channel can be independently adjusted for water depth, standing or flowing water, and duration of flooding. Selected grasses, legumes, and tree species are being evaluated for flood tolerance. The flood tolerance of hardwood planting stock and genetic variation in ecotypes from seed collected from bottomland and upland stands is also being evaluated.



Forage Shade Study:

In 1994, researchers began this project by examining

27 forage species (native and exotic legumes, warm season and cool season grasses) for the effect of shade on dry weight production and nutritional value. During the intervening years, additional species have been studied. All species are evaluated under 3 shade levels: 0% (full sun), 55% shade and 80% shade. The goal is to determine their growth and development under different shade levels when grown as companion crops in agroforestry practices or for savanna and woodland restoration.

Bioterracing Demonstration: This project demonstrates the value of bioterracing on highly erodible soils. Bioterraces are a combination of trees, shrubs and grasses planted in rows along the contour to help trap soil and debris as they move down a slope in surface water flow.

Nut Tree Improvement: The tree improvement program focuses on identifying and testing selections of



black walnut (*Juglans nigra*), pecan (*Carya illinoensis*) and chestnut (*Castanea mollissima*) for incorporation into agroforestry (cont.)



Evaluating the MDC quail cover bundle shrubs:

The Horticulture and Agroforestry Research Center

Research Initiatives

plantings. Major components of this research include (1) testing cultivars on various sites; (2) identifying superior rootstocks for grafting; (3) developing improved vegetative propagation techniques; and (4) creating a breeding program to develop improved selections. A significant component of the tree improvement research program at HARC is nut tree repositories, which serve as germplasm collections to study the adaptation and commercial potential of various cultivars of nut bearing trees to Missouri. Repositories at HARC include walnut (*Juglans nigra*), pecan (*Carya illinoensis*), Chestnut (*Castanea mollissima* and *Castanea hybrids*), and Hazelnut (*Corylus hybrids*).



National Arboretum / NC-7 Trials: Evaluating Rare Plants



The purpose of this planting is to serve as a germplasm repository and evaluation site for newly introduced and rare woody plants with potential ornamental value. A cooperative agreement in 1996 designated HARC as the U.S. National Arboretum Midwest Research and Education Site. Since then, many National Arboretum introductions have been planted, including red maples, alders, disease resistant elms, 'Green Giant' arborvitae and many other specimens of new and unusual plants.

Preserving a Missouri Treasure: The 1819 Thomas Hickman House



One of Missouri's oldest intact brick houses, the Thomas Hickman House, was built in 1819 and stands on the property of the HARC farm. This 1,800 square-foot house represents the southern "Georgian" cottage design, a distinctive architectural style that hallmarks the early development of the Boonslick region of Missouri. The home rests just two miles from Old Franklin - the site where William Becknell and his party began the legendary Santa Fe Trail in 1821.

The goal of this project is to restore the house to its historic condition and to develop it as a visitor center for the HARC farm. The Hickman House will hold permanent educational displays of local archeological, geological and historical interest. Botanical collections will focus on the natural heritage of the Boonslick region, and exhibits will also introduce visitors to current research projects at the Center.

Period gardens and native warm season grass prairie will be established to reproduce an early nineteenth-century landscape, and the grounds will be developed to accommodate a picnic area, parking facilities and restrooms. The Hickman House will be open to all to enjoy, and we welcome your support as we strive to restore this treasure of the Horticulture and Agroforestry Research Center for generations to come.



The 1819 Thomas Hickman House is one of Missouri's oldest brick homes and rests on the Horticulture and Agroforestry Research Center at New Franklin, Mo. The Center's restoration plans include opening the home as an interpretive visitors' center, depicting the early agricultural history of Howard County.

Agroforestry and Wildlife Habitat

Effects of agroforestry practices on wildlife species in major alluvial floodplains

Project Team:

Mickey Heitmeyer, Principal Investigator; Shawn Papon, Shane Pruet, John Vradenburg and Adam Warwick (Graduate Students); Frank Thompson (U.S. Forest Service Co-Advisor and Cooperator)



Agroforestry plantings near remnant bottomland forests greatly enhance abundance and diversity of wildlife communities in large floodplains.

This study is designed to understand the role agroforestry lands play in supporting wildlife species and populations in large river floodplains. Specifically, the project is investigating the role of various types, sizes, and locations of forest patches in sustaining wildlife communities in the 100-year floodplain of the Mississippi River in southeast Missouri. Fifteen 4-square mile study sites were randomly selected to represent landscapes containing various amounts and types of forest, including agroforestry patches.*

Historically, these floodplains were mostly bottomland hardwood forests that supported rich biodiversity and abundance of fish and wildlife species. As these floodplains were cleared and drained for agriculture, wildlife populations have been reduced in abundance and distribution.

Agroforestry plantings in floodplains are attractive to landowners because they provide financially and ecologi-

cally beneficial options and alternatives to traditional intensive row crop production in flood-prone areas. These **agroforestry sites also provide valuable resources to wildlife and provide recreational opportunities to landowners**, the potential to reduce exotic agricultural pests **and income through hunting and recreational leases**.

To date, studies have been completed (or are near completion) on the distribution and abundance of 7 key wildlife species groups (amphibians, reptiles, songbirds, birds-of-prey, swamp rabbits, bats, waterbirds). Collectively, **this is the largest and most comprehensive landscape-level study of wildlife communities and agroforestry plantings ever conducted** on privately owned forest and

agricultural lands in a major alluvial floodplain. Ongoing studies are investigating specific questions about nest success of forest birds in agroforestry sites in floodplains and how flood dynamics affect waterfowl use of agroforestry areas over long periods.

Until this study, little was known about how the size, configuration, distribution and proximity of agroforestry patches affected resource values and wildlife species. By understanding these landscape ecology issues, future agroforestry plantings can be strategically placed to improve both tree production and wildlife benefits. Scientifically, understanding the values of agroforestry in floodplain ecosystems potentially offers great insight into how wildlife adapt and live in intensively farmed landscapes and how wildlife conservation efforts at many geographical scales can be most effective.

* Note: This is the habitat of the recently rediscovered Ivory Bill Woodpecker.

Key Findings Among Wildlife Communities:

Bats: Through the use of mist nets and bat detectors, results indicated that bat abundance and diversity was higher in landscapes containing greater amounts of forest cover. Bat abundance and activity was similar in natural forest remnants and agroforestry patches.

