University of Missouri Center for Agroforestry

2005 Research Highlights: Research, Partnerships & Technology Transfer

"First of all a new point of view is needed, namely that **farming should fit the land**... I see a million hills green with crop-yielding trees and a million neat farm homes snuggled in the hills ... **and so a vast work is proposed.** It is nothing less than the deliberate creation of a whole new set of crop trees, and then to make a new agriculture based upon the use of these new crop trees.."

- J. Russell Smith, father of temperate-zone agroforestry and author of "Tree Crops: A Permanent Agriculture." circa 1929

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

ABOUT THE CENTER

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.

Center for Agroforestry Goals:

- To create new income opportunities and markets 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 in rural and urban areas

UMCA Key Accomplishments, 2005:

- Supported 104 diverse agroforestry research projects in 11 strategic research clusters, managed by a team of more than 60 staff and collaborators
- Hosted the 3rd annual Missouri Chestnut Roast, drawing a crowd of more than 4,000 guests to the Center's research farm to explore agroforestry
- Received a USDA Sustainable Agriculture Research and Education (SARE) Professional Development Program grant to conduct a series of Agroforestry Training Workshops for natural resource professionals and landowners, utilizing "real-world" farm case studies to teach participants how to extend agroforestry knowledge
- Trained and supported 15 Master's and PhD students toward advanced degrees related to agroforestry, spanning 10 departments
- During the past year, UMCA researchers published more than 80 articles in proceedings, refereed journals, abstracts and the popular press

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.

Riparian Forest Buffers

Riparian Forest Buffers are living filters comprised of 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 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, like red osier dogwood, curly willow and berries planted in the shrub zone, provide additional income from riparian buffers.

Windbreaks

Windbreaks are planned and managed as part of a crop and/or livestock operation to enhance production, protect livestock, and control soil erosion. Field windbreaks protect a variety of wind-sensitive row, vegetable, orchard and vine crops; control 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.

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Greetings from the Director

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

> *"First of all a new point of view is needed, namely that farming should fit the land. . . I see a million hills green with crop-yielding trees and a million neat farm homes snuggled in the hills . . . and so a vast work is proposed. It is nothing less than the deliberate creation of a whole new set of crop trees and then to make a new agriculture based upon the use of these new crop trees."*
> - J. Russell Smith, father of temperate-zone agroforestry and author of "Tree Crops: A Permanent Agriculture."

Dear Friends of UMCA,

We are delighted to share the Center's 2005 review of research and technology transfer efforts with you. As you will see as you read through the Highlights, our activities continue to yield results that are directly applicable to Missouri forest and farm landowners and natural resource professionals.

Farming should fit the land . . .

During the past eight years, our Center for Agroforestry has been hard at work trying to realize the challenges set forth by J. Russell Smith back in 1929. The Center for Agroforestry does not wish to reinvent the successes of modern agriculture, but to broaden the ways in which we view and practice agriculture for the benefit of the family farm and society as a whole. Agroforestry, as a form of agriculture, is more than just the sum of its parts - trees, crops and livestock. Through proper design and application, agroforestry practices can achieve increased productivity and profit while also enhancing resource stewardship and land conservation.

Our Center, in cooperation with our many research partners, is developing the scientific understanding to explain and further improve agroforestry practices. When properly integrated, our research tells us trees will protect crops and improve crop yield. Trees will shelter livestock – and they will reduce animal stress and improve weight gain. Concurrently, nutrients applied to crops benefit tree growth. Through these carefully designed interactions, farming practices will indeed fit the land.

And so a vast work is proposed . . .

Sharing in the vision of J. Russell Smith, we diligently strive to improve upon our crop trees. A great deal of time and strategic effort is invested to develop improved cultivars of our native pecan and black walnut trees, and to introduce Chinese chestnut as a new option for Missouri landowners. In fact, when it comes to northern pecan, eastern black walnut and Chinese chestnut improvement, the Center has the most significant research and technology transfer program in the U.S.A.

We ended 2005 on a high note with the completion of the 2nd edition of our Agroforestry Training Manual. This manual represents the State of the Art in agroforestry, incorporating all we have learned during the past three decades of research and putting it into practice for the benefit of the family farm. We are certainly at the forefront of a new agriculture, and we invite you to join our efforts as we continue this "vast work" of developing farming that fits Missouri's land.

Sincerely,

Gene

Gene Garrett

FRIENDS & PARTNERS

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.

MU 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 Memorial Research Center, Novelty, Mo.*

External University Partnerships

- **The Agroecology Issue Team, Iowa State University**

Federal and State Agency Partnerships

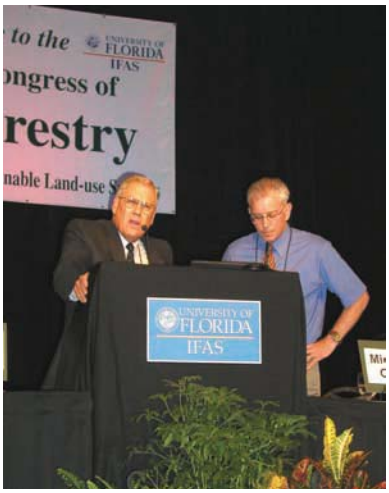
- **The United States Department of Agriculture NRCS/USFS National Agroforestry Center, Lincoln, Neb.**
- **USDA ARS Dale Bumpers Small Farm Research Center, Booneville, Ark.**
- **USDA ARS Cropping Systems and Water Quality Research, Columbia, Mo.**
- **USDA Forest Service Central Hardwoods Research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

Private Lands and Research Initiatives

- **Missouri Department of Agriculture**
- **USDA Forest Service State and Private Forestry Division**
- **U.S. Department Of Energy**
- **USDA ARS National Germplasm Resources Laboratory**
- **Mid-America Regional Council, Kansas City, Mo.**

Professional Associations:

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



"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."

- Gene Garrett, UMCA Director

A TEAM EFFORT

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Rob Myers, Ph.D. - Jefferson Institute
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Jerry Van Sambeek, Ph.D. - USFS
Doug Wallace, M.S. - NRCS State Forester
Gary Wells - NRCS/NAC
Bruce White - NRCS/NAC

Agroforestry Research Clusters: Science in a Systems Context

Since 2003, UMCA has been supported by and managed three significant USDA - ARS programs, representing more than 100 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:

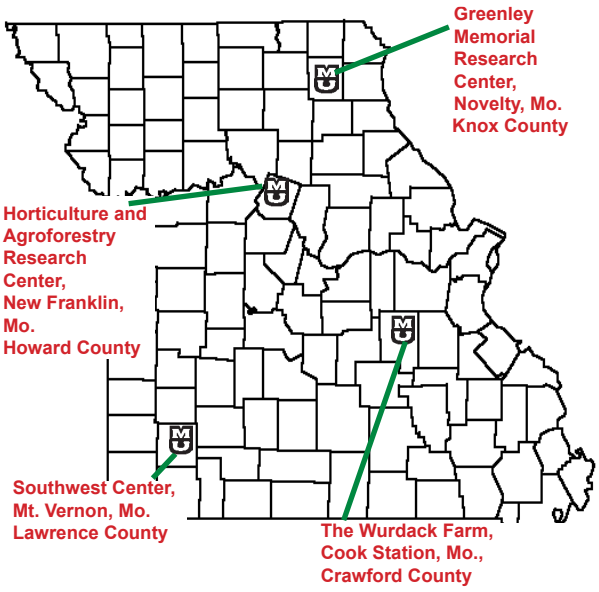
1) Nut tree research: Features research on pecan, black walnut and chestnut, including field studies, market research and outreach. UMCA supports the nation's most comprehensive research programs for developing the eastern black walnut and Chinese chestnut as nut crops for agroforestry practices.

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 in collaboration with Iowa State University scientists.

3) Flood tolerance research: A state-of-the-art flood tolerance research facility at the Horticulture and Agroforestry Research Center is used 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 dimensions of a given enterprise. These dimensions 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 wildlife restoration and biodiversity research: Bottomland hardwood restoration and management studies; quantifying effects of bottomland agroforestry practices on wildlife species.

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 understory shade tolerant forages and stand regeneration.

8) Horticulture research: Ongoing studies with gourmet mushrooms, medicinals, phytochemicals, 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.

Left: *The Center for Agroforestry focuses its research on four University of Missouri outlying farm properties, representing the economic and ecological diversity of the state.* ***Below:*** *Entrance to the 660-acre HARC farm, New Franklin, Mo., the Center's primary research location.*

TECHNOLOGY TRANSFER & ACCOMPLISHMENTS

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.

These outreach activities are introducing the benefits of agroforestry practices, and the products made through these practices, to land and forest owners, natural resource professionals and consumers. Each of these activities creates an "impression" of the Center's research and its resources – and over time, these total impressions will be translated into direct benefits to land and forest owners and their surrounding communities, the natural environment and consumers on a broad spectrum.

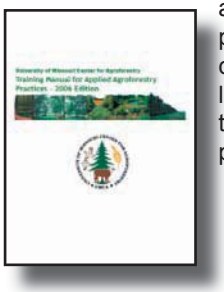
During 2005, the UMCA Technology Transfer team participated in more than 30 agricultural and natural-resource related conferences and events, serving as featured speakers at many of these events. From the National Small Farms Trade Show to the Chestnut Growers of America convention, the Missouri State Fair 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, 2005: Special Events

Photo: (above) Jason Jenkins; (right): Jim Curley

Agroforestry Training Grant In the fall of 2005, the Center was awarded a Sustainable Agriculture Research and Education (SARE) Professional Development Program grant to fund a series of agroforestry trainings geared toward a targeted audience: individuals from state and government federal agencies, University Extension personnel, and non-profit and professional organizations dealing with issues that directly impact landowners and their management of forests and farms.

Revised Agroforestry Training Manual A newly revised and updated Training Manual for Applied Agroforestry Practices was completed in December 2005. This manual represents the state-of-the art in agroforestry, incorporating the latest agroforestry research findings with landowner success stories and a real world case study. In addition to expanded chapters on all five recognized agroforestry practices, the manual contains updated and/or new sections on planning, wildlife, marketing and economics. A workbook for agroforestry planning was created to help landowners put the ideas into practice.



Riparian Forest Buffer Field Day The maintenance of existing forests in areas adjacent to streams, and the establishment of productive trees, shrubs and grasses in these flood-prone areas, is one of the Center's major research areas. To extend current research knowledge about buffer function and market opportunities through riparian forest buffers, the Center for Agroforestry and its research partners - including the Missouri Department of Agriculture Forest Land Enhancement Program - hosted a field day focusing on buffers and their application on the land. Topics included planting configurations on the landscape, species selection for riparian buffers, buffer function and design, value added opportunities, wildlife management and financial considerations.

Shiitake Mushroom Production: From Tree to Table Specialty and gourmet mushroom production, including shiitake mushrooms, is a promising component of the Center's forest farming research dimension. In April 2005, the Technology Transfer team collaborated with Ozark Forest Mushrooms (a successful retail mushroom business located in southern Missouri) with funding from the Sustainable Agriculture Research and Education Program (SARE) to host a hands-on workshop, featuring demonstrations of shiitake mushroom production and profitable forest management through agroforestry practices. Participants learned step-by-step about the shiitake mushroom process, from the management of the forest for mushroom log production to packaging and marketing fresh and dried shiitakes for retail sale.

"Agroforestry is about rural America and trying to help the family farm. It's impossible in today's environment and economy for the family farm to compete with what's going on in the corporate farm," Garrett said. "What we're trying to do in our program is to find niche opportunities for the family farmer."

Gene Garrett, UMCA Director

Ninth North American Agroforestry Conference of the Association for Temperate Agroforestry (AFTA), Rochester, Minn. The Center for Agroforestry Technology Transfer team and its research collaborators were among a diverse list of presenters detailing current research and future plans utilizing agroforestry at this national meeting held in June of 2005. Sessions included economics, markets, and policy issues affecting agroforestry, as well as environmental and watershed management issues.

Missouri State Fair Representatives from the Center for Agroforestry traveled to the Missouri State Fair to participate in the Missouri Department of Agriculture's "AgCitement" attraction. Through educational games and activities, hundreds of families learned about the growth, production and marketing of chestnuts.

Small Farm Trade Show The Small Farm Today magazine National Small Farm Trade Show is one of the largest in the nation, with dozens of educational presentations, exhibits and booths. The Center for Agroforestry maintains a longstanding presence at the event, offering talks on ways to increase profitability on smaller acreages and free publications to hundreds of visitors.

Annual Missouri Chestnut Roast The Technology Transfer team and HARC staff hosts educational events and tours regularly, including the annual Missouri Chestnut Roast. The family-oriented event draws a crowd of more than 4,000 guests each fall to showcase the benefits of agroforestry – including the production of value added products like chestnuts, pine straw and decorative woody florals – at the HARC farm in New Franklin, Mo. See page 10 for more information about this premier outreach event.

Native Plants Field Day One of the hallmarks of agroforestry practices are the environmentally and ecologically protective benefits they generate – especially the preservation and incorporation of valuable native plant species. George and Penny Frazier, owners of Goods from the Woods, an on-farm pine nut and wild craft herbal business, in cooperation with local farmers and natural resource organizations -- including the Center for Agroforestry -- hosted a field day in July to focus on native plant systems and the market opportunities they present. The Fraziers work with neighbors to preserve the fragile Ozark ecosystem through the cultivation of native forest plants and outreach activities to educate fellow landowners, and the public, about the medicinal and household properties found in many native species.

by Bob McEowen

Every year, Americans lift their voices in song and reminisce about "chestnuts roasting on an open fire." Though almost everybody knows that turkey and cranberry sauce help to make the Christmas season bright, few Americans have actually tasted chestnuts, a starchy nut that all but disappeared from our shores as a blight decimated native chestnut trees at the dawn of the 20th century.

Unless you're a recent immigrant or grew up in an Eastern city where street vendors roast imported chestnuts, it's likely your sentimental view of chestnuts comes mostly from "The Christmas Song." Nat King Cole and Bing Crosby aren't Missouri's place in America's food but researchers and marketing experts at the University of Missouri Center for Agroforestry want to make a place for it on our dinner table.

Over the past five years, the center's staff has raised more than 30 types of Asian chestnut trees in an effort to form recommendations for commercial growers. Meanwhile, they've begun raising awareness of the nut by hosting an annual Chestnut Roast, introducing the nut's flavor to chefs and taking the nut to consumers' tables.