Swamp rabbits: Areas with high forest cover were used most by swamp rabbits. More swamp rabbits were found in natural forest remnants and in agroforestry plantings located adjacent to natural forest patches, in comparison to other habitats and locations.

Waterbirds: Abundance, species diversity, and distribution of waterbirds on agroforestry sites was strongly related to landscape setting and the propensity of areas to flood from backwaters of the Mississippi River and its tributaries. Long-term analyses of frequency, timing, duration, and extent of flooding indicate floods benefited waterbirds, especially mallards, in many ways by increasing access to flooded floodplain forests including agroforestry plantings. Agroforestry areas were used most by waterbirds if they were near, or adjacent to, other floodplain wetlands.

Nesting Success of Forest Birds: In summer 2004, nests of indigo bunting (*Passerina cyanea*), acadian flycatcher (*Empidonax virescens*), and prothonotary warbler (*Protonotaria citrea*) were located and monitored in remnant natural floodplain forests and agroforestry areas managed for fiber and pulp production. Preliminary analyses are currently underway on data including the stage and status of the nests, parasitism and nest predation.

Sources: Heitmeyer et.al., 2004; Heitmeyer, 2005; Warwick, 2004.

Riparian Buffers and Water Quality

Bioremediation of Herbicides in Grass and Agroforestry Buffers

Project Team:

C.H. Lin, R.N. Lerch, M.F. George, R.P. Udawatta, and H.E. Garrett

Herbicides are among the non-point source pollutants of greatest health concern in the Midwestern United States. **More than 70% of the herbicides used in the U.S. are applied in the Midwest for corn and soybean production.** Many herbicides, such as atrazine, are relatively persistent in soils with an average half-life ranging from 4 to 57 weeks. Not surprisingly, herbicides and their metabolites are commonly found in the wells, surface runoff, shallow aquifer, and surface drinking water supply throughout Missouri.

Drinking water sources contaminated with herbicides are a serious public concern, as many rural communities in Missouri rely on private wells or shallow ground water for drinking water and livestock. **Many smaller drinking water treatment plants are not equipped to eliminate the herbicides and their metabolites from drinking water,** since removal of herbicides from ground and drinking water requires expensive chemical adsorption procedures, using activated charcoal. For larger, well-equipped drinking water treatment plants, the compliance costs can be substantial to meet the Environmental Protection Agency drinking water standard. For instance, St. Louis County estimated the capital costs of compliance for their five treatment plants (by the installation of granular activated carbon) at \$164 million, with operation and maintenance costs of \$7 million per year.

A well designed tree-shrub-grass riparian buffer strip is recognized as one of the most cost-effective approaches to alleviate non-point source pollution from adjacent crop lands. Current UMCA research involves four projects with the goals of optimizing riparian

buffer designs in agroforestry systems to 1) reduce herbicide transport to nearby agricultural lands before they reach riparian areas (streams and lakes) and 2) to enhance the degradation process of the herbicides trapped within the buffers.



Vegetative filter strips are studied at the University of Missouri Bradford Research Center.

Specific Project Focus Areas:

- Screen suitable ground cover species for tree-shrub-grass riparian buffer strips for the purpose of sequestering, degrading and immobilizing agronomic herbicides such as atrazine, metolochlor, glyphosate and Balance™ (isoxaflutole) in surface runoff and subsurface flows;
- Investigate the physical and biological effects of selected forages on the transport and transformation of these herbicides;
- Evaluate the sensitivity of shade tolerant forages to highly concentrated herbicides in the surface runoff and the related detoxification mechanisms of these forages;
- Study the effectiveness of various tree-grass buffer designs in reducing the transport of herbicides.

This research will provide valuable tools for government agencies and landowners to optimize a cost-effective buffer strip design and improve

the effectiveness of buffer strips for the bioremediation of herbicides derived from agricultural operations. A well-designed forest riparian buffer will not only minimize the amount of herbicide and their metabolites transported into the shallow aquifers or surface water, which are used for private and public drinking water sources, but also minimize the amount of lands required to be taken out of crop production to reduce pollutants to acceptable levels. Other benefits may include significantly reduced operation and maintenance costs of local water treatment facilities. Findings from the research may also encourage local governments to implement more extensive cost-share, annual incentive or rental payment programs for landowners for the adoption of tree-shrub-grass riparian buffers.

Study Designs:

A field experiment has been conducted at the University of Missouri Bradford Research Center consisting of four vegetative filter strips replicated three times each. These strips include traditional fescue, switchgrass hedge in combination with fescue, switchgrass hedge in combination with native grass and forb species, and continuous cultivated fallow as a control.

A walk-in growth chamber study using ¹⁴C-atrazine was performed to investigate the uptake and degradation of atrazine by eight forage species during a 100-day growth period: orchardgrass, ryegrass, smooth brome grass, tall fescue, hoary tick clover, Illinois bundle flower, eastern gamma grass and switchgrass.

An experiment of national significance in the science of agroforestry is the paired watershed at the University of Missouri Greenley Memorial Research Center consisting of 1) a corn-soybean/tree-grass buffer, 2) a corn-soybean/countour grass buffer, and 3) a control treatment with a corn-soybean rotation only is being evaluated to determine the effect of buffers and topographic factors on herbicide degradation, sediment, runoff and fertilizer reduction. (See Udawatta, p. 23, for source).

Key Findings, Bioremediation Study:

- Grass buffers significantly reduced herbicide transport in surface runoff. Switchgrass, tall fescue and smooth brome grass are good candidates for incorporation into the tree-shrub-grass riparian buffer systems designed for the bioremediation of atrazine and Balance.TM
- Grass buffers with native species displayed the best season-long effectiveness to reduce herbicide transport.
- **A filter strip eight meters in width of native species buffers removes about 75-80% of atrazine, metolochlor and glyphosate from surface runoff.**
- The placement of switchgrass hedges situated at the beginning of the tall fescue buffers enhanced the reduction rates of atrazine and metolochlor transport by 13% and 9%, respectively, at a distance of 1 m from the herbicide application source.
- Warm-season switchgrass is shown to have the highest capacity to degrade and immobilize atrazine in soils, **degrading more than 80% of applied atrazine** to less toxic metabolites within 25 days of application.

Sources: ^ALin et. al., 2004.

^BLin et. al., 2004.