"The chestnut could be a $15 million a year industry in 20 years here. It could be huge," says Michael Gold, associate director of the center, located at New Franklin, which works to advance the science and practice of agroforestry on behalf of family farmers.

Although fresh chestnuts are most often eaten whole as a yuletide treat, Gold would like to see Americans incorporate the nut into their daily diets. "There is no end of ways that you can cook with them," Gold says. "You can put them in stuffings for fish or salads and add new flavor to stuffings for fowl. Chestnuts can be cooked like potatoes and carrots in soups or ground to flour for baking. There are even dessert recipes that call for pureed or glazed chestnuts.

Craig Cyr, executive chef and co-owner of The Wine Cellar and Bistro in downtown Columbia, has demonstrated chestnut cooking at the Agroforestry Center's annual Chestnut Roast and has begun offering chestnut dishes to his customers. His latest creation is a ravioli, stuffed with chestnuts, apples and cheese.

"It's a nice medium for a filling for a ravioli," Cyr says of the nut. He says, "When you puree it, it gets really nice and smooth. It holds its shape very well and you can mix a lot of different things into it."

A large nut with a thin shell, the chestnut is often confused with the buckeye. The similarity ends with appearance, though. A sure way to tell them apart is that chestnuts grow inside a spiny bur. "Does it look like a porcupine?" Gold asks. "Then you have a chestnut."

Unlike pecans or walnuts, chestnuts are low in fat and high in moisture. "We call it the un-nut," Gold says. "It's really like a grain that grows on a tree."

Ken Hunt, the research scientist responsible for the agroforestry center's chestnut orchard struggles to describe the flavor. "It's a little like a sweet potato. It's starchy but it's not," Hunt says. It has a sweet, delicate, earthy flavor.

Chestnut trees grow well in the hills above the Missouri river — the same soil where apple and peach crops thrive. The agroforestry center has begun touting chestnuts as a supplemental crop for Missouri's fruit growers because the trees are similar. Other potential growers include tobacco farmers, faced with the loss of price supports, and vintners.

"When you think about the possibility of mixing vineyards and chestnut orchards, the ambiance that we could create for Missouri is really exciting," says Howard Dierckx, a viticulture specialist for the agroforestry center, which is served by Howard Electric Cooperative.

While the state's agroforestry experts say they are absolutely "nutty" about chestnuts, they insist their expectations are realistic. "We're trying to do this based on our research and not based on what we wish would be," Gold says. "We're very careful to hold expectations to a place that we don't think is outrageous."

The United States Department of Agriculture imports about 5 million pounds of chestnuts and produces less than 2 million pounds domestically. Producers can't keep up with demand, says Gold, whose staff edits the newsletter of the Western Chestnut Growers Association and keeps close tabs on the market.

If Americans only know chestnuts from Christmas carols, who's buying all those nuts?

Demand is strong among ethnic groups, particularly Asians and southern Europeans, agroforestry experts say. "There is a huge market for chestnuts that are familiar with chestnuts and will gobble them up," Hunt says. "They'd love to buy some and have trouble finding them."

Between immigrants and Americans seeking new and different flavors, the chestnut has a strong future. And Missouri may be in a unique position to capitalize on it, Gold says.

Much of the state's advantage comes from the work done at the agroforestry center in New Franklin. Originally Missouri's horticulture research station, the center was expanded to include agroforestry in 1991. Unlike similar stations in other states, Missouri's center is well-funded and expertly staffed with collaborating university faculty and graduate students.

The center's projects are diverse and include alley cropping, in which traditional crops grow among rows of trees; forest farming of ginseng, shiitake mushrooms and other crops; silvopasture, which combines trees, forest and livestock; and the study of windbreaks to control soil erosion and forest buffers to protect groundwater. At the 210-acre agroforestry plant research site, the center evaluates ornamental trees and shrubs to determine cold hardiness and resistance to disease and insects. A flood tolerance laboratory includes a dozen 600-foot-long channels where researchers study the impact of standing or flowing water on trees.

Several of the center's projects hold promise for small farmers. Needles from pine trees may prove to be a profitable source of mulch and orchard-grown black walnuts may offer an alternative to traditional wild harvests. Few projects have generated the enthusiasm that the center has received for ginseng.

"We're excited. It's something that this state is out ahead on and it's going to have a good side, I think," Gold says. "It's nice to do something handily anyone else is doing when you know you're onto something viable."

For more information, write the University of Missouri Center for Agroforestry, 203 Anheuser-Busch Natural Resources Building, Columbia, MO 65211; phone (573) 884-2874; or log onto www.centerforagroforestry.org.

Ken Hunt, a research scientist at the University of Missouri Center for Agroforestry, walks among rows of chestnut trees at the research center near New Franklin. The center is working to develop Asian chestnuts as an alternative crop for Missouri's small farms.

New Franklin

The un-nut

University ag researchers eye a nationwide chestnut market just waiting to be cracked

A day for chestnuts

The third-annual Missouri Chestnut Roast will be held at the University of Missouri Center for Agroforestry, Oct. 29. The event, which drew 3,000 visitors last year, is a showcase for the center and educates the public about the state's agroforestry industry.

Visitors to the festival may sample roasted chestnuts, as well as other treats made from chestnuts. A number of other Missouri agricultural products will also be featured, including pecans and walnuts, jams and jellies, wine and locally produced cheese, meat and honey.

Guided tours of the 660-acre facility will be offered, as well as presentations of ongoing research projects. Visitors will also see the 1819 Hickman House, currently under restoration. Children will have their own play area while kids from 1 to 92 can enjoy musical entertainment, crafts and artwork on display.

For directions to the center, located just north of Interstate-70 near Boonville, call (573) 882-3213 or log onto www.centerforagroforestry.org.

34 RURAL MISSOURI

Public relations and outreach: From radio program coverage on chestnuts and mushroom production, reaching more than 35,000 listeners, to nation-wide Associated Press news coverage and specialized tours, the Center for Agroforestry continues striving to make "agroforestry" a household name. Media appearances and special events are tailored to the specific audience, from the health benefits of nut consumption to the market possibilities for value-added niche products produced through agroforestry practices.

MISSOURI CHESTNUT ROAST

Connecting Missouri Families to the Land

The Missouri Chestnut Roast, held annually in October, is quickly becoming one of the premier family-oriented events for mid-Missouri and the MU College of Agriculture, Food and Natural Resources. 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 4,000 in attendance at the third annual Chestnut Roast, Oct. 29, 2005
- Guided tours of 660-acre Horticulture and Agroforestry Research Center featuring diverse agroforestry practices
- Cooking demonstrations by local gourmet chefs featuring Missouri chestnuts
- 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, live music and family activities
- 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 local artists exhibits portraying the unique landscapes

New Attractions at 2005 Event:

- *Live bat presentation from the U.S. Forest Service*
- *Wreath making demonstration (using decorative florals grown through agroforestry) from the Native Plant Society*
- *Storytelling, featuring Boonslick area history*
- *Wood lathe demonstration with souvenirs for children*
- *Tree grafting presentations*

Save the Date!
4th Annual Missouri Chestnut Roast
Saturday, Oct. 14, 2006

College of Agriculture Food and Natural Resources

"It was great to have so many resource professionals thinking about ways that we might improve our conservation and production practices through agroforestry."

- Idolour Farm manager J. Arbuckle, regarding case study of farm at Agroforestry Training Workshop

UMCA Co-Sponsors Agroforestry Grants for Landowner Demonstrations

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 2005, UMCA sponsored the following grants to focus on sustainable projects that involve agroforestry:

Native Plants Create Neighbor-Friendly Buffer Zones for an Organic Garden: Grant recipient Linda Williams of Windrush Farm, Farmington, Mo., is establishing a buffer to protect organic market garden crops from airborne pollutants and erosion. By using native plants, she is striving to create a buffer that will be attractive to birds and other wildlife, as well as to her human neighbors.The carefully designed buffer is also helping prevent the entry of pesticides from neighboring properties as Linda works to meet customer demand for organic products. Upon completion, this buffer will serve as a model other growers can use for meeting the requirements of organic certification.

Trial of Novel Eurasian and Native North American Continental Climate-adapted Woody Perennial Fruits and Berries as Commercial Crops for Northern Missouri Steven Salt of Kirksville, Mo., is developing small-scale commercial plantings of newly-available woody perennial fruiting plants, including aronias, Cornelian cherries, honey berries, and paw paws. Salt is evaluating their adaptability to northern Missouri, identifying pest problems (many of the plants are said to be free of most pests and diseases), and exploring harvest techniques and post-harvest storage and handling procedures. Through his family's farmers' market stand, CSA service, and grocery store and restaurant sales, he is also evaluating the market potential for these fruiting plants. This project holds the potential to open up new markets for farmers with alternative woody crops that can grow on steep ground unsuitable for row crops and grazing.

Using Valuable Shade-Loving Native Plants for Diversification and Expansion of a Forest Farming Operation: Heather O'Connor of Columbia, Mo., is evaluating planting techniques for native medicinal plants (e.g. ginseng, bloodroot, goldenseal, and black cohosh), and for native plants that can be sold as shade-tolerant landscape plants. Taking the project full-circle, O'Connor is also researching market opportunities and testing deer-control strategies. Her study will help provide high-value alternatives for farmers who have wooded hilly land they are not able to use for traditional crop production.

Center Begins Series of Professional Trainings

As part of an ongoing commitment to increase the knowledge and adoption of agroforestry practices across Missouri and the Midwest, the University of Missouri Center for Agroforestry has expanded the depth and reach of its training program. This effort began with a successful Agroforestry Professional Training Workshop held Jan. 10 and 11, 2006, in Columbia, Mo.
In the fall of 2005, the Center was awarded a Sustainable Agriculture Research and Education (SARE) Professional Development Program (PDP) grant to fund a series of agroforestry trainings geared toward a targeted audience: individuals from state and government federal agencies, University Extension personnel, and non-profit and professional organizations dealing with issues that directly impact landowners and their management of forests and farms. More than 50 professionals representing several disciplines in the natural resource-based fields attended the January training. The training was designed to increase core agencies' knowledge about agroforestry practices and the benefits they offer when applied as sustainable farming practices, and to foster the establishment of social networks for assisting resource professionals and landowners in finding answers regarding the establishment and management of agroforestry.

In addition to classroom instruction, a tour of the Horticulture and Agroforestry Research Center at New Franklin, Mo., featured demonstrations of diverse agroforestry practices.

Natural resource professionals broke into smaller multi-agency work groups to evaluate implementing agroforestry practices into a real-world agroforestry case study, on the Idolour Farm in Boone County, Mo.

"It was great to have so many resource professionals thinking about ways that we might improve our conservation and production practices through agroforestry," said farm manager J. Arbuckle. "One of the things that was most interesting to me was how the groups came up with so many ideas for agroforestry applications for such a small farm - windbreaks, riparian buffers, silvopasture, forest farming - all on under a hundred acres. Plus, they gave me good ideas on how we might find some funding to help with establishment costs. It was a fun learning experience and we plan to implement some of those ideas over the coming years."

As part of the SARE PDP grant, ten additional trainings will be held during the next three years.

"If a farmer has a small plot in the woods devoted to mayapples, or a similar plant, he could potentially harvest hundreds of plants without disturbing the soil."

- John Marlin, woodland wildlflower entrepreneur

Paul Smith

Bill Slaughter

Ron Risdal

Alley Cropping:
Paul Smith implemented a 20-acre alley cropping practice in Northwest Missouri, near Claremont.

"I guess I was a little hesitant at first to plant trees. I wondered at times what some of my farmer friends and neighbors would think of covering good bottom land with trees. My wife reminded me that her father had spent his lifetime clearing this land of trees, and now we're planting them back. In 1999 we seeded this field to orchard grass, and alfalfa. The first cutting produced about 3 tons per acre. We benefit from alley cropping because we have the short term benefit of the crops between the tree rows, and eventually my family, or someone else, will benefit from the tree crop."

Silvopasture:
Bill Slaughter, cattle/walnut silvopasture practice near St. Joseph, Mo.

"We rotationally graze our silvopasture areas, then pull the cows off, then let the grass grow back. This way we have a chance to market a crop every year through the calves that we sell in the fall, instead of having to wait 20 or 40 more years for these trees to be mature and sell the logs."

Riparian Forest Buffers:
Ron Risdal, Story County, Iowa

Ron Risdal has experienced similar success with the riparian buffer he installed more than 12 years ago. Risdal rotates corn, soybeans, and alfalfa on his farm.

"There's always something new. We can go fishing, or we can go out here and kick up a deer or pheasant or partridge. I don't think we've lost hardly any stream bank since 1993, but before we were moving fences almost every year. Yesterday morning when it was flooding, it stopped at the buffer strip instead of washing all over the bank. We don't have to haul rocks in the gullies like we used to do years ago."

Forest Farming:
Marlin family woodland wildflower sales, Urbana, Ill.

When it comes to earning a little spending money, the Marlin children think way beyond the basic neighborhood lemonade stand. For nearly the past fifteen years, John and Kathrine Marlin, and their father, John C. Marlin, of Urbana, Ill., have propagated and sold woodland wildflowers from their front yard. The family business continues to gain popularity and earn a sustainable income while educating the community about the uniqueness and beauty of woodland wildlflowers.

When the Marlins purchased their home more than 25 years ago, the previous owners had already established a selection of native plants, spurring the new owners' interest in wildlflowers. John continued to expand his front yard wildflower collection, gathering species from landowner friends to maintain consistent genotypes. When John's children, John and Kathrine, came to him one summer asking to have an ice cream sale or popsicle stand, John senior suggested the family try selling some of the front yard wildflowers that had become quite prolific.

"We put plants in pots, had a little sale, and to our surprise, ended up selling out within a few hours and earned $400," said John. "Over the years, the kids have taken responsibility for propagation and marketing."

The Marlins earn several hundred dollars per year from the sale of woodland wildflowers, including blue bells and the mayapples, species that tend to overrun each other and would eventually need removed.

Aside from its profitability, the Marlins encourage others to propagate wildlflowers to help protect the species. "We are not going into the woods, natural areas, or state and federal areas and taking the plants," said John. "Poaching native species is a huge problem -- people just go into the woods and take what they can find."

Katherine Marlin

John suggests landowners with small forest land holdings, especially, can learn from their example. “If a farmer has a small plot in the woods devoted to mayapples, or a similar plant, he could potentially harvest hundreds of plants without disturbing the soil,” said John. Marlin suggests establishing a plot on the edge of a wooded area with a species like the Trillium and Jack-in-the-Pulpit that thrive in both sunlight and shade.