BalanceTM (isoxaflutole) was introduced commercially during the 1999 growing season to 16 U.S. corn-producing states. Within three years, it was applied to an estimated 4 to 23% of corn acreage in the Midwest. UMCA initiated a pioneer study to research the impacts of Balance and a remediation approach for potential water contaminants caused by the formula.

Effectiveness of Riparian Forest Buffers in Headwater Watersheds of the Western Corn Belt Plains Ecoregion

Project Team: Tom Isenhardt and Dick Schultz, Iowa State University (ISU) Dept. of Natural Resource Ecology & Management; Bill Simpkins, ISU Dept. of Geologic & Atm. Sciences; ISU Research Associates/ Scientists Leigh Ann Long, Jin-Kie Yeo

In addition to providing alternative income sources, like decorative woody florals, berries or lease hunting of upland game birds, riparian buffers serve another critical function — helping reduce nitrates and potential non-point source pollution before it ever reaches surface and groundwater, significantly improving the condition of stream water quality.

UMCA collaborators at Iowa State University are studying the impact of riparian forest buffers in the headwaters of the Crooked Creek watershed in Missouri's Mark Twain Watershed by monitoring associated groundwater wells. Results of these tests indicate that **riparian forest buffers composed of combinations of warm or cool season grasses, shrubs and trees remove significant amounts of nitrates from the groundwater** moving toward the stream.

In conjunction with measuring the impact of buffers on stream and groundwater quality, researchers are studying the impacts of both row-crop agriculture and streamside grazing on water quality.

The initial investment of establishing a riparian buffer is being offset by many landowners through the Conservation Reserve Program (CRP). To assist landowners in planning effective buffers, researchers are utilizing GIS analysis of the flood plains of three

watersheds in the Mark Twain Watershed to inventory the amount of existing riparian forest, grassland and crop land within a 200-foot zone (the maximum width of buffer allowed by the CRP program) on either side of the creeks.

Conclusions from Mark Twain Watershed Research:

- Groundwater moving below crop fields contains significantly higher levels of nitrates from fertilizers than groundwater moving below lightly used stream side pastures.
- **Properly designed riparian buffers containing trees, shrubs and native warm or cool-season grasses can effectively intercept sediment and surface chemicals** before they enter a stream.
- The effective buffering capacity of existing forest strips growing along Missouri streams depends on the width of the strip and the health of the plant community.
- **42% of the forested strips along first order streams in the Crooked Creek watershed, and 10% of the higher order forested strips, are narrower than the NRCS recommended widths.** Efforts to establish riparian buffers should be targeted toward first and second order headwater streams, as these are in closest contact with agricultural activities.

Sources: Schultz et al., 2004; Zaimes et. al., 2004.



Riparian forest buffers provide income potential through planting decorative woody florals in the shrub zone, as well as excellent wildlife habitat for lease hunting.

Tree/Crop Interactions

Shade Tolerance of Forage Crops Research

Project Team: Jerry Van Sambeek, Gene Garrett, Bob McGraw, Nadia Navarrete-Tindall

When utilizing agroforestry practices for short and long-term income, especially in an alley cropping, silvopasture or forest farming setting, the management of ground cover under decreasing amounts of light as the tree canopy develops is critical. The landowner must understand how different plant species will respond when grown under the shade of trees.



UMCA's shade tolerance research project is conducted in a specially designed shade laboratory at the Horticulture and Agroforestry Research Center to evaluate these factors. The laboratory allows researchers the opportunity to evaluate forage yield and quality of grasses and legumes with light as the only limiting factor. The goal of the project is to identify which species or cultivars should be further tested in field trials for optimizing their success in agroforestry practices.

Within the shade tolerance laboratory, 20 to 27 grasses and legumes are simultaneously grown under 20, 45, and 100 percent of full sunlight and periodically harvested to determine yield and forage quality as percent crude protein, neutral detergent fiber (NDF), and acid digestible fiber (ADF). Through multiple screening trials,

researchers have determined a ranking of the shade tolerance of grasses and legumes.

The following species have performed well under moderate to heavy shade in multiple studies (ranked from very shade tolerant to moderately shade tolerant):

Very Shade Tolerant

	Hoary tick clover (<i>Desmodium canescens</i>)
	Kura clover (<i>Trifolium ambiguum</i>)
	Crownvetch (<i>Coronilla varia</i>)
	Crimson clover (<i>Trifolium incarnatum</i>)
	Cluster fescue (<i>Festuca paradoxa</i>)
	Paniculated tick clover (<i>Desmodium paniculatum</i>)
	Reed canarygrass (<i>Phalaris arundinacea</i>)
	Kentucky bluegrass (<i>Poa pratensis</i>)
	Red clover (<i>Trifolium pretense</i>)
	Subterranean clover (<i>Trifolium subterraneum</i>)
	Kentucky 31 tall fescue (<i>Festuca arundinacea</i>)

Moderately Shade Tolerant

Key Findings: Shade Tolerance Research

- Several forage grasses and legumes can exhibit higher yields under moderate shade than when grown in full sunlight.
- Although warm-season grasses under moderate shade have higher total yields than cool-season grasses, yield of warm-season grasses declines more rapidly under increasing shade than for cool-season grasses.
- Increasing shade tends to increase forage quality by increasing both crude protein and digestibility (reduced lignin fiber content).

Sources: Van Sambeek et al., 2004. Navarrete-Tindall et al., 2003, 2004.



Initial shade tolerance studies demonstrated substantial differences exist among forage crops in response to increasing shade. Shade tolerance study designs are continually enhanced at HARC.

Biodiversity, Pesticide Reduction, and Crop Management in Forage and Oil Seed Crops Alley Cropped with Black Walnut

Project Team: Marc J. Linit, W. Terrell Stamps, Robert L. McGraw, Larry Godsey, Shawn Conley, Terry Woods

Scientific theory suggests that a more diverse plant community supports a more diverse insect community, with the side benefit of reducing pest insects. However, a longstanding agricultural trend in North America is to reduce diversity in



Current design for the shade tolerance laboratory at HARC.