“Without a large operation and greenhouses, you can still grow several thousand pots of plants on a sustainable basis with a very small amount of land and a modest amount of labor, provided you’ve got a market for them,” said John.

Missouri pecan growers seek “sweet spot” in organic market

From the first bite of a native Missouri pecan, people know there’s something special and different about these nuts.

The Missouri Northern Pecan Growers LLC, (MNPG) based in Nevada, Mo., has found three simple words to describe this distinction: “sweeter by nature.” The tagline is meant to express that pecans grown in Missouri naturally offer a sweeter, richer flavor than southern-grown pecans, due to a smaller size and higher oil content.

In 2003, the small farmer-owned company began capturing consumer attention with something more than just the sweet, rich flavor – the distinction of “American Native” Pecan, Certified 100% Organic, accompanied by the USDA Certified Organic logo. The company received its certification from the Missouri Department of Agriculture Certified Organic program in 2003.

“The organic certification shows we are serious about offering a product that is not only healthy, but also protects the environment from unnecessary pollutants,” said Drew Kimmell, MNPG managing partner.

Organic pecans are a top-seller at retail outlets.

According to the Organic Trade Association, the organic industry is booming - growing at a rate of 20 percent annually - with U.S. retail sales of organic products projected to exceed $20 billion.

MNPG pecans have been shipped to all 50 states, and internationally, to Japan, England, Germany, Austria and 3 Canadian provinces. Retail specialty grocers, health food stores and confectionaries are additional profitable markets.

Kimmell said Midwestern growers may have a unique niche market opportunity, in that there are few traditional growers working actively in the organic market.

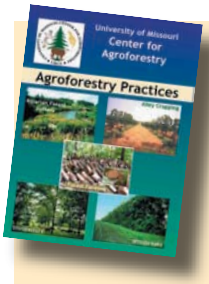
“The challenge is to identify and grow directly for the consumer who recognizes the value of a certified organic product,” said Joe Wilson, MNPG partner.

Wilson is confident that the distinct flavor and quality of the growers’ pecans will continue to open doors in several markets. “We believe the ‘Missouri flavor’ will introduce a new image for our pecan taste,” he said. “Processing and removing the shell of our smaller native pecan provides a more convenient product for the purchaser, great for snacks or cooking.”

The University of Missouri Center for Agroforestry has worked within the state’s native pecan industry for many years, and is hoping to collaborate actively with MNPG to improve organic pecan production through enhanced pest control, increased nitrogen through crop rotation of flood and shade tolerant legumes,

and effective native grove management. The Center is currently working to connect with nutrition and dietetics professionals for possible joint research and grant activities evaluating the health benefits of locally grown nuts in patients’ diets.

“Missouri landowners have a history of harvesting native nuts,” said Michael Gold, UMCA associate director. “Now these landowners are in a position to establish a strong presence in the organic produce market, bringing a host of benefits for family farms and the state’s natural environment.”
For more information, visit www.mopecans.com.



See additional examples of successful implementation of agroforestry in the Center for Agroforestry DVD “Agroforestry Practices,” available through University of Missouri Extension at http://extension.missouri.edu.

HORTICULTURE & AGROFORESTRY RESEARCH CENTER (HARC)

The Horticulture and Agroforestry Research Center (HARC), located at New Franklin, Mo., is the primary research site for UMCA. This 660-acre farm 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 Site.

HARC is one of the University of Missouri's 14 outlying research farms, a network of sites across the state hosting state-of-the-art programs that bring Missouri agricultural land and forest owners new information for reaching maximum income potential and environmental benefits on a variety of land types and ecoregions.

Interdisciplinary cooperation at HARC allows researchers from several departments including entomology, plant pathology, horticulture, agronomy, animal science and agroforestry to combine knowledge and research efforts to address a more diverse array of topics. The University of Missouri Center for Agroforestry supports the agroforestry research and demonstration program at HARC to further its mission to initiate and coordinate agroforestry activities within the state of Missouri and

Aerial view, 660-acre Horticulture and Agroforestry Research Center, New Franklin, Mo.

enhance the development of agroforestry within North America and the temperate zone, world wide.

The farm hosts educational events and tours regularly, including the annual Missouri Chestnut Roast. The family-oriented event draws a crowd of more than 4,000 guests each fall to showcase the benefits of agroforestry, including the production of value added products.

History

The Horticulture Research Center opened in 1953 with a focus on horticultural research. In 1993, the agroforestry research program was introduced to the 540-acre farm. The Horticulture Research Center became the Horticulture and Agroforestry Research Center in 1995. A recent land purchase of 118 acres to the west of the existing property expands the total acreage to nearly 660 acres.

Long before the first experimental tree plantings, the land which is now the HARC farm played a key historical role for Missouri and the Midwest. Lewis and Clark passed through the area in 1804, finding a trading post had already been established in present-day Howard County. Just two miles south of the farm is the site of the original town of Franklin, Mo., which was established in 1816 and grew to a population second only to St. Louis by 1820. As

Through an interdisciplinary approach, UMCA leads the nation in key research areas conducted at the HARC farm:

- *Extensive bioremediation, non-point source pollution and shade and flood tolerance studies.*
- *An innovative, outdoor 12-channel flood tolerance research laboratory*
- *Projects for producing gourmet, high-value mushrooms, including morel and shiitake*
- *The U.S. National Arboretum Midwest Plant Research and Education Test Site*
- *Location of one of Missouri's oldest brick homes, the historic 1819 Thomas Hickman House*
- *Premier research studies on the development of eastern black walnut, northern pecan and Chinese chestnut into profitable orchard crops*

Ongoing restoration of the historic 1819 Thomas Hickman House is a highlight of the HARC farm.

the starting point for William Becknell's party and the legendary Santa Fe Trail, Franklin became a major point of commerce and trade for the Westward Expansion movement.

One of the Midwest's most outstanding examples of early architecture remains today on the farm, the historic 1819 Thomas Hickman House. The 1800-square foot home is an outstanding example of the Georgian Cottage – an architectural design once popular across the Midwest as settlers migrated from the southern regions - and is one of the oldest brick homes in the state. Recognizing the homestead's unique architectural, cultural and agricultural significance, the University began a restoration project in 1996 with the excavation of the home's summer kitchen site. 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, holding permanent educational displays of local archeological, geological and historical interest. Learn more about this project on page 36.

Land and Soils – The Missouri River Hills region

Visitors to the research farm often comment on the beautiful, rolling hills and exceptional views. The farm is positioned amidst the Missouri River Hills at one of the highest elevations in Howard County, creating a diversity of establishment sites for researching plant and tree combinations.

The current acreage sits on seven recognized soil associations. The most common soil type — rich, fertile, well-drained, windblown silt-loam known as loess — covers the bulk of the property and is over 100 feet deep at its center.

Examples of Current HARC Research Projects:

The University of Missouri Center for Agroforestry promotes a remarkable diversity of research at the farm to explore tree, grass, crop and livestock combinations that are optimum for establishing demonstrations of the five agroforestry practices – alley cropping, silvopasture, forest farming, windbreaks and riparian forest buffers.

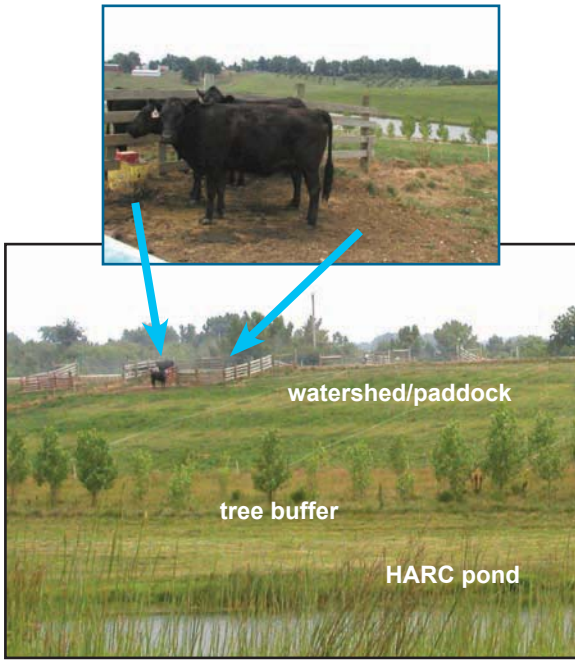
Pitch x Loblolly Pine and Black Walnut Winter Forage Alley Cropping Study:

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, emulating an alley cropping practice.

Agroforestry and Grass Buffers to Improve Water Quality:

Landowners often look to the USDA-NRCS agency for assistance in selecting conservation practices to qualify for cost-share support and to meet price support payments. To assist NRCS and other natural resource-based agencies, the Center has developed a watershed study at the HARC farm to measure the effects of agroforestry and grass buffers for reducing non-point source pollution from grazing. The study will also provide data for calibrating a GIS model simulating the conservation benefits of agroforestry buffer systems.

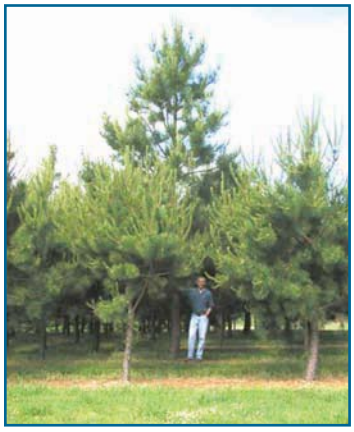
Soil samples from the watershed are compared among grazing, grass buffer, agroforestry buffer and control areas to examine how management treatments affect the soil's properties, including the ability to capture plant nutrients. Runoff samples collected after each rain are analyzed for sediment, bacteria, nutrients and antibiotics. Soil pore sizes are evaluated, along with treatment effects on soil compaction and possible reductions in soil and nutrient transport as an effect of buffer length.



A watershed study at the HARC farm measures the effects of agroforestry and grass buffer treatments on the reduction of non-point source pollution from grazing. This photo shows the tree buffer treatment area.

Pitch x Loblolly Pine Progeny Testing:

Superior selections of pitch x loblolly and cold-hardy Loblolly pine are being evaluated for their potential use by landowners to produce timber and pine straw mulch. The evaluation includes insect and disease pests, cold hardiness, growth rate and length and yield of needles.



Mushroom Trials for Forest Farming:

Researchers are evaluating morels, shiitakes and other gourmet mushrooms for landowner production and profit. 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, including non-merchantable stems and branch wood. Utilizing shade levels and understory from a forest farming practice, UMCA scientists and collaborators are determining the best suited types of mushrooms for Missouri soils. The goal of this research is to refine established production techniques for a diverse suite of outdoor mushroom species and enable Missouri landowners to capture a growing gourmet market.

Cottonwood Clonal Trial/ Flood Tolerance Evaluation:

Eastern Cottonwood (*Populus deltoides*) is a fast-growing, soft hardwood tree used to produce biomass for products including Oriented Strand Board and pulp and paper production. In 1997, cottonwood clonal trial studies began at the research farm to evaluate cultivars for their growth response and adaptability to Missouri conditions, allowing researchers to identify the best cottonwood cultivars for agroforestry plantings.

In addition to biomass for the construction or paper industries, cottonwood can be grown as a source of biomass for carbon sequestration, fuel and energy production, and levee protection, due

to its suitability for floodprone areas. In 2004, a secondary study was initiated to evaluate survival and growth of the ten most productive cottonwood clones under four different flooding regimes.

The ultimate goal of this project is to identify productive cottonwood clones to enhance farm revenue through biomass production and carbon sequestration.

Silvopastoral Practice:

Through well-managed grazing areas on the farm, 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; how grazing and forage production affect tree growth; and how trees affect forage growth by utilizing the pine/black walnut alley cropping demonstration area for controlled grazing.

Pine-Straw:

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 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 this hybrid are being evaluated for cold hardiness, growth rate, needle length and needle yield. Results to date indicate that some of the pitch x loblolly genotypes in the plantation are hardy, fast growing, long-needled pines, suitable for commercial pine straw in Missouri.

Missouri Gravel Bed for Nursery Stock:

The Missouri Gravel Bed (MGB) is a method, developed at HARC, that allows planting of bare root 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.

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.

Forage Shade Tolerance Study:

Managing correct shade levels is critical in a successful agroforestry practice. In 1994, researchers began a shade tolerance 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. In 2005, the shade tolerance facility was completely rebuilt and expanded to 15 structures. New treatments added included a treatment that compares intermittent shade as sunflecks to continuous dense shade. All species are currently being evaluated under 5 shade level treatments: 0% (full sun), 30% shade, 55% shade, 80% shade and 78% shade (sunflecks). Research emphasis has recently switched from cool-season forages to warm-season forages.

The goal of the project is to determine growth and development under different shade conditions to help identify forages suitable for agroforestry practices or for savanna and woodland restoration.

Promising forage species identified through this study will be out-planted in field plots and in actual agroforestry practices. Results of this work will help determine the best forage species for use in agroforestry practices such as alley cropping, silvopasture and riparian buffers. Some species may also have potential for use as ground covers for erosion control and food and habitat for wildlife.

Cherrybark Oak Spacing Study:

Cherrybark oak (*Quercus pagoda*) have been planted at spacings creating alleyways of 10, 20, 30 and 40 feet. The study purpose is to create uniform shade conditions for field testing promising agroforestry forages coming from the forage shade tolerance laboratory.

Quail Cover Bundle Habitat Study:

Bobwhite quail populations are declining in the Midwest, an occurrence linked with a loss of suitable habitat — especially woody shrub cover next to feeding areas. To help regenerate

suitable quail habitat, the Missouri Department of Conservation and several private nurseries are now packaging seedling bundles of mixed shrub species for planting along the edge of fields to create quail nesting and roosting

areas. Researchers at the HARC farm are evaluating the survival and growth of five of these shrub species at two different spacings, and studying the species' response to prescribed fire. Bare root seedlings of false indigo, wild plum, fragrant sumac and dogwoods (*Amorpha fruticosa, Prunus americana, Rhus aromatica,* and three *Cornus spp*) were established in 2002. Research indicates false indigo is the easiest to get established, grows rapidly, and readily re-sprouted following a prescribed fire in 2005.

Flood Tolerance:

A Flood Tolerance Laboratory was constructed along Sulphur Creek in the Missouri River floodplain at HARC. This facility provides one of the nation's most comprehensive and unique field laboratories 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.