“To develop a successful agroforestry practice for both short and long-term income, the landowner must understand how different plant species will respond when grown under the canopy of trees.” -- Jerry Van Sambeek, UMCA Collaborator

pursuit of maximum yields and profits. The practices of agroforestry, strategically incorporated into crop management, look to modify the trend towards a monoculture landscape while maintaining and enhancing profitability. Agroforestry's rapidly growing popularity can be attributed to the practice's potential capacity to positively impact the environment through reduced pesticide applications and improved water quality, as well as to positively impact long-term profits and income stability. Landowner's growing interest in agroforestry and good land stewardship in general has led the United States Department of Agriculture (USDA) to provide funds for agroforestry research.

Alley-cropping, the planting of traditional or value added crops between tree rows, is one of the most commonly instituted agroforestry practices in the Midwest. Researchers are examining various aspects of the impact of alley cropping on crop yield and pest problems. Project goals include: (1) Determine the impact of alley-cropping forages and oilseed crops in black walnut tree rows on insect and pest populations; (2) Investigate the economics of alley cropping, **with the overall goal of providing growers with a comprehensive set of data by which to make informed decisions on adopting agroforestry practices** for farm and other land use; 3) Compare the conventional monocrop practices of forage or oilseed with alley cropping practices.

Research to meet these goals has been targeted at the Sho-Neff Walnut Plantation near Stockton, Mo. The plantation is a privately-owned enterprise with more than 450 acres of black walnut grown in an alley cropped configuration. The insect populations and crop yields among traditionally-grown (open-field, monoculture) alfalfa and two different alley widths of alfalfa intercropped with black walnut trees are being compared.

Future studies will evaluate the economics of alfalfa and canola yields in combination with the nut and wood value of the walnut trees. This comprehensive approach to examining alley cropping as a viable land use practice in Missouri continues to place the state in the forefront of this unique area of research.



Alfalfa intercropped with Black Walnut.

Key Findings: Black Walnut/Alfalfa Alley Cropping Research

- At wider alley widths (80 ft), alfalfa production equals that of traditionally grown alfalfa, indicating a **landowner would not jeopardize production rates by planting alfalfa in an alley cropping practice.**
- No differences in quality measures (i.e. acid detergent fiber and neutral detergent fiber) were noted between the monocropped plots of alfalfa and alley cropped plots of alfalfa.
- Insect populations were twice as diverse -- and **the number of beneficial insects that can help control pests was significantly increased** -- in alley cropped alfalfa as compared to monocropped alfalfa.

Source: Stamps, W.T., T.W. Woods, M.J. Linit and H.E. Garrett, 2002. *Agroforestry Systems* 56(2): 167-175.

Missouri Gravel Bed: A Method of Facilitating Tree and Shrub Planting

Project Team: Chris Starbuck, Jerry Van Sambeek and Steven Kirk

The Missouri Gravel Bed (MGB) research project, conducted at the Horticulture and Agroforestry Research Center, is evaluating a method for handling trees and shrubs that allows bare root plants to be planted throughout the year with excellent survival rates. Currently, the planting of bare root trees and shrubs is limited to the dormant season, but the MGB process is more cost efficient to landowners than the expense of pots, manual labor and other materials associated with planting container-grown stock.

Within the MGB system, dormant, bare root plants are placed with their roots in frequently-irrigated river rock that contains 10% masonry sand and allowed to develop roots in the rock. **Plants can be removed from the gravel after approximately 10 weeks and planted bare root, in full leaf, and with a survival rate equal to or greater than those expected for balled and burlapped or container grown trees of the same size and species.** Research results have documented **outstanding survival of a wide range of summer-planted bare root plants, including "difficult to transplant" species** such as dogwood, black gum and hawthorn. This method has good potential as a tool for improving outplanting survival of species such as black walnut, pecan and cottonwood commonly utilized in agroforestry plantings. Source: Kirk et. al., 2004.



Profit in Agroforestry

Cultivation of Gourmet and Medicinal Mushrooms in Agroforestry

Project Team: J.N. Bruhn & J.D. Mihail, University of Missouri Plant Microbiology & Pathology

UMCA supports one of only two research programs in the nation working to develop the European black truffle as a forest farming crop for landowners. Current successes indicate this premium, high-dollar mushroom grows well in Missouri soil and may be very successful when grown in agroforestry practices.

detailed, scientifically sound set of guidelines for cultivation of a diverse suite of gourmet and medicinal mushrooms in Missouri. These guidelines will guide Missouri landowners in establishing mushroom cultivation enterprises or in expanding existing enterprises to include new mushroom species.

Research is also being conducted to develop morel, shiitake and other gourmet mushrooms into profitable agroforestry crops for landowners. Not only can specialty mushrooms be grown on a range of acreage allotments, mushroom cultivation is a sustainable and profitable way to recycle low-value forestry by-products, like branches, wood chips and sawdust.



Market Value, Specialty Mushrooms

Fresh shiitake	\$10 - \$15/ pound (chefs and select retail grocers)
European black truffle	\$150 - \$250/ pound
Morel	\$20 - \$30/ pound

The mushroom research program is developing a

Selecting Pines for Pine Straw Mulch Production in Missouri

Chris Starbuck, MU Division of Plant Sciences

Pine straw, the naturally shed needles of pine trees, is an excellent mulch material and a multi-million dollar industry in the southeastern United States for landscape plantings. The needles (sold in small bales) knit together and stay in place during heavy rains; are lightweight, attractive and easy to apply; and because the needles decompose like leaves on a forest floor, they maintain a healthy, balanced soil pH over time. Pine straw is also an excellent mulch for its sustainability – the needles are naturally shed year after year while the tree continues to mature for future timber harvest.

Managing pine forests and wind-breaks for pine straw production can provide significant income to landowners. However, shortleaf pine (*Pinus echinata*) — the only pine native to Missouri — has needles too short to

bale using conventional equipment. The purpose of this study is to evaluate pitch x loblolly hybrid pines (*Pinus rigida x taeda*) for their suitability for the production of pine straw mulch by



Missouri landowners. Because of its excellent needle characteristics, the loblolly pine is used extensively for pine straw production in the southern U.S. but its natural range extends only as far north as central Arkansas. The pitch pine's range extends from southern Maine to Northern Georgia. The original purpose of hybridizing these two pine species was to create a pine with the cold hardiness of a pitch pine and the fast growth rate of a loblolly. Fifteen genotypes of these controlled crosses are being evaluated at the Horticulture and Agroforestry

Research Center for cold hardiness, growth rate, needle length and needle yield.

Observations indicate that some of the genotypes (selections) in the plantation are hardy, fast growing, long-needled trees, likely to be suitable for commercial pine straw production in Missouri in plantation or windbreak settings. The trees in this study **were field planted in spring of 1999 as one year seedlings, and some trees in the planting are already 25 feet tall and are beginning to produce measurable yields of pine straw.** Data collected during the next few years will allow selection of genotypes with obvious potential for Missouri land and forest owners to capture a segment of the profitable pine straw industry.

Pine Straw Coverage (4 inches deep)	Hardwood Bark Mulch Coverage
One bale = 70 - 100 square feet coverage (retail price: \$6 - \$9 per 35 lb. bale)	One bag = 10-20 square feet coverage
1 acre of pine plantation yields \$100 - \$350 of pine straw (net value)	

The Chestnut Marketplace : A “New” Crop for Missouri Producers

Project Team: Michael Gold, Ina Cernusca, Larry Godsey, Ken Hunt



The Chinese chestnut, an ancient crop that is largely unknown to Americans since the near extinction of the American chestnut forest from chestnut blight, shows excellent potential for Missouri landowners as a cash income crop, with growing demand exceeding supply.

The American Chestnut forest, once an abundant source of lumber and nut production across the southeast and eastern regions of the U.S., was completely destroyed by blight by 1950. However, Missouri soils and climate are excellent for production of the sweet, starchy and versatile Chinese varieties of the chestnut, which can be planted in an orchard or alley cropping practice. The trees are blight-resistant, much smaller in structure than the American Chestnut, and spread outward like a large fruit tree while producing a significant quantity of nuts. In addition, chestnuts provide excellent food for wildlife and can be utilized as savory feed for gourmet pork production. The nuts are low in fat and high in vitamins, and items like baking flour made from chestnuts are emerging to meet demand in the gluten-free and restricted diets market.

The Center for Agroforestry is working to establish a viable chestnut industry, focusing its efforts on three key areas: national market research, production techniques/orchard management and increasing consumer demand and awareness. The long term objective is **to change the image of chestnuts** from that of a holiday tradition to a healthy year round food. The outcome of this effort will be an active program that reaches out to potential producers and establishes **a multi-million dollar chestnut industry within the state of Missouri.**

Evaluating Market Potential: Last year, through a national market survey, chestnut producers, processors, distributors, retailers and others involved in the chestnut industry were contacted and identified to glean additional insights into the emerging chestnut market for the Midwest.

Key Findings, 2004 National Chestnut Market Research:

- Chestnut cultivation can be a source of profit due to high demand, good prices, high value of imports compared to domestic production and relatively low initial investment requirements.
- Producing chestnuts can be a way to diversify an existing agricultural business.
- Chestnuts can be grown organically, have many nutritional and health benefits (e.g., gluten free flour) and are associated with positive feelings such as tradition, holiday and family that can help promote the product.



Chestnuts: Potential Income Source

In the Midwest, Chinese chestnut trees begin bearing commercial quantities of nuts between ages 6 and 9.

Planted at 30' x 30' spacing, and bearing 15-30+ pounds per tree by age 10, easily reach 1,000 pounds per acre.

At the farm gate, Iowa growers receive \$1.60 per pound for small-sized chestnuts. Gross return = **\$1,600/acre.**

Demand for quality chestnuts currently exceeds supply!

Asian and European ethnic consumer markets are the largest current outlet.

American consumers who have eaten chestnuts like the taste BUT, 2/3rds have never tried them.

Survey results from 2004 Missouri Chestnut Roast indicate 87% of consumers have very little or no familiarity with cooking and preparing chestnuts. Consumers and retailers also need education in the storage and preparation of chestnuts.

Source: Gold et. al, 2004. HortTechnology.



Markets for chestnuts are expanding, both in the U.S. and overseas. Left: Sample literature from an Australian producer marketing frozen, peeled chestnuts. **Above:** Fresh chestnuts bring prices of \$4 to \$6 per pound. Chestnut flour is nutritious and excellent for baking.

Chestnuts are low in calories, high in vitamin C and a good source of fiber. They are also cholesterol free and taste great roasted or baked in recipes. For additional nutritional information and recipes for chestnuts, pecans and black walnuts, visit www.centerforagroforestry.org and select Nutrition and Your Health.

Extending the Value of Agroforestry



Mourning Dove as a Lease Hunting Opportunity in an Agroforestry Practice

Researcher: Josh Millsbaugh

One example of a profitable agroforestry practice may include mast bearing trees, harvestable game birds and additional income from lease hunting options.

Mourning doves, in particular, offer an abundant and economically valuable resource for landowners. **In Missouri, there are approximately 40,000 dove hunters who achieve annual expenditures of an estimated \$5 million, yet current demand for dove hunting continues to exceed supply.** The hunting lease options that have been proposed for Missouri may also increase the profit potential of this industry, and many collaborators are investigating dove harvest dynamics and national management objectives.

The Center for Agroforestry is the only entity conducting research to evaluate the efficacy of different sizes and configurations of sunflower plantings to attract and concentrate mourning doves for harvest.

Researchers are developing techniques for establishing mast bearing trees in floodplains through agroforestry practices, while considering mourning dove lease hunting and native plant production practices. Researchers are also working to determine optimal sunflower field size and configurations to attract mourning doves within an agroforestry setting.



Silvopasture Research: Providing Greater Economic Returns for Livestock

Project Team: Robert Kallenbach, Monty Kerley, Erin Venable, Gene Garrett, Ryan Lock, and Kenneth Bader



More than 20 percent (22.5 million head) of the beef cattle in the United States are raised in the lower Midwest (USDA, 1998). This region, which includes Missouri, Kentucky, Tennessee, Kansas, Arkansas, and Oklahoma, uses more than **62.9 million acres of private grasslands** and engages more than 312,000 farm families in its beef operations (Vesterby 2001)*. Despite the enormity of this industry, most beef operations in the lower Midwest are only marginally profitable. The average beef producer has a net operating margin of \$23.75 per head per year (Short 2001)*.

The integration of grazing livestock into well-managed silvopastures (trees in conjunction with pastures) may provide greater economic returns than livestock grazing in pure pasture settings in the lower Midwestern region, especially during a long-term investment. Research findings from the 2003 silvopasture study determined that well-managed silvopastures can reduce **winter feed costs by approximately 20 percent.** (Source: Kallenbach et. al, 2003).