Changes in soil redox potential, temperature, soil volumetric water content, pH, and oxygen content are continuously monitored using Campbell Scientific, Inc. CR23X microloggers and sensors installed at depths of 10 and 20 cm in each of the 12 channels. The data generated from these continuous measurements helps to characterize the effects of each flooding regime treatment on soil properties with time of treatment.

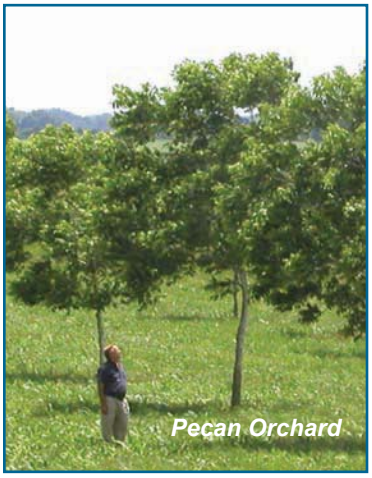
Selected grasses, legumes, soybeans and tree species are being evaluated for flood tolerance. The flood tolerance of hardwood planting stock and genetic variation in ecotypes from seed collected from bottomland and upland stands is also being evaluated.

Bioterracing Demonstration:

This project demonstrates the value of bioterracing on highly erodible soils. Bioterraces are a combination of trees and shrubs planted in rows along the lands topographic contour to help trap soil and debris as they move down a slope in surface water flow. Over time these same trees and shrubs will also begin to filter sub-surface flow of water through the soil. Depending on the space between the tree/shrub rows, annual crops like milo, corn, soybeans or sunflowers, for example, may be produced. Through the combination of appropriate trees, shrubs and crops, quail habitat can then be created and/or enhanced while also maintaining land productivity.

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 inclusion in agroforestry plantings. Major components of this research include (1) evaluating a wide array of nut cultivars on various sites in Missouri and adjoining states; (2) identifying superior rootstocks for grafting; (3) developing improved vegetative propagation techniques; and (4) initiating breeding program(s) to develop improved selections.

- **Nut Tree Improvement: Chinese chestnut: A "new" agroforestry crop for Missouri**



Pecan Orchard

The Chinese chestnut, a crop that is largely unknown to Americans since the near extinction of the American chestnut forest from chestnut blight (1900-1950), shows excellent potential for Missouri/Midwestern landowners as a cash income crop. Currently, demand exceeds supply for this sweet, starchy nut that boasts a high nutritive value.

Chinese chestnut cultivar research at the HARC farm began in 1996.The research repository includes more than 50 cultivars under evaluation in an orchard setting to determine the best-suited selections for Missouri's promising chestnut industry.

The Center 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

Photo: Jim Curley

awareness. 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 and surrounding states.

The Center continues to promote cultivar research and market research initiatives for Chinese chestnut, recently completing a national market analysis and hosting the annual Missouri Chestnut Roast to raise awareness for this delicious, versatile nut. (Learn more about the Center's market research on page 28).

- **Nut Tree Improvement: Premier black walnut research**

Black walnut is a promising native nut tree crop for Missouri. Most black walnuts are currently harvested by hand as they drop from wild trees in a forested setting. The Center is developing new cultivars that produce consistent yields, a consumer-preferred flavor and predictable harvest dates — allowing landowners to achieve higher profits from this nut crop.

An applied breeding program to develop new black walnut nut varieties for use in agroforestry-based practices was initiated in 1996 at the HARC farm. Since then, a total of 70 different black walnut nut cultivars have been acquired and placed in a series of grafted orchard collections. Beginning in 2000, a series of careful observations ("descriptors") were initiated on an annual basis for all of the repository trees. This information allows researchers to learn more about how a species can vary for a number of commercially important characteristics. Some of the important commercial traits of interest include: early and annual nut productivity, disease resistance, nut size and kernel percent.

- **Genetic "fingerprinting" of cultivars**

In addition to these traditional descriptor values, the Center has initiated an effort to further characterize these trees on the basis of their unique "genetic fingerprint." This project will help determine which trees are closely related, or which are mislabeled. These results are helping to accurately identify all the trees in the Center's collection — critical to the overall goal of developing new nut cultivars for Missouri.

National Arboretum testing site

- **Cultivation for an orchard setting**

In addition to evaluating both the parent trees and their seedling offspring in the breeding program, the Center is developing a better understanding of how to cultivate this species in an orchard setting. For example, pruning schedules, fertilization and pest control measures, etc., can have a major impact on orchard productivity and profitability. These studies are helping to create a promising future for the black walnut in Missouri.

Native Plants Demonstration Area:

Native perennial shrubs, forbs, and grasses have been established in demonstration plots in Zone 5 (a climate test area adjacent to the NC-7 Trials, see below) at HARC and in the field. Some of the shrubs and forbs included are false wild indigo, dwarf Amorpha, shining wild indigo, Ouachita false indigo, swamp milkweed, shining blue star, and wild quinine. Grasses included are eastern gamma grass, dropseed, cluster fescue, and river oats. These plots are used for demonstrations during field days.

National Arboretum / NC-7 Trials: Evaluating Rare Plants

A cooperative agreement in 1996 designated HARC as the U.S. National Arboretum Midwest Research and Education Site for Climate Zone 5. Since then, many National Arboretum introductions have been planted, including red maples, alders, disease resistant elms, 'Green Giant' arborvitae and other specimens of new and unusual plants. This planting serves as a germplasm repository and evaluation site for newly introduced and rare woody plants with potential ornamental value. A number of species for inclusion in various agroforestry practices are being evaluated and demonstrated within the test site.

Horticultural Research with Orchard Crops: Pest Control Strategies

Within an alley cropping or silvopasture practice, a land or forest owner has the opportunity to harvest nuts and fruits from a tree crop while simultaneously growing row crops and/or managing livestock. Horticultural studies on apple crops at the research farm are helping UMCA collaborators understand the effects of insecticides on pest populations, and potentially alter the impact of detrimental moth species. Alternative pest control strategies, such as mating disruption, are also being evaluated for Midwestern conditions. These studies may provide apple growers with objective information regarding the use of environmentally-friendly pest control methods. The impact of nut tree pests, including weevils, on improved cultivars of eastern black walnut and chestnut grown in the Midwest is also under evaluation. The overall goal of this project is to provide biological data for the development of an effective monitoring/managing tactic for these nut tree pests.

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 aquifers, 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. Compliance costs for larger water treatment plants can also be quite substantial.

A well designed and well-maintained 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. Stiff-stemmed, warm season grass buffer systems can slow run-off velocity -- reducing the impact of non-point source pollution – while trapping sediments, nutrients and herbicides. A strategically implemented buffer should also promote rapid breakdown of deposited herbicides so that they are not released later in the surface and subsurface water flow.

Current UMCA research in the Water Quality/Riparian Forest Buffer cluster involves four projects. Goals are to optimize riparian buffer designs to 1) reduce herbicide transport to nearby agricultural lands before they reach riparian areas (streams and lakes) 2) enhance the degradation process of the herbicides trapped within the buffers 3) trap sediment within buffers and 4) uptake and utilize excess non-point source pollutants (N and P) within the tree-shrub-grass buffer.

A Paired Upland Watershed Comparison to Assess Agroforestry and Contour Strip Effects on Runoff and Nutrient Loss

Project Team: Ranjith Udawatta, "Gene" Garrett, Stephen Anderson, Peter Motavalli, Clark Gantzer, Neil Fox, Robert Kremer, and Neal Bailey

In 1997, agroforestry and grass buffers were established on two watersheds of a paired watershed study at the University of Missouri Greenley Memorial Research Center. A third "control" watershed remains unbuffered. The three watersheds are on a no-till corn-soybean rotation, two significant agricultural crops grown in the region. The project goal is to compare the effects of agroforestry and grass buffer treatments on non-point source pollution reduction from corn-soybean watersheds.

Two grass species, one legume and three tree species were planted in the treatment watersheds. Agroforestry and grass buffer watersheds consist of grass-legume buffer strips (4.5 m wide) of redtop (*Agrostis gigantea* Roth), smooth bromegrass (*Bromus inermis* Leyss.), and birdsfoot trefoil (*Lotus corniculatus* L.). These cool season grasses and legumes help to reduce non-point source pollution during the spring and fallow periods when crop water use is negligible.

Container grown pin oak (*Quercus palustris* Muenchh.), swamp white oak (*Q. bicolor* Wild.), and bur oak (*Q. macrocarpa* Michx.) seedlings were planted at 3-m intervals in the center of the grass-legume strips to create the agroforestry watershed. These three species grow well in the soil, site, and climatic conditions of the study area and are found growing on adjacent sites.

Method: Water samples were collected from the three watersheds after each runoff event, and they were analyzed for sediment and nutrient concentrations. Researchers determined how agroforestry buffers can be used to reduce nutrient and sediment losses from these watersheds protecting water sources including streams, lakes and rivers.

Key Findings: Non Point Source Pollution Reduction in a Paired Watershed Study

- During the 2005 sampling season — a major summer drought year — agroforestry and grass buffer watersheds reduced runoff volume by **11 and 12%,** respectively, compared to the control.
- The agroforestry and contour grass buffer treatments reduced sediment loss **by 8 and 11%** respectively, compared to the control.
- The respective treatments reduced total nitrogen loss **by 5%** compared to the control.
- Results of the study show that adoption of agroforestry and contour grass buffer strips reduce non point source pollution from row crop agriculture. Furthermore, incorporation of these practices will also help to reduce runoff, sediment and nutrient loss during the fallow periods when most of the losses occur from the row crop watersheds.

Source: Udawatta et al., 2005, Agronomy abstracts

Left: *Oak trees in the middle of grass buffer strips on the agroforestry watershed in early summer 2005. Buffer strips are 4.5 m wide and 22-36 m apart, depending on the landscape position.*

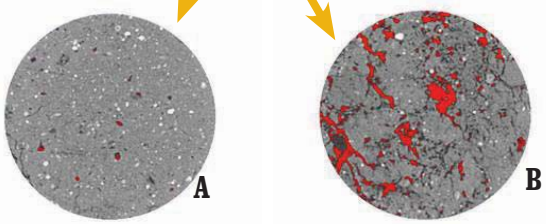
Buffer Effects on Soil Physical and Hydraulic Properties

Project Team: Ranjith Udawatta, H. E. "Gene" Garrett, Stephen Anderson, Clark Gantzer, Tshepiso Seobi

Runoff is a significant challenge in the Midwest, affecting water quality and contributing to the loss of valuable soil and nutrients each year that are vital to successful agricultural production. Soil bulk density and saturated hydraulic conductivity (or number of soil pores that allow for the movement of water) are important for determining runoff volume and water infiltration. **The higher the bulk density**, or soil denseness, **the greater the potential for runoff.** Denser soil restricts water infiltration into the soil and generates more runoff, carrying away significant quantities of soil and plant nutrients. In contrast, **the higher the saturated hydraulic conductivity, the more water moves into the soil** – generating less runoff and retaining more soil and nutrients. Research has shown that perennial vegetation enhances water infiltration and increases number of soil pores (porosity). Larger soil pores -- called macropores, with diameter > 1 mm -- rapidly channel surplus water, thereby reducing losses from runoff.

The objective of this study is to assess the effects of agroforestry and grass buffers on soil bulk density, saturated hydraulic conductivity, and pore size distribution to understand how management practices reduce runoff, soil and nutrient loss. The study approach consists of traditional and X-ray computed tomography (CT) procedures to compare differences among the treatments.

For the first time in this type of study, researchers utilized computer-tomography images from a medical X-ray machine to investigate seven soil parameters. Undisturbed soil cores from the agroforestry buffer, grass buffer and crop areas were collected in six replicates during June 2003 and scanned using the x-ray technology. **Results show that agroforestry and grass buffer practices have increased the number of total pores, and more importantly, the number of larger pores – resulting in reduced soil density and increased soil porosity, conditions necessary for reduced levels of runoff** and non-point source pollution.



Above: *Five soil cores were collected from the surface to the 50-cm depth at 10-cm increments with six replicates. Above shows an intact soil core (76-mm diameter by 76-mm long) being prepared in the field. Soil cores were then scanned using X-ray technology to produce a cross-sectional view of the soil density and pores.*

Top Left: *A hospital X-ray technician scans a soil sample to identify differences in porosity among soils from crop, grass and tree areas. This is the first known study of its kind to utilize X-ray technology for measuring the effects of riparian forest buffers on the capacity of soil to store moisture.*

Bottom Left: *X-ray scans of soil cores show fewer and smaller soil pores (shown in red, **image A**) in the corn-soybean row crop treatment, as compared to a higher number of larger pores found in soil from the grass and tree buffer treatments **(image B).***

Key Findings: Buffer Effects on Soil Physical and Hydraulic Properties

- **Bulk density** was 2.3% lower within the grass and agroforestry buffers compared to the row crop control.
- **Porosity:** Perennial, undisturbed roots from agroforestry and grass buffers increase the number of large pores in agricultural soils. Traditional procedures showed total porosity and coarse mesoporosity (60 to 1000 µm diameter) were 3 and 33% higher, respectively, for the grass and agroforestry buffer treatments compared to the row crop treatment. Using CT-measured procedures, the number of pores, number of macropores, area for the largest pore, macroporosity, and mesoporosity were shown to be significantly higher in soils from tree and grass treatments than the row crop treatment.
- Soils under the trees had 2.5 and 3.6 times greater number of larger soil pores than grass and crop areas, respectively.
- **Saturated hydraulic conductivity** was 3 and 14 times higher in grass and agroforestry treatments, compared to row crop treatments.

Sources: Seobi et al., 2005, Soil Science Society of America; Udawatta et al., 2006. Soil Science Society of America. [In Press].