Our understanding of the interactions between tree growth, forage production and grazing in a silvopasture practice continues to expand with further studies. The current study at the Horticulture and Agroforestry Research Center is designed to determine under which conditions silvopastures are profitable and how to make these systems sustainable, with the long-term goal of developing silvopasture systems that enhance the profitability of the forage-livestock and forest industries in the lower Midwest.

Experimental hardwood silvopasture research at the Wurdack Farm:

Hardwood silvopasture research efforts at the University of Missouri Wurdack Farm near Cook Station, Mo., are designed to measure the value of timber improvement and the value of the forage produced in a silvopasture setting. Three treatment areas have been established: thinned forest, un-thinned forest/control, and open pasture. Annual tree measurements conducted in the silvopasture experiment area emphasize the parameters of growth as they relate to volume of wood produced, and quality parameters such as wound closure and the development of small branches on the lower portions of a tree.

New trees have been established to initiate the second generation of forest on the silvopasture sites. To date, 400 containerized white oaks have been established and researchers are now installing a 1.5-foot radius cage (60 inches in height) around each seedling. The cages are designed to eliminate indiscriminate browsing by cattle and/or deer. Future research may include placing weather stations on the different treatment areas in an effort to understand differences in microclimate that may be occurring, such as relative humidity, temperature and wind speed.

* Sources: Short S.D. 2001. Characteristics and production costs of U.S. cow-calf operations. USDA Economic Res. Serv. Stat. Bull. 974-3. U.S. Gov. Print. Office, Washington, DC.

Vesterby M., and Krupa K.S. 2001. Major uses of land in the United States, 1997. Economic Res. Serv. Stat. Bull. 973. U.S. Gov. Print. Office, Washington, DC.

UMCA Research Clusters

Since 2003, UMCA has been supported by and managed three significant USDA - ARS programs, representing more than 50 individual projects. The Center seeks 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, our research efforts have been organized into eleven research "clusters" to enhance creativity and productivity among a range of investigators from many disciplines. UMCA research continues to serve as a catalyst for stimulating the development of agroforestry throughout the United States.

Clusters include:

1) Nut tree research: Features research on pecan, black walnut and chestnut, including field studies, market 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.

2) Water quality and riparian forest buffer research: Focus is to demonstrate the environmental benefits of woody/grass buffers on non-point source pollutants. Includes a paired watershed study, animal bioremediation study and work on riparian forest buffers.

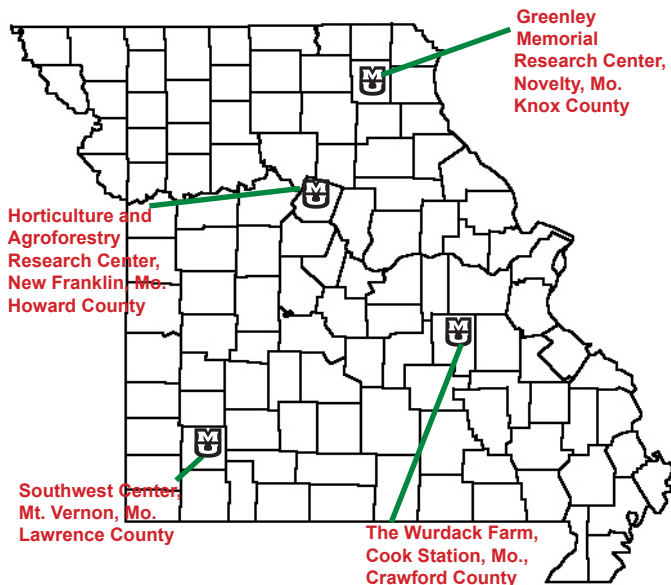
3) Flood tolerance research: Focus is to use the state-of-the-art flood tolerance research facility at the Horticulture and Agroforestry Research Center to study the effects of short- and long-term flooding on woody and non woody plants. Results link directly to the ongoing EPA funded "green infrastructure" project in Kansas City with the Mid-America Regional Council and National Agroforestry Center.

4) Socio-economic-marketing research: The cluster's integrated approach responds to the need to facilitate adoption of new practices in

agroforestry, which requires understanding of the social and economic relations of a given enterprise. These relations include institutions, networks, markets, technology, and environment. Research activities provide an understanding of important factors that facilitate or constrain involvement in agroforestry and are directly linked to the technology transfer program.

5) Fast growing hardwood biomass research: Focus is to quantify growth of Populus clones and other species for biomass production, flood tolerance and levee protection.

6) Forest bottomland and wild-life restoration and biodiversity research: Bottomland hardwood restoration and management studies; quantifying effects of bottomland agroforestry practices on wildlife species.



The Center for Agroforestry focuses its research on four University of Missouri outlying farm properties, as indicated above.

7) Silvopasture Research: Studies include response of cattle and trees in pastures with planted trees; extending the grazing season with early/late season forages sown under alley cropped pine; effects of managed hardwood forest stands and grazing upon understorey shade tolerant forages and stand

regeneration.

8) Horticulture research: Ongoing studies with gourmet mushrooms, medicinals, pot-in-pot production, pine straw, woody and non-woody florals.

9) Tree/Crop interactions: This cluster impacts all biophysical research clusters, with a focus on multiple above and below-ground interactions between trees and crops, and also includes insect predator-prey dynamics.

10) Carbon sequestration cluster: Above/below ground carbon balance studies; excavation of exposed ancient riparian stream wood to reconstruct climate record for past 14,000 years.

11) Technology transfer cluster: Efforts are centered around four outlying university research properties, with a focus on ongoing agroforestry research and landowner demonstrations in adjacent locations complimented by socio-economic studies. See map on left for location of outlying research properties.



2004 Publication Highlights

Wildlife Habitat Research:

Dugger, S., Dey, D.C., Millsbaugh, J.J. 2004. Vegetation cover affects mammal herbivory on planted oaks and success of reforesting Missouri River bottomland fields. In Connor, K.F., ed. Proceedings 12th Biennial Southern Silvicultural Conference. 24-28 February 2003. Biloxi, MS. General Technical Report SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service Southern Research Station. 3-6

Heitmeyer, M. E., R. J. Cooper, J. G. Dickson and B. D. Leopold. 2004. Ecological relationships of warm-blooded vertebrates in bottomland hardwood ecosystems. In L. H. Fredrickson, S. A. King and R. M. Kaminski, eds. Ecology and management of bottomland hardwood ecosystems: the state of our understanding. University of Missouri Press, Gaylord Memorial Laboratory, Puxico, MO.

Hodges, J., A. Ezell, L.H. Fredrickson, M. Staten and P. Hamel. 2004. Silviculture and management of hardwood forests. In L. H. Fredrickson, S. A. King and R. M. Kaminski, eds. Ecology and management of bottomland hardwood ecosystems: the state of our understanding. University of Missouri Press, Gaylord Memorial Laboratory, Puxico, MO.

Warwick, J. A. 2004. Distribution and abundance of swamp rabbits and bats in fragmented wetland forests of southeast Missouri. M. S. Thesis, University of Missouri-Columbia, Columbia, MO. 127pp.

Tree/Crop Interactions:

Bailey, N.J., P.P. Motavalli, R.P. Udawatta, and K.A. Nelson. 2004. Soil C and N distribution and gaseous flux due to landscape position and temperate alley cropping practices in an agricultural watershed. Agron. Abstr., American Society of Agronomy, Madison, WI.[non-paginated CD-ROM]

Jose, S., A.R. Gillespie and S.G. Pallardy. 2004. Interspecific interactions in temperate agroforestry. *Agroforestry Systems* 61: 237-255.

Navarrete-Tindall, N.E., J.W. Van Sambeek, and R.A. Pierce. 2004. Cluster fescue (*Festuca paradoxa* Desv.): a multipurpose native cool season grass. In: Proceedings, 4th Eastern Native Grass Symposium. 3-5 October 2004; Lexington, KY. Lexington, KY: University of Kentucky Press. (In Press.)

Van Sambeek, J.W., H.E. Garrett, N.E. Navarrete-Tindall, C.-H. Lin, and R.L. McGraw. 2004. Percentile rank as an approach to evaluating shade tolerance of ground covers in Agroforestry. In: Working Together for Sustainable Land-use Systems: Proceedings, 1st World Agroforestry Congress. 24 June - 4 July 2004; Orlando, FL. Gainesville, FL: University of Florida. p. 285.

Van Sambeek, J.W. and H.E. Garrett. 2004. Ground cover management in walnut and other hardwood plantings. In: Michler, C.E. and others, eds. Black Walnut in a New Century. Proceedings, 6th Walnut Council Research Symposium. 25-28 July 2004; Lafayette, IN. Gen. Tech. Rep. NC-243. St. Paul, MN: USDA FS NCRS. P. 85-100.

Kirk, S.D., J.W. Van Sambeek and C.J. Starbuck. 2004. Missouri gravel bed and a pot-in-pot system superior to white polyethylene

and foam for overwintering *Syringa patula* liners. Proceedings of the International Plant Propagators Society. (In Press.)

Silvopasture and Forages:

Kallenbach, R.L., G.J. Bishop-Hurley, M.D. Massie, M.S. Kerley, and C.A. Roberts. 2003. Stockpiled annual ryegrass for winter forage in the lower Midwestern USA. *Crop Sci.* 43 (4): 1414-1419.

Garrett, H.E., M.S. Kerley, K.P. Ladyman, W.D. Walter, L.D. Godsey, J.W. VanSambeek and D.K. Brauer. 2004. Hardwood silvopasture management in North America. In: Nair PKR, Rao MR, and Buck LE (eds), *New Vistas in Agroforestry: A Compendium for the 1st World Congress of Agroforestry*, Kluwer, Dordrecht, The Netherlands, 2004. [Also in *Agroforestry Systems* 61: 21-33]

Fike, J.H., A.L. Buegler, J.A. Burger, and R.L. Kallenbach. 2004. Considerations for establishing and managing silvopastures. Online. Forage and Grazinglands. doi:10.1094/FG-2004-1209-01-RV.

Niedermann, M.L. and R.L. McGraw. 2004. Effects of light on nonstructural carbohydrate accumulation in roots of alfalfa. Proceedings 8th Biennial AFTA Convention, Corvallis, Oregon. S. Sharrow, ed. June 22-25, 2003. p. 206-212.

Climate Change/Carbon Sequestration Research:

Guyette, R.P., M.C. Stambaugh, and D.C. Dey. 2004. The American long oak chronology (ALOC): development of a Holocene climate reconstruction for the agricultural heartland. EOS. (In Press.)

Nut Trees:

Reid, W., Coggeshall, M.V., Hunt, K.L. 2004. Cultivar evaluation and development for black walnut orchards. In: Michler, C.H., ed, and others, *Black walnut in a new century*. Proceedings, 6th Walnut Research Symposium. 2004 July 25-28; Lafayette, IN. Gen. Tech. Rep. NC-243. St. Paul, MN: U.S.D.A. Forest Service, North Central Research Station (In Press).

Alley Cropping:

Mungai, N.W., P.P. Motavalli and R.J. Kremer. 2004. Soil organic C and N fractions in long-term temperate alley cropping practices. Proceedings 8th Biennial AFTA Convention, Corvallis, Oregon. S. Sharrow, ed. June 22-25, 2003. p. 196-205.

Riparian Forest Buffers and Water Quality:

Bentrup, G. and T. Kellerman. 2004. Where should buffers go? - modeling riparian habitat connectivity in northeast Kansas. *Journal of Soil and Water Conservation* 59:209-213.

Bentrup, G., M.M. Schoeneberger, M.G. Dosskey, and G. Wells. 2004. The fourth 'P': planning for multi-purpose riparian buffers. Proceedings of the 8th North American Agroforestry Conference. Corvallis, OR. June 22-25. p. 26-37.

Bentrup, G. and T. Kellerman. 2004. Agroforestry and GIS: achieving land productivity and environmental protection. Proceedings of the 8th North American Agroforestry Conference.

Corvallis, OR. June 22-25. p. 15-25.

Coggeshall, M.V., Van Sambeek, J.W., Schlarbaum, S.E. 2005. Flood tolerance evaluation of bottomland oaks in a multi-channel field laboratory. In: Weigel, D., Van Sambeek, J.W.; Michler, C., eds, Ninth Workshop on Seedling Physiology and Growth Problems in Oak Plantings (Abstracts). 2004 October 18-20; West Lafayette, IN. Gen. Tech. Rep. NC - ###. St. Paul, MN: U.S.D.A. Forest Service, North Central Research Station. (In Press).