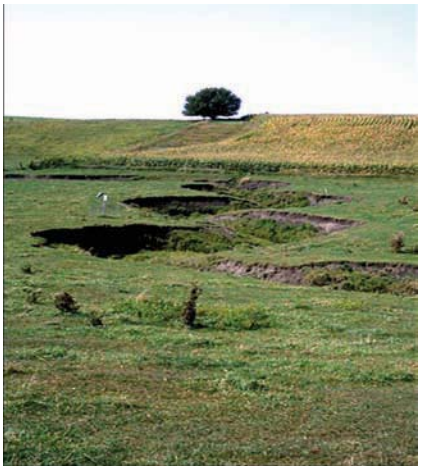
Effectiveness of Riparian Forest Buffers in Headwater Watersheds of the Western Corn Belt Plains Ecoregion

Agroecology Issue Team, Leopold Center for Sustainable Agriculture - Iowa State University

Project Team: Tom Isenhart, Dick Schultz, Bill Simpkins, Leigh Ann Long, Joe Herring, Jin-Kie Yeo

UMCA collaborators at Iowa State University are studying the impact of riparian forest buffers in the headwaters of the Crooked Creek, Otter Creek and Long Branch Creek watersheds in Missouri's Mark Twain Watershed by monitoring associated groundwater wells. The project goal is to assess the ability of riparian forest buffer zones under various land-use practices to reduce non-point source pollutants that originate upslope of the stream.

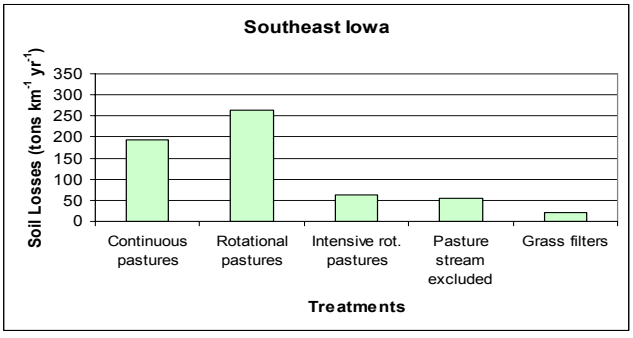
In addition to measuring the impact of buffers on stream and groundwater quality, researchers are studying the impacts of both row-crop agriculture and streamside grazing on streambank erosion rates. During 2005, a project to compare streambank erosion rates under different land uses was completed. In conjunction with this study, research has begun to determine the erosion impacts of livestock loafing areas and entry points into stream channels using simulated rainfall.



Because streams with healthy riparian forest buffer areas show the lowest amounts of total sediments and phosphorus, a riparian forest buffer practice consisting of trees and shrubs may be developed to serve as a living fence along stream channels in riparian pastures. These living fences will control livestock access to stream channels while also providing additional streambank support and stability.

Left: *Unfenced stream corridor, before establishment of living fence (i.e., buffer).* ***Right:*** *Stream corridor with living fence of shrub rows of wild plum, dogwood and ninebark.*

These studies indicate stream channels with direct entry points for livestock may be a major source of both sediment and phosphorus inputs into the channel. Riparian pastures with high levels of streamside loafing areas for livestock show the highest concentration of phosphorus in stream waters. Research results suggest that reductions in phosphorus and sediment levels can be accomplished by reducing livestock access to stream channels, while continuing to allow livestock to graze the remainder of the riparian pasture.



Results from southeast Iowa indicate that row-cropped fields and grazed pastures where cattle have free access to streams showed the highest soil and phosphorus losses to erosion.

Key Findings: Impacts of Both Row-crop Agriculture and Streamside Grazing on Streambank Erosion Rates

Riparian forest buffers, grass filters and pastures with cattle intentionally excluded from the stream channel had the lowest erosion rates.

Highest erosion rates were found for the continuously grazed pastures and row cropped land.

Intensive rotationally-grazed pastures showed some indications of reducing soil and phosphorus losses from bank erosion compared to continuous pastures. Total eroding lengths varied from about 11% for the buffered and cattle excluded streams, to 27% for the intensive rotational, up to 38% for continuously grazed pasture and row cropped land.

Source: Zaimes, et al. 2005.

Flood Tolerance Cluster: This project seeks to identify potential flood-tolerant herbaceous species for use in mid-western agroforestry buffers, floodplains, and for use in urban "green infrastructure" plantings, which require species adapted to stormwater flood conditions. Using the 12-channel flood tolerance laboratory at HARC, this cluster studies the effects of short- and long-term flooding on woody and non-woody plants. The flood tolerance laboratory was constructed along Sulphur Creek in the Missouri River floodplain, and each of the 12 channels is approximately 6-m (20') wide by 180-m (600') long. Channels can be independently adjusted for water depth, standing or flowing water, and duration of flooding. Currently, plans are underway to convert the 12 flood channels into 24 independent channels, each 90-m (300') long.

As part of an oak restoration study within the Flood Tolerance cluster, UMCA researchers are also exploring the impacts of planted oak forests on wildlife habitats in floodplain areas.

Evaluating the Flood Tolerances of Bottomland Hardwood Seedlings

Project Team: John M. Kabrick, Daniel C. Dey, Robert L. McGraw, Jerry W. Van Sambeek, Mark V. Coggeshall, John F. Thompson, Jimmy H. Houx

Millions of acres of Missouri bottomland forests have been cleared for agricultural production, creating some of the state's most productive farmland.

Aerial view, 12-channel flood laboratory.

However, this practice has resulted in a dramatic decrease in the acreage of this diverse habitat type. **Only 20 percent of the bottomland forests that once existed in the United States remain today, and in Missouri, only 1.5 million acres remain.** Many of these bottomland forested areas are prone to periodic flooding and may be considered only marginal for agricultural production - but through agroforestry practices and sound timber management, these areas can still be very productive for landowners and can support valuable wildlife habitats.

***Top Left:** Aerial view, Missouri River bottomland area. Top **Right:** The 12 channels of the HARC flood laboratory can be independently controlled for water flow. **Bottom:** Researchers evaluate hardwood seedlings planted in a flood laboratory channel.*

One of the Center's research initiatives is to investigate methods for reestablishing oak and other hardwood tree species in floodplains. The reestablishment of hardwood tree species in these areas provides several benefits to landowners, including diversifying native forests; combining timber, acorn production and the management of wildlife habitat for recreational operations; and restoring waterfowl habitats using integrated agroforestry practices. In addition, bottomland forests intercept pollutants from both ground and surface water and protect streambanks from erosion while offering invaluable protection against flood damage to levees. UMCA scientists are collaborating with a project team from the U.S. Forest Service in a study to evaluate regeneration methods for establishing valuable hardwood species in floodplains.

One aspect of this study compares the rate of survival, recovery and growth after flooding of commercially available hardwood seedling planting stock available from tree nurseries within the central hardwood region. The project goal is to determine which species are best for use in Midwestern riparian and bottomland plantings.

During the spring and summer of 2004, six different tree species were tested, including pin oak (*Quercus palustris*), swamp white oak (*Q. bicolor*), bur oak (*Q. macrocarpa*), black walnut (*Juglans nigra*), eastern cottonwood (*Populus deltoides*), and pecan (*Carya illinoensis*). Twenty-five seedlings of each species were planted in each of the 12 channels of the flood tolerance laboratory at the HARC farm (totaling 1,800 seedlings, 300 per species). At the end of the growing season, 150 seedlings were examined for survival and stem dieback, number of growth flushes, shoot growth, and stem caliper (indirect measure of root growth).

This experiment was repeated in 2005 using the same six species, with the addition of black oak (*Quercus velutina*), selected to serve as a more sensitive indicator of flood stress than black walnut. **(See Key Findings, next page).**

Key Findings: Testing the Flood Tolerance of Bottomland Hardwood Seedlings

As expected, black walnut suffered the greatest mortality and growth reduction in flooded channels.

Cottonwood, shown to be very flood tolerant and able to maintain high survival and growth rates during 3 week floods, showed declining survival rates during the 5 week flood.

While only moderately flood tolerant during the 5 week flood treatment (showing less than 70% survival), cottonwood was the only species to grow substantially in height and diameter during flood treatments. All other species were essentially stagnant in height and diameter growth in response to flood treatments.

Both swamp white oak and pin oak had greater survival than cottonwood, exceeding a 95 percent survival rate regardless of treatment.

Of the three oak species, bur oak appeared to be the most sensitive to flooding and had reductions in survival and growth in all flood treatments.

Pecan had very high survival, but also substantial height growth reductions due to stem dieback in all treatments.

Source: Kabrick et al., 2006. [In Press.]

Hardwood tree species seedling survival ranked in order of flood tolerance: (highest to lowest)

Flood Tolerance Survival Level	Tree Species
Very Flood Tolerant	*Pecan* *Pin Oak* *Swamp White Oak*
Moderately Flood Tolerant	*Cottonwood* *Bur Oak*
Poorly Flood Tolerant	*Black Walnut*

Agroforestry and Wildlife: Reforesting Bottomland Crop Fields with Oak to Restore Wildlife Habitat

Project Team: Dan Dey, John Kabrick, Josh Millspaugh, Dirk Burhans

Missouri's bottomland forests, though prone to flooding, can provide excellent opportunities for wildlife habitat and diversified income through timber production when agroforestry practices are applied. In conjunction with the oak regeneration project, the Center is working to evaluate the effects of planted oak habitats on key wildlife species, including songbirds.

Songbirds are among Missouri's most conspicuous wildlife, and represent an increasingly popular recreational activity. For example, in 2001 wildlife recreationers spent $108 billion, or 1.1% of the GDP, on wildlife-related activities, and a large percent of this was for feeding, watching, or traveling to watch birds. However, concern is mounting among scientists in recent decades about apparent population declines of many of America's most popular songbirds.

The songbird study was conducted at Plowboy Bend and Smoky Waters, two conservation areas along the Lower Missouri River managed by the Missouri Department of Conservation. Each site is divided into 40-acre blocks having (1) planted oaks with a covercrop of redtop grass (*Agrostis* gigantea); (2) planted oaks with no redtop covercrop, and (3) control blocks with no oaks or covercrop.

Results suggest these planted Missouri River bottom land habitats contain some of the state's most colorful song bird species, including many species of conservation concern. These habitats may also represent sources for self-sustaining songbird populations in a landscape that is increasingly fragmented by human land use.

As the project continues, management guidelines for songbirds in reforesting agricultural floodplains will be developed. Research results will also yield recommendations about habitat management for sensitive prairie species. The study will also be evaluated in future years to determine the effects of changing forest development upon the avian guilds.

Key Findings: Songbird Nesting Success Study

- Cowbird parasitism at Missouri River sites was less than half that at other sites in Missouri. Indigo Buntings, for example, showed only a 22% rate of cowbird parasitism at Missouri River floodplain areas, compared to a 48% rate in Missouri oldfields — formerly cultivated fields that have been removed from agricultural production and allowed to return to natural succession. (Cowbirds are parasitic songbirds that lay eggs in other birds' nests, resulting in reduced growth or death of the young in the host nest.)

- Red-Winged Blackbirds, an abundant North American songbird often considered to be an agricultural pest, prefer territories with denser, taller grass -- even more so than habitat areas with high numbers of branches appropriate for song perches. Initially, researchers suspected the species would favor planted oak areas, but grass cover was demonstrated to be the key habitat determinant.

Source: Furey, M.A. and D.E. Burhans. 2006. Red-winged blackbird territory selection. Wilson Bulletin (in press).

Establishment of Quail Cover Bundle Shrubs for Habitat Restoration

Project Team: Nadia Navarrete-Tindall, Jerry Van Sambeek, Kenny Bader

Bobwhite quail populations are declining in the Midwest, an occurrence linked with a loss of suitable habitat -- especially woody shrub cover next to feeding areas. To help regenerate suitable quail habitat, the Missouri Department of Conservation and several private nurseries are now packaging seedling bundles of mixed shrub species for planting along the edge of fields to create quail nesting and roosting areas.

Project team members are evaluating the survival and growth of shrubs or tree species at two different spacings, observing their responses to little or no weed control and their tolerance to fire. This same study was established at Prairie Fork Conservation Area, an MDC site in Williamsburg, Mo., and on private properties near Columbia and Chillicothe, Mo. Funding was provided by the Prairie Fork Trust.

Bare root seedlings established in 2002 for quail cover bundle study:

- false wild indigo (*Amorpha fruticosa*)
- wild plum (*Prunus americana*)
- fragrant sumac (*Rhus aromatica*)
- rough-leaf dogwood (*Cornus drummondii*)
- silky dogwood (*Cornus obliqua*)

Key Findings: Quail Cover Bundle Habitat Study

Of the bare root seedling species evaluated, research indicates false wild indigo is the easiest to get established, grows rapidly, flowers the second year after planting, and readily sprouted following a prescribed fire in spring 2005.

Excellent performance of false wild indigo may be related to its ability to fix atmospheric nitrogen.

Survival and growth of wild plum and dogwoods have been poor suggesting these shrubs would benefit from more intensive weed control.

Shrub mortality following prescribe fire was minimal with most shrubs sprouting near the soil line and putting on rapid growth in early spring.

Source: Navarrete-Tindall, Nadia and R. A. Pierce 2005. 2005 Final Report: Quail Cover Bundle Project. Submitted to the Prairie Fork Trust. Williamsburg, Mo. 7 p. (Available from Navarrete-Tindall)

Top: *UMCA is evaluating the woody shrub cover bundles prepared by the Missouri Department of Conservation for their potential to create successful quail nesting and roosting areas.*

Below: *False wild indigo is one of five bare root seedlings established for the quail cover bundle shrub study. Research indicates this species is easily established and grows rapidly.*

The Tree/Crop Interactions Cluster features three research projects designed to study the complex interactions between trees and crops that are inherent to agroforestry: interactions between trees and crop plants in agroforestry practices; evaluating the shade tolerance of ground covers for use in agroforestry; and biodiversity, pesticide reduction, and crop management in forage and oil seed crops alley cropped with black walnut.

Evaluating the Shade Tolerance of Warm and Cool Season Forages for Use in Agroforestry

Left: *The shade tolerance laboratory includes fifteen shade structures at 20, 22, 45, 70, and 100% full sun.* ***Below:*** *(Left) A sunfleck structure allows variable shading. (Right) Shade structure at 30% shadecloth. (70% full sun).*

Project Team: Jerry Van Sambeek, Doug Wallace (NRCS), John Thompson

To optimize 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 both in greenhouse settings and in a specially designed shade laboratory at the Horticulture and Agroforestry Research Center to evaluate these factors. The shade tolerance 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.

The shade tolerance laboratory was completely remodeled in 2005. Fifteen structures, 4.9 m wide, 9.8 m long, and 2.4 m high, were built. Five structures within each row or block have been randomly assigned to shade treatments of 0% (full sun), 30% shade, 55% shade, 80% shade and 78% shade (sunflecks).

Twenty to 30 grasses and legumes are simultaneously grown under these shade levels and periodically harvested to determine yield and forage quality as percent crude protein, neutral detergent fiber (NDF), and acid digestible fiber (ADF).