Dey, D., and J. Kabrick. 2004. Regenerating oaks in Missouri's bottomlands. *Missouri Conservationist* 65(7): 18-22.

Dey, D.C., Lovelace, W., Kabrick, J.M., Gold, M.A. 2004. Production and early field performance of RPM seedlings in Missouri floodplains. In: Michler, C.H., Pijut, P.M., Van Sambeek, J., Coggeshall, M., Seifert, J., Woeste, K., Overton, R., and Ponder, F. Black walnut in a new century, proceedings of the 6th Walnut Council research symposium; 2004 July 25-28; Lafayette, IN. Gen. Tech. Rep. NC-243. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 59-65.

Dey, D.C., Kabrick, J.M., Gold, M.A. 2004. Evaluation of RPM™ oak seedlings in afforesting floodplain crop fields along the Missouri River. In: 9th workshop on seedling physiology and problems in oak plantings. 18-20 October 2004. West Lafayette, IN. USDA Forest Service, North Central Research Station. General Technical Report NC - ###. (In Press.)

Dey, D.C., J.M. Kabrick, and M.A. Gold 2004. Tree establishment in floodplain agroforestry practices. In Proceedings 8th North American Agroforestry Conference. 22-25 June 2003. Oregon State University. Corvallis, OR. p. 102-115.

Ellis, E.A., G. Bentrup, and M.M. Schoeneberger. 2004. Computer-based tools for decision support in agroforestry: current state and future needs. *Agroforestry Systems* 61: 401-421.

Guyette, R.P, D.C. Dey and M.A. Gold. 2004. A temporal perspective on coarse woody debris, carbon sequestering, and aquatic habitat in riparian ecosystems. In Proceedings 8th North American Agroforestry Conference. 22-25 June 2003. Oregon State University. Corvallis, OR. Published abstract and presentation. p. 307-308.

^ALin, C.H., Lerch, R.N., Jordan, D., Garrett, H.E., and George, M.F. 2004. The effects of herbicides (atrazine and Balance) and ground covers on microbial biomass carbon and nitrate reduction. Proceedings of the 8th North American Agroforestry Conference, June 22-25, 2003 Corvallis, Oregon. p. 182-195.

^BLin, C.H., Lerch, R.N., Garrett H.E. and George, M.F. 2004. Incorporation of selected forage grasses in riparian buffers designed for the bioremediation of atrazine, isoxafutole (Balance) and nitrate. *Agroforestry Systems*. 63: 91-99.

Schultz, R.C., T.M. Isenhardt, W.W. Simpkins, and J.P. Colletti. 2004. Riparian forest buffers in agroecosystems – lessons learned from the Bear Creek watershed, Central Iowa, USA. Chapter 2 In: P. K. R. Nair, M. R. Rao, and L. E. Buck (Eds.) *New Vistas in Agroforestry*. [Also in *Agroforestry Systems* 61: 35-50].

Udawatta, R.J., P.P. Motavalli and H.E. Garrett. 2004. Phosphorus loss and runoff characteristics in three adjacent agricultural watersheds with claypan soils. *J. Environ. Qual.* 33:1709-1719.

Van Sambeek, J.W., and Coggeshall, M.V. 2004. Evaluating physiological response and genetic variation of oak species for flood tolerance. *Missouri Forestry Newsletter*. 20(2): 3-4.

Zaimes, G.N., R.C. Schultz, and T. M. Isenhardt. 2004. Stream Bank Erosion Adjacent to Riparian Forest Buffers, Row-cropped Fields, and Continuously-grazed Pastures along Bear Creek in Central Iowa. *Journal of Soil and Water Conservation* 59:19-27.

Socio-economics, policy, marketing:

Godsey, L.D., M.A. Gold and M.M. Cernusca. 2004. Eastern red cedar: a competitive market analysis. In: Proceedings 8th Biennial Conference on Agroforestry in North America. S. Sharrow, ed. June 22-25, 2003, Corvallis, OR, USA p. 128-141

Gold, M.A., M.M. Cernusca and L.D. Godsey. 2004. Comparing consumer preferences for chestnuts with eastern black walnuts and pecans. *HortTechnology* 14(4):583-589.

Gold, M.A., L.D. Godsey and S.J. Josiah. 2004. Markets and marketing strategy for agroforestry specialty products in North America. *Agroforestry Systems* 61:371-382.

Gold, M.A., L.D. Godsey and M.M. Cernusca. 2004. Eastern red cedar market analysis. UMCA Publication 48 p. <http://agebb.missouri.edu/umca/profit/redcedar/analysis.pdf>

Valdivia, C. and S. Konduru. 2004. Interest in agroforestry practices and the role of government transfers in farmer diversification strategies. In: Proceedings 8th Biennial Conference on Agroforestry in North America. S. Sharrow, ed. June 22-25, 2003, Corvallis, OR, USA p. 281-296.

From the National Agroforestry Center:

CanVis: an image-editing software program that allows planners to add buffers into an existing image to depict design alternatives.

Visual Simulation Guide: a multi-media guide for using image-editing software to create realistic and accurate visual simulations for agroforestry and other resource planning.



A variety of agroforestry and agricultural information is offered to guests at the annual Missouri Chestnut Roast.



The University of Missouri Center for Agroforestry ... Toward New Horizons



The future of profitable, sustainable management for agricultural and forested lands continues to unfold at the University of Missouri Center for Agroforestry.

Through innovative research in dozens of multi-disciplinary areas and a team of nearly 50 faculty, staff and associated collaborators, the Center is emerging as a leading force in the nation for enhancing the science and technology of agroforestry practices.

Each year, new findings in agroforestry research help landowners reduce grazing costs; earn short-term income while a timber crop matures; or profit from non-timber products, like mushrooms, chestnuts, pine straw and medicinal herbs.

The Center's research is impacting the environment with a reduction in non-point source pollution from riparian buffer systems, providing enhanced habitat for wildlife across the state and reducing the impacts of periodic flooding.

We welcome your support as we work to sustain Missouri's family farms and agricultural and forested landscapes — not only for today, but for future generations. Together, we will continue to work cooperatively for natural resource stewardship.

The University of Missouri Center for Agroforestry
203 ABNR
Columbia, Mo 65211
(573) 884-2874
umca@missouri.edu
www.centerforagroforestry.org