In 2005, 22 accessions of big bluestem, three of eastern gamagrass, one of little bluestem, one of Virginia wildrye, one of river oats, and two of cluster fescue were tested in the remodeled shade tolerance laboratory:

- The big bluestem accessions include nineteen accessions that had been found growing in partial sun in open woodlands in Missouri, Oklahoma, and Iowa. Accession #16 noted for its "light blue" foliage, and accessions #26 and #28 have been released as "Ozark-70" and "Rountree", respectively.
- The three eastern gamagrass accessions included #1, a potential new release, and #23 and #27 already released as "Pete" and "Verl", respectively.

Dormant rhizomes of the warm season grasses where obtained from the NRCS Plant Materials Center, Elsberry, Mo., in the spring and started in the HARC greenhouses. Plants were moved to the shade tolerance laboratory in June of 2005 and clipped to 20 cm stubble.

Key Findings: Shade Tolerance Laboratory Research

Comparing all big bluestem accessions, significant differences were found. Highest early boot biomass was 38.9 g/pot; lowest was 12.0 g/pot. Number of culms ranged from a high of 8, down to a low of 3.

Big bluestem plant biomass (grams/pot) was similar in 100%, 70% and 45% of full sun (28.6 g, 31.4 g, 30.6 g, respectively). Biomass dropped dramatically at 20% full sun and 22% as sun flecks (21.2 g, 22.7 g)

Two released cultivars of eastern gamagrass yielded higher harvestable biomass with increasingly higher amounts of shade. These results confirm previous research with eastern gamagrass showing that this species does not follow the expected decline in biomass with decreasing light found with most warm-season C_4 grasses.

Eastern gamagrass showed maximum biomass as 45% and 20% of full sun (19.8 g/pot).

Source: Wallace et al., unpublished findings

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

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

Agroecological theory suggests that a more diverse plant community supports a more diverse insect community, with the side benefit of reducing pest insects. However, the history of agriculture in North America has been to focus on reducing diversity in the pursuit of maximum yields and profits.

The five practices of agroforestry take a different approach to land management while maintaining and enhancing profitability. Agroforestry's growing popularity can be attributed to its demonstrated ability to positively impact the environment through crop and livestock protection and improved water quality, as well as to generate long-term profits and income stability.

The Tree/Crop Interactions project team is examining various aspects of the impacts of alley cropping on crop yield and pest problems. A crop management system that reduces insecticide use in forages and provides both short-term returns (forage) as well as long-term profits (nuts/wood) would greatly benefit the landowner. Within this research area, project goals include: (1) Determining the impact of alley-cropping forages and oil-seed crops (such as canola) in nut tree rows on insect and pest populations, (2) Determining the impact of alley cropping on crop yield and quality, and (3) Investigating 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 this practice.

To achieve these goals, researchers are comparing crop yields and insect pest populations between various alley cropped and conventional forage/oil-seed agroforestry systems. Primary project research has been conducted 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. Years of sampling data have been gathered, including insect sweeps and the collection and identification of alfalfa weevil larvae. Researchers are comparing insect populations and crop yields among traditionally-grown (open-field, monoculture) alfalfa with two different alley widths of alfalfa intercropped with black walnut trees.

Further studies will explore the economics of alfalfa yields in combination with nut and wood value of the walnut trees to complete a comprehensive picture of the potential benefits of alley cropping in Missouri. In 2005, the research shifted to Shepherd Farms in Clifton Hill, Mo., and is examining the potential benefits of a wheat/canola rotation intercropped with nut trees.

Key Findings, Black Walnut/ Alfalfa Alley Cropping Study:

- The centers of wide alley widths (80 ft) produce as much alfalfa as traditionally grown alfalfa. However, because overall yield is less near the trees, and space is lost for tree growth, total yield of alley cropped alfalfa is less than traditionally grown alfalfa on an acre basis.
- Wider alleyways achieve more successful crop yields than narrower alleyways. Alfalfa yield in open plots, and the center of wide alleyways, was greater than under dripline or narrower alleyways. In addition, alfalfa matured faster in open plots and at the center of wide alleyways compared to dripline or narrower alleyways.
- Insect populations are twice as diverse — and the number of beneficial insects that may adversely impact pests increases significantly — in alley cropped alfalfa compared to monocropped alfalfa.
- Intercropping alfalfa results in a higher mortality rate of the major alfalfa pest, the alfalfa weevil.

Sources: [A]McGraw et al., 2005. Proceedings of the 9th annual North American Agroforestry Conference. Stamps et al., 2005. Proceedings of the 9th annual North American Agroforestry Conference.

Alfalfa is grown in a black walnut alley cropping practice to determine the impact of tree rows on pest populations and the impact of alley cropping on crop yield and quality.

***Top:** Alfalfa planted in 40-foot alleyways.*
***Bottom:** An 80-foot black walnut/alfalfa alleyway (foreground) leading into a 40-foot black walnut/alfalfa alleyway (background). Wider alleyways encourage higher forage yields.*

MARKET OPPORTUNITIES: NICHE PRODUCTS FROM AGROFORESTRY

> "This type of focused research, combined with numerous cultivation studies, places UMCA at the forefront of medical herb studies."
> - Andy Thomas,
> MU Southwest Research Center

Enhancing opportunities for landowners to earn income from value-added and niche products -- such as medicinal herbs, nuts and gourmet mushrooms -- is a primary objective of the Center's research program. Opening doors for new products and new markets draws upon work from across several disciplines, including the Horticulture, Socio-Economic/Marketing, and Nut Tree research clusters.

Developing Nut, Fruit, and Herb Production for Midwestern Farmers through Agroforestry

Principal Investigator: Andrew Thomas

Study Site: University of Missouri, Southwest Research Center, Mt. Vernon, Mo.

Medicinal herbs hold significant potential as profit sources for Missouri landowners pursuing production through the agroforestry practices of forest farming or alley cropping. Ginseng, goldenseal or black cohosh, for example, can be planted in between tightly-spaced rows of pecan or black walnut trees in an alley cropping practice, where a shade overstory is present, or established within a wooded area as a forest farming practice.

A healthy black cohosh rhizome.

Black Cohosh: A Native Medicinal Herb in Great Demand

One of the nation's most significant research programs on the cultivation of potential agroforestry crops is based at the University of Missouri's Southwest Research Center, Mt. Vernon, MO. Located in the Ozarks region of the state, this 900-acre research farm is an ideal setting for the cultivation and study of a wide variety of tree and crop plants appropriate to agroforestry.

The herb black cohosh (*Actaea racemosa*) is found naturally in the Ozark and Appalachian regions of the USA, and has been used medicinally by Native Americans for centuries. Its roots and rhizomes are now commonly sold in health food stores for treatment of menopausal symptoms. "Black cohosh is presently among the top ten medicinal herbs grown and used in North America and Europe. The species is being significantly over-harvested from its natural range, which is causing serious concern," said Thomas. "We're one of the few institutions studying the cultivation of this plant in an effort to increase profit potential for producers while reducing harvest pressures on declining native populations." Nearly all black cohosh is harvested from the wild in the U.S., with very little in cultivation. Currently 95% of the black cohosh harvested is exported to Europe, where it is prescribed by doctors.

Black cohosh has been clinically proven to relieve menopausal symptoms, such as hot flashes, in some women. Such positive clinical results, combined with concerns about possible serious side effects of hormone replacement therapies, have fueled great interest and demand for black cohosh products. But cultivating black cohosh is a long-term undertaking, as plants must be 3 to 5 years old before their rhizomes are large enough to harvest. And then, once they are of age, the entire plant is destructively harvested. One of the experiments at the Southwest Center is exploring the possibility of harvesting targeted medicinal compounds from tissues such as leaves and flowers. "Our research indicates that there is two to three times the amount of certain medicinal compounds in the leaf, and 10 times the amount in flowers compared with rhizomes," said Thomas. "The possibility exists to establish annual harvests of various renewable plant tissues (such as leaves, stems, flowers) for specific medicinal compounds, rather than destructively harvesting the entire plant only once after 3 to 5 years. This type of focused research, combined with numerous cultivation studies, places UMCA at the forefront of medical herb studies."

Black cohosh flowering under shade cloth.

Key Findings, Black Cohosh:

- Proper site selection, including well-drained soils, is essential.
- Generally easy to grow in Missouri; can be produced in shadehouse or forest.
- Numerous pathogenic organisms are capable of attacking black cohosh if the conditions are suitable.
- The disease "black root and crown rot of black cohosh" is associated with 3 species of *Phytophthora*, 6 species of *Pythium*, 1 species of *Rhizoctonia*, and at least 1 species of *Fusarium*.

Sources: Abad et al., 2005. Thomas et al., 2006.

Key UMCA Partnerships, Medicinal Herb Research:

- *Missouri Botanical Garden, St. Louis*
- *USDA – ARS – National Soil Tilth Laboratory, Ames, Iowa*
- *USDA – ARS – Horticultural Crops Research Laboratory, Corvallis, Ore.*
- *Missouri State University – State Fruit Experiment Station, Mountain Grove, Mo.*
- *University of Arkansas -- Arkansas Agricultural Research and Extension Center, Fayetteville, Ark.*

Elderberry: A Versatile, Easily-grown Shrub for the Midwest

Elderberry (*Sambucus canadensis*) is another native species with tremendous interest and potential. Because it is a tough, multi-purpose shrub, it could easily become an important component of a variety of agroforestry practices and is well-suited to riparian forest buffers and alley cropping.

The fruit and flowers are edible, and are traditionally used for making wines, jams, syrups, and natural food colorings. However, the "nutraceutical" (or health tonic market) is rapidly overtaking these other markets and fueling an increasing demand for the fruit. The plant has other attributes, including attracting and benefiting birds and wildlife, tolerating somewhat wet or poor soil conditions, and producing massive root systems that can help reduce soil erosion.

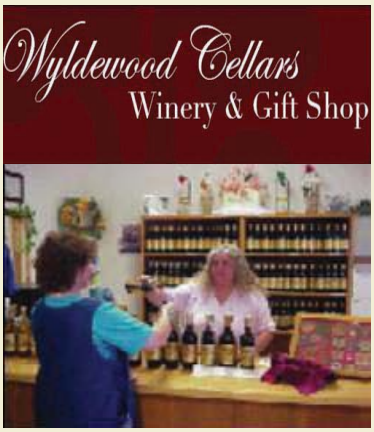
More than 55 new selections of elderberry from the Midwest are under evaluation at the Southwest Center. Two of these cultivars have already proven their superiority and are slated to be named and released soon. Most of the research now being conducted focuses on very basic horticultural questions, such as how do we propagate, prune, fertilize, and protect these plants. The interest in the medicinal potential of this species has inspired additional studies to sort out the production of various anti-oxidants throughout the plant.

Key Findings, Elderberry Research:

- Easy to grow in Missouri; easy to propagate by seed or cuttings.
- Flowering period, fruit ripening, and fruit yield in elderberry are highly dependent on genotype and environment.
- Knowledge of a variety of fruit juice characteristics is important in wine-making. Preliminary evaluations of elderberry juice across multiple cultivars, locations, and seasons reveal the following characteristics for elderberry juice: °Brix = 11.94, pH = 4.65, Titratable acidity = 0.88%.**

Source: ** Byers and Thomas, 2005.

Elderberry Success Story: Wyldewood Farms, Mulvane, Kan.



Since 1994, the brother and sister team of John and Marry Brewer have been making Wyldewood Cellars Winery one of the most well-known in the Midwest. The family-owned farm business headquartered in Mulvane, Kan., specializes in unique wines and fruit/nut products, including elderberry wine and concentrate.

For the Brewers, what began as a way to "make the family farm pay" suddenly blossomed into a new agricultural industry. Farmers and ranchers began growing the elderberry plants as a cash crop, and Wyldewood Cellars purchased all the supply they could find.

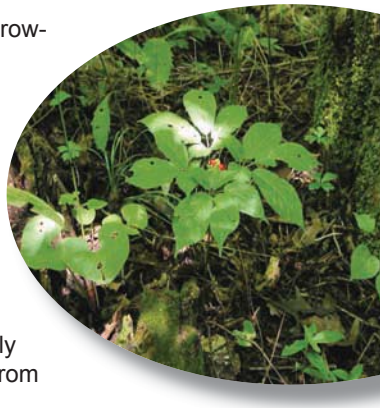
Having won more than 130 national and international awards for their wines, Wyldewood Cellars is quickly climbing the ladder of recognition as a serious competitor. While elderberry products are the mainstay of the winery, they also have wines, jellies, syrups, and even some fudges made from other fruits and berries. Wyldewood Cellars was a featured vendor at the Center for Agroforestry Missouri Chestnut Roast last fall, attracting visitors to learn more about elderberry and other niche agricultural crops.

Ecology and Cultivation Potential of American Ginseng

Project Team: Rose-Marie Muzika and Susan Farrington, (MU Forestry graduate research assistant)

American ginseng (*Panax quinquefolius L.*) is a long-lived perennial that is rare throughout its native range of eastern and central North America, and is becoming rarer, likely due to over harvesting and excessive deer browsing, leading to a reduction of its preferred habitat. It is a valuable forest crop, highly sought by root diggers in Missouri since the 1850's and frequently poached from protected lands.

While ginseng can be commercially farmed, cultivated roots have a very different appearance than those that have grown "wild" in the forest. The wild root is highly prized by the Asian market, and brings a much higher market price than the cultivated root: $125 to $500 per dried pound for wild roots versus $6 to $12 for cultivated roots. **Exports of wild American ginseng from the U.S. in 2001 totaled $59 million.**



An alternative to growing ginseng under intensive cultivation is to grow wild simulated ginseng, which is ginseng sown in forest habitat and left to grow naturally. Ginseng grown in this manner is generally indistinguishable from

Key Findings, American Ginseng Research:

- Through seed germination trials in 4 Missouri counties over 2 growing seasons, researchers found that seed sown at a depth of 1 to 3 cm (approximately ½"-1¼ ") germinates more readily than seed sown deeper, or seed merely sown on the surface of the soil.
- Research has documented the long-noticed but seldom proven characteristic of a ginseng plant to remain completely dormant for one or more seasons. In a given year, an average of 2.5% of the study's ginseng population will not emerge at all, remaining dormant for as long as three years.
- In following these slow-growing plants for eight years, only 16 of the 252 seedlings observed have reached reproductive size. It took an average of 4.4 years for these plants to reach this stage, producing only a few seeds each -- and none have become large reproductive plants. This information may be helpful in establishing harvesting guidelines.

Source: MS Thesis. Susan Farrington. Completed January 2006. An Ecological study of American ginseng (*Panax quinquefolius L.*) in the Missouri Ozark Highlands: Effects of herbivory and harvest, ecological characterization and wild simulated cultivation. 175 pp

A variety of products are made from ginseng, including herbal supplements and teas.

truly wild ginseng, and can command an equally high market price. Wild simulated ginseng can be a potentially lucrative additional cash crop for landowners managing rich slopes for timber production.

To aid Missouri landowners in choosing appropriate locations for sowing ginseng, Center for Agroforestry collaborative researchers are studying the ecological characteristics of ginseng in the Ozark Highlands of Missouri. Nineteen naturally growing populations of ginseng have been identified in 13 counties, with measurement data reflecting the basal area, species composition of the trees present and the degree of canopy shading. Herbaceous plants growing with the ginseng have been identified to determine which are the best indicators of successful ginseng growing sites.

Using data collected through soil samples at each site and seed germination trials, UMCA researchers will produce a grower's guide for Missouri to assist landowners in choosing appropriate locations for sowing and cultivating ginseng.

Cultivation of Gourmet and Medicinal Mushrooms in Agroforestry

Project Team: Johann Bruhn and Jeanne Mihail

UMCA supports one of only two research programs in the nation working to develop the premium, high-dollar European black truffle as a forest farming crop for landowners, and is finding that this gourmet mushroom grows well in Missouri soil. Research is also being conducted to develop morel, shiitake and other gourmet mushrooms into profitable agroforestry crops.

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, such as branches, wood chips and sawdust. As they strive for efficient, sustainable management through agroforestry, Missouri land and forest owners are developing new partnerships with natural resource agencies. The Center for Agroforestry is working to refine established production techniques for a diverse suite of outdoor mushroom species and capture a growing gourmet market.

Through international collaborations and information exchanges, and programs close to home -- including a series of guidesheets and annual Specialty Mushroom Workshops -- the Center continues to accumulate a practical, scientifically-sound knowledge base for the benefit of Missouri landowners who are entering the specialty mushroom market.

Fresh shiitake mushrooms are attractively packaged by Ozark Forest Mushrooms, a successful forest farming enterprise near Timber, Mo.

Key Findings: Specialty Mushroom Research

- For optimum shiitake mushroom production, wait 10 weeks between forced fruiting.
- Truffles require high pH soils, ~ 7.8 - 8.0, therefore heavy application of lime is required to raise the pH. To raise soil pH by 0.1, 2 tons of lime per hectare are required.

Source: McCoy and Bruhn. 2005. Agroforestry in Action - Growing Shiitake Mushrooms in an Agroforestry Practice. AF1010-2005. Available at www.centerforagroforestry.org or http://extension.missouri.edu

Market Opportunities with Missouri Nuts: Chinese Chestnut Cultivar Performance in Missouri

Project Team: Kenneth L. Hunt, Michael A. Gold, Michele R. Warmund and Bill Reid

Chinese chestnut is a potential new orchard crop in Missouri and in the Midwestern United States. Missouri River Hill 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 stature than the American Chestnut, and spread outward like a large fruit tree while producing a significant quantity of nuts. Markets continue to expand both domestically and overseas for chestnuts and products such as gluten-free chestnut flour, showing significant profit potential for Missouri landowners.

For new chestnut orchards to succeed, reliable cultivar information must be made available. Beginning in 1996, a repository of 20 cultivars and accessions (generally 2 replications) of Chinese chestnut and chestnut species hybrids was established at the Horticulture and Agroforestry Research Center (HARC) at New Franklin, Missouri, in fertile, well-drained, erodible, loess "River Hill" soil. Chestnut cultivars and accessions have been added on a yearly basis to total 56 currently. UMCA study objectives are to identify outstanding, locally-adapted cultivars that have traits suitable for commercial chestnut production (e.g., large size nuts, consistent yields, excellent flavor, long storage potential) and to develop field trials to manage these elite cultivars for nut quality and yield. Cataloging descriptors such as bud break date, flowering date, nut size, nut weight, nut maturity and nut yield has been a primary focus. Beginning with the 2005 crop, many cultivars under test in Missouri have now begun bearing commercial quantities of chestnuts. (Source: *Agroforestry in Action: Growing Chinese Chestnuts in Missouri, 2005*. Available at www.centerforagroforestry.org)

Recommended Chinese chestnut cultivars for Missouri, 2005:

Cultivar	Comments
'Eaton'	Nuts have excellent flavor and sweetness and store well. Ornamental glossy leaves. Nut size can be small if conditions aren't ideal.
'Peach'	Tall, upright tree. Good quality nut grown at Empire Chestnut Company in Ohio. Large nuts with "peach fuzz."
'Gideon'	Uniform attractive nuts. More cold hardy than many Chinese chestnuts. Bear consistent, high yields of easy peeling nuts with excellent flavor. Grown at Empire Chestnut Company in Ohio.
'Sleeping Giant'	Hybrid - Chinese x (Japanese x American). A larger sized tree with proven blight resistance. Excellent nut quality and flavor. Variety is grown and sold as a seedling and requested by people interested in timber form.
'Qing'	Spreading, compact tree. Good branch angles. Vigorous grower with consistent nut bearing. Shiny, medium to dark mahogany nuts. Excellent, sweet flavor. Stores well. Can set too many nuts causing nut size to drop. Delayed graft failure a problem.
'Au (Auburn) Homestead'	Consistent, moderate yields. Large burs may drop early in wind storms.
NO LONGER RECOMMENDED: WILLAMETTE	Nut size dropped dramatically with higher production; tree is leggy and prone to limb breakage.

Chinese chestnut cultivar research is explained during a tour of HARC. Photo: Bob McEowen

Chestnut Market Research Project

Project team: Ina Cernusca, Larry Godsey, Michael Gold

This project consists of a comprehensive program to stimulate both production and consumption of chestnuts. The program focuses on generating demand by increasing consumer awareness about chestnuts by using a "pull strategy." At the same time, by providing information and support to actual and future producers, the team intends to generate enough local production to meet the created demand.

The first step in the implementation of the pull strategy was the creation of the Missouri Chestnut Roast Festival, organized with the intention to expose the general public to chestnuts (plus pecans, black walnuts and many other agroforestry specialty crops) by offering information and samples of fresh, roasted and prepared nuts. In 2004, the specific objective was to conduct a marketing study during the festival to get additional data concerning the familiarity of participants with chestnuts to determine their interest in buying, consuming, and preparing these nuts and the key attributes that

influence purchase decisions. The 2004 survey also determined participants' primary interests in obtaining more information about the production, marketing, cooking, preparation and nutrition of these nut species.

The second phase of the project was focused on producer market research. In late 2004 and early 2005 a national survey was conducted to identify and describe the chestnut (*Castanea spp.*) product market value chain. This consisted of a nationwide survey of individuals and businesses active in the U.S. chestnut production and sales.

Key Findings, Chestnut Market Research:

Consumer research (2004-2005):

- There is limited consumer awareness of the product.
- Quality and nutrition-diet-health were perceived as the most important attributes influencing purchase decisions.
- Consumers and grocery produce managers must be educated in handling and using chestnuts. Recipes and information about health and nutritional benefits at the point of sale will help motivate consumers to try chestnuts.

National chestnut market findings: (2006)

- The U.S. chestnut industry is in its infancy. The majority of chestnut producers have been in business less than 10 years and are just beginning to produce commercially.
- Volume of production is low (less than 1.5 million pounds).
- U.S. chestnut producers are mainly part timers or hobbyists with small, manually harvested operations. The majority of respondents sell fresh chestnuts.
- Demand exceeds supply, and wholesale prices range from 0.75 to $7.00 per pound, averaging $3.50 a pound.

Sources: Gold, M.A. et al., 2004. *HortTechnology* 14(4):583-589. Gold, M.A. et al., 2005. *HortTechnology* 15(4):904-906. Gold, M.A. et al., 2006. *HortTechnology* 16(2): 360-369.

Development of Improved Black Walnut Selections for Use in Agroforestry Practices

Project Team: Mark V. Coggeshall, Michele R. Warmund, Ken Hunt, Aaron Brown

Black walnut is an admired Missouri tree species, known for high-value lumber and rich, distinct nut flavor. However, black walnut nuts are typically harvested in Missouri from the wild -- usually by hand by a landowner – often collected as they fall from trees in forested areas. This type of harvesting allows for significant inconsistencies in quality, size, flavor and level of ripeness, complicating production of this nut for consumer purchase. Due to these inconsistencies, wild-harvested nuts also command a lower market price than similar nuts produced with consistent qualities, such as the familiar size, color and flavor of the California walnut.

The Center for Agroforestry has been working since 1996 to develop black walnut into an orchard crop, striving for identification of the best-suited cultivars for Missouri climate and soils. Since the start of the applied breeding program, approximately 70 different black walnut nut cultivars have been acquired and placed in a series of grafted orchard collections at the University of Missouri Horticulture and Agroforestry Research Center (HARC) in New Franklin, Mo. Through orchard production, a consistent, top-quality nut can be harvested to meet consumer demand for a milder flavor and lighter color while retaining the black walnut's revered heart-healthy source of fat.

Black Walnut Genetic "Fingerprints"

In attempting to shift black walnut from a "backyard hobby nut tree" to a serious orchard tree crop, it is essential that the exact genetic makeup of each cultivar is known. Dozens of named cultivars exist, with many of these names created by tree hobbyists and shared among one another. However, nut tree specialists must know how these cultivars differ genetically to pursue hybridization techniques for producing improved black walnut cultivars for an orchard setting. The genetic make-up, or "fingerprint," of each cultivar must be known as the first step in an accurate breeding program.

To identify the genetic makeup of the Center's black walnut collection, nut tree researchers submitted leaf samples from all trees in the black walnut repositories at HARC in 2004 to the Hardwood Tree Improvement and Regeneration Center (HTIRC) at Purdue University. These samples provided DNA material for use in creating genetic fingerprints for each tree using a series of microsatellite markers.

Key Findings: Black Walnut Genetic Fingerprinting Study

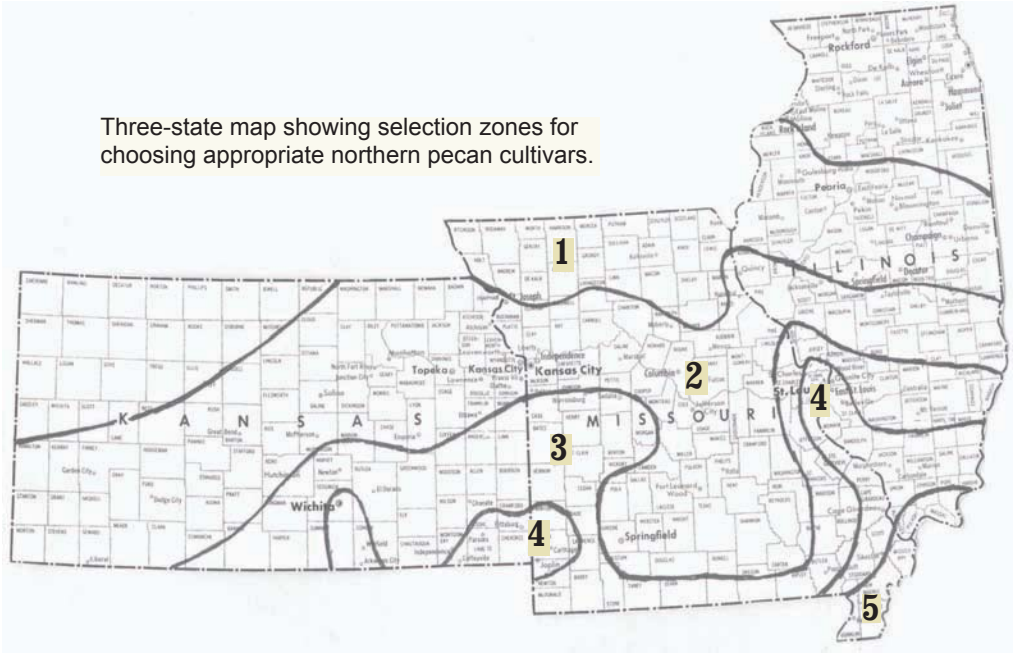
- Of the more than 100 "cultivars" originally established at the HARC farm, less than 70 are actually genetically different from one another.
- Additional leaf samples from 20 different cultivars in the Kansas State University collection were submitted to the HTIRC in August 2005. During 2006, results from these analyses will be compared with traditional "orthodox" and species-specific descriptors for all grafted trees that may have questionable identities.

Matching Pecan Cultivars with Soil Zones for Optimum Nut Maturity

Project Team: Ken Hunt, Bill Reid (Kansas State University)

Pecan research at the University of Missouri Center for Agroforestry, conducted primarily at the Horticulture and Agroforestry Research Center (HARC), New Franklin, MO, is another opportunity for the Center to assist Missouri landowners with profitable nut crops. Native pecans grown in Kansas, Missouri, and Illinois (Upper South) tend to have a higher oil content compared to pecans grown in the Southwest and Southeast United States. The higher oil content gives Missouri's pecans a richer, sweeter flavor than Southern pecans, potentially commanding a higher price at grocers, specialty retail vendor or wholesale outlets.

Since 1995, a large collection of pecan cultivars have been planted at HARC to catalog several descriptors, including date of nut maturity, nut size, percent kernel and nut yield. Drawing from collaborative pecan research efforts conducted at Kansas State University and the Pecan Experiment Field Station in Chetopa, KS, nut tree specialists have developed initial recommendations based on growing season climatic zones of the tri-state region. The recommended climatic zone was chosen for each cultivar based primarily on length of growing season required to mature the nuts, but modified by such variables as relative winter hardiness for each cultivar. This will assist pecan growers in choosing proven cultivars that will provide consistently profitable nut yields. Following is a sample of data from 2005 showing a selection of cultivars and appropriate zones for Missouri, Kansas and Illinois, as indicated by the map.



Three-state map showing selection zones for choosing appropriate northern pecan cultivars.

Note: Recommendations may change as trees mature and come into full commercial production.

Nut yield in Pecan Cultivar Trial, Fall 2005. Location: Silt-loam soil near Sulfur Creek bottom, along edge of Missouri River floodplain, New Franklin, Mo. (Trees, age 10 from graft, are not irrigated.)

Cultivar	Mean yield (lbs.)	Recommended Zone(s)
Colby	8.9	2,3
USDA 64-11-17	7.4	3,4
James	6.4	2,3
Kussman	6.1	2,3
Posey	6.1	2,3,4
Shepherd	3.9	2,3,4
Peruque	3.6	2,3,4
Witte	3.7	2,3
Kanza	3.5	3,4,5
Norton	2.3	2,3
Goosepond	2.2	2,3,
USDA 62-1-15	2.0	3,4
Canton	1.8	2,3
USDA 64-15-85		3,4
Ste. Genevieve	1.3	4,5
Warren #346	1.0	1

FACILITATING ADOPTION OF AGROFORESTRY

Socioeconomic Cluster: Facilitating adoption of agroforestry practices

Understanding the social and economic conditions related to landowner adoption of agroforestry practices is a key component of the Center's research program. Institutions such as natural resource organizations, community educational and outreach programs, networks among professionals and landowners and the markets in which agroforestry products are sold play a critical role in the successful application of agroforestry practices to forest and crop lands.

Primary objectives of the Center's socioeconomic research cluster are to 1) analyze the roles that agriculture and related organizations play in agroforestry adoption and 2) explore the perceptions and attitudes toward agroforestry among landowners, as well as the perceptions of employees of natural resource organizations. Specific research areas include: the socioeconomic, market and policy factors that affect adoption and diffusion of agroforestry practices; factors driving interest in agroforestry practices; and analyzing the markets for traditional and nontraditional Midwestern agroforestry products.

The Non-Operator Landowner and Agroforestry

Project Team: J. Arbuckle, Sandy Rikoon, Corinne Valdivia, Hilary Dorr

Land tenure has long been considered a critical factor in determining the adoption and long-term maintenance of agroforestry practices. However, in the U.S., more than 40 percent of the private land employed in agriculture is farmed by someone other than the owner. Using data from a 1999 survey in northeast and southeast Missouri, this study provides insight into the factors associated with non-operator landowner interest in agroforestry. These conclusions can help guide research and outreach efforts toward increasing agroforestry adoption levels and can serve as a first step toward generating openness toward the practices.

Key Findings, Landowner Interest in Agroforestry Adoption:

- Respondents with greater knowledge of agroforestry were more interested in potential implementation on their land.
- Non-operator landowners who place high importance on the environmental and recreational dimensions of landownership expressed more interest in agroforestry.
- Those with closer ties to farming and stronger financial motivations for landownership were less interested in agroforestry.
- Frequency of contact with natural resource professionals (NRPs) such as Soil and Water Conservation District technicians was positively associated with interest in implementation of agroforestry practices.

These results indicate:

- Increasing non-operator landowner knowledge of agroforestry should translate into greater interest in implementation.
- There are opportunities for agroforestry promotion among non-operator landowners who place high importance on the environmental and recreational values of their land. For people who depend less on their land for income – for example those who have purchased farms for retirement, earn their living in urban areas but own farms, or purchase working farms for hunting purposes – the aesthetic and conservation-oriented dimensions of agroforestry may be more important drivers of interest in adoption than economic potential.
- For landowners with closer ties to conventional farming and strong financial motivations behind landownership, an outreach emphasis on the economic potential of agroforestry might be most effective.
- As non-operator landowners who have more contact with NRPs show stronger interest in agroforestry, efforts to enhance agroforestry knowledge and comfort level among NRPs could lead to increases in implementation. (The Center is addressing this challenge with a series of SARE Professional Development Program training events. See page 11 for more information.)

Source: Arbuckle et al., 2005.

New Developments

As you explore this year's research highlights, we hope you see — as we do — that 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 60 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.

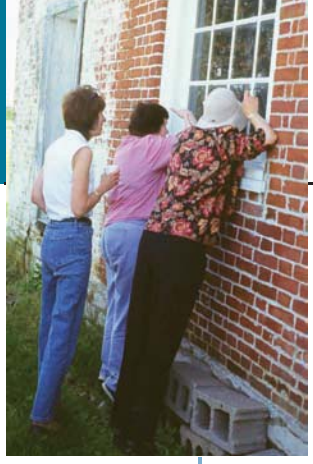
The Center's research is impacting the environment with a reduction in non-point source pollution from riparian forest buffer practices, providing enhanced habitat for wildlife across the state and reducing the impacts of periodic flooding.

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 and to establish farming that "fits the land."

660-acre HARC farm, New Franklin, Mo.

(above) Aerial view, 1819 Thomas Hickman House. The historic homestead is the site of the future HARC visitor's center and one of UMCA's exciting new developments. ***(Read more, next page.)***

From Left: *MU Chancellor Brady Deaton; U.S. Senator Christopher "Kit" Bond; UMCA Director Gene Garrett; and College of Agriculture, Food and Natural Resources Dean and Vice Chancellor Tom Payne gather to celebrate the recent announcement of $500,000 in federal funding secured by Sen. Bond for restoration of the 1819 Thomas Hickman House, located on the HARC farm at New Franklin, Mo.* Photo: Jason Jenkins



Top: *Visitors to the HARC farm, New Franklin, Mo., are intrigued by the home and peer into a fully-restored 12-pane by 12-pane window.*

Preserving a Missouri Treasure: Funds Secured to Restore Historic Thomas Hickman Homestead

Nearly 200 years before the Missouri River Hills began yielding innovative plant and tree research, the land that is now the Horticulture and Agroforestry Research Center (HARC) at New Franklin harbored one of the Midwest's earliest and most intriguing agricultural homesteads.

One of the state'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 an outstanding example of 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 open the homestead as a visitor center for the HARC farm, telling the story of the region's agricultural heritage. Recent federal and University funding are bringing this vision close to reality.

The Dream: Restoration of Thomas Hickman House and development of visitor's center, interpretive exhibits, period gardens, and fully accessible facility to preserve region's agricultural/architectural history.

The Progress: $100,000 awarded by James B. Weathers family in 1997; window/roof repair begun.

2005: $500,000 awarded in federal funds, secured by U.S. Sen. Kit Bond; $250,000 match presented by MU College of Agriculture and Natural Resources. National Register nomination process initiated.

2006: Search for final $250,000 underway to complete the restoration project.

MEDIA RELEASE: UNIVERSITY OF MISSOURI RECEIVES FEDERAL SUPPORT TO RESTORE HISTORIC MID-MISSOURI HOMESTEAD (SOURCE: MU EXTENSION)

DEC. 5, 2005: NEW FRANKLIN, Mo. – A rare historical building, which sits on a University of Missouri research center, will soon get a significant renovation thanks to $500,000 in federal funds.

Hickman House, one of the oldest hand-made-brick buildings in Missouri, will get a major renovation thanks to funds supported by U.S. Sen. Christopher "Kit" Bond.

"We should not let historical sites decay or fall victim to development," Bond said during an announcement ceremony at the MU Horticultural and Agroforestry Research Center Nov. 30, 2005.

"The Hickman House has a lot to teach us about Missouri history, about early agriculture and about architecture," Bond said. "We should bring the history of the Hickman House alive to this and future generations of Missourians."

The 1,800 square-foot house is one of the oldest brick structures in Missouri, and the oldest in the Boonslick area. It was built in 1819, the year after Thomas Hickman, his wife, Sarah Prewitt Hickman, and their four children arrived in the wilderness that was Howard County from Bourbon County, Ky.

Hickman, along with several partners opened a dry goods and hardware store in what is now known as Old Franklin. He also began land speculation and raised his family in the southern Georgian-style home overlooking forested valleys and tall-grass prairies of what is now the MU HARC farm.

"The Hickman House has tremendous historical value, and once restored, it will draw thousands to the area and the farm. Once they're here, they won't leave until they know about agroforestry."

- Gene Garrett, UMCA Director

The Franklin region was a critical outpost in Missouri's early days, and was the original starting point of the Santa Fe Trail.

Historians believe the house was built of bricks hand-kilned on the property. Brick masons used the then-popular Flemish bond technique—one long brick alternating with one short brick—for the front facade, and the simpler common bond pattern on the end walls and rear wall of the house.

Once restored, the house and surrounding gardens will play a critical role in bringing citizens to see the cutting-edge of agroforestry technology and other research taking place at HARC, said Gene Garrett, research farm superintendent.

"The Hickman House has tremendous historical value, and once restored, it will draw thousands to the area and the farm," he said. "Once they're here, they won't leave until they know about agroforestry."

HARC is one of the leading centers in the country focused on creating systems where traditional agriculture—growing crops or raising livestock—and tree and forest production not only co-exist, but augment each other.

"We must create teachable moments to get new technologies adopted," Garrett said. "In order to be effective, we need to get the potential user on the farm for demonstration purposes."

Bond secured the restoration funds in the 2006 Transportation-Treasury-HUD Appropriations bill, which passed Congress in late November 2005.

Top: *East side view of the 1,800-square foot Thomas Hickman House.*

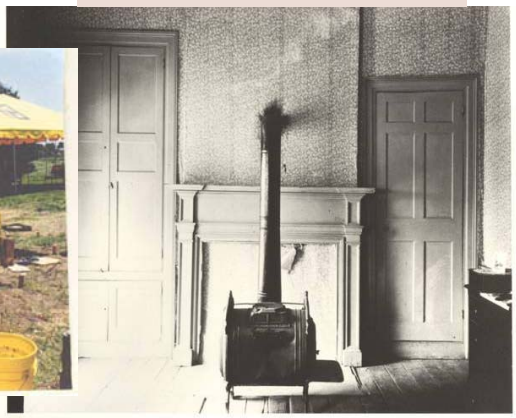
Left: *Artist's sketch showing the home's original decorative fan light and entrance, rare architectural elements that will be replaced as part of the restoration.*

Below, from Left: *Sen. Bond and UMCA Director Gene Garrett lead a discussion of the walnut logs used as beams to support the home. The logs are intact, with bark still exposed. A large portion of the home's original woodwork and interior elements also remain intact.*

Middle: *MU researchers excavated the site of the original summer kitchen in 1997, located near the northeast corner of the home. Several historic artifacts were removed and placed in storage for future exhibit.*

Right: *In 1930, the home was selected for a Historic American Buildings Survey instituted by the National Park Service. This photo from the survey shows the former interior of a bedroom.*

Photo: Jason Jenkins



2005 PUBLICATIONS

Technology Transfer:

Dwyer, J.D, L.D. Godsey, H.E. Stelzer, 2005. **Managing your timber sale tax.** University of Missouri Extension publication # G5056.

Godsey, L.D. 2005. **Tax Considerations for the Establishment of Agroforestry Practices.** UMCA Agroforestry in Action Guide AF1004-2005 12 p. (updated) www.centerforagroforestry.org/pubs/agrotaxcons.pdf.

Godsey, L.D. 2005. **Funding Incentives for Agroforestry in Missouri.** UMCA Agroforestry in Action Guide AF 1005-2005 24 p. www.centerforagroforestry.org/pubs/fundincent.pdf.

Hunt, K., M. Gold, W. Reid and M. Warmund. 2005. **Growing Chinese Chestnut in Missouri** (revised). UMCA Agroforestry in Action Guide AF1007-2005. 12 p. www.centerforagroforestry.org/pubs/chestnut.pdf.

McCoy, R. 2005. **Establishing and Managing Riparian Forest Buffers.** UMCA Agroforestry in Action Guide AF 1009-2005. 20 p. http://www.centerforagroforestry.org/pubs/ripbuf.pdf.

McCoy, R. and J. Bruhn. 2005. **Growing Shiitake Mushrooms in an Agroforestry Practice.** UMCA Agroforestry in Action Guide AF 10010-2005 12 p. www.centerforagroforestry.org/pubs/mushguide.pdf.

Horticulture:

Abad, Z.G., J. Phillips, and A.L. Thomas. 2005. **Black root and crown rot of black cohosh (*Actaea racemosa* L.) is associated to Phytophthora and Pythium species.** Phytopathology 95:S1. (Abstract).

Byers, P. and A.L. Thomas. 2005. **Elderberry Research and Production in Missouri.** Proceedings of the 25th Missouri Small Fruit and Vegetable Conference 25:91-97. Southwest Missouri State University. Springfield, MO.

Kirk, S.D., C.J. Starbuck and J.W. Van Sambeek. 2005. **Missouri gravel bed and a pot-in-pot system superior to white polyethylene and foam for overwintering *Syringa pubescens subsp. patula* liners.** Combined Proceedings International Plant Propagators' Society 54: 516-521.

Starbuck C., D.K. Struve and H. Mathers. 2005. **Bareroot and balled-and-burlapped red oak and green ash can be summer transplanted using the Missouri Gravel Bed System**. HortTechnology. 15:122-127.

Thomas, A.L., R.J. Crawford, Jr., L.J. Havermann, W.L. Applequist, B.E. Schweitzer, S. Woodbury, and J.S. Miller. 2006. **Effect of Planting Depth, Planting Season, and Fungicide Treatment on Establishment of Black Cohosh in a Poorly-drained Soil.** HortScience 41(2):374-376.

Silvopasture and Forages:

Ares, A., D.K. Brauer and D.M. Burner. 2005. **Growth of southern pines at different stand configurations in silvopastoral practices.** In: Proceedings of the 9th North American Agroforestry Conference-Moving agroforestry into the mainstream. K.N. Brooks and P.F. Ffolliott (ed.) June 12-15, 2005, St. Paul, Minnesota. Department of Forest Resources, University of Minnesota, St. Paul, MN.[http://cinram.umn.edu/afta2005/pdf/Ares.PDF].

Kallenbach, R.L., M.S. Kerley, and G.J. Bishop-Hurley. 2006. **Forage accumulation, quality and livestock production from an annual ryegrass and cereal rye mixture in a pine-walnut silvopasture.** Agroforestry Systems 66:43-53.

Navarrete-Tindall, N.E.; Van Sambeek, J.W.; Pierce, R.A. **Cluster fescue (*Festuca paradoxa* Desv.): A multipurpose native cool season grass.** In: Proc., Fourth Eastern Native Grass Symposium. (in press).

Walter, W.D., D.C. Dey, J.P. Dwyer. 2006. **Epicormic response when converting a hardwood forest to a silvopasture.** In: Proc. 15th Central Hardwood Forest Conference, Knoxville, TN, February 27 – March 1, 2006 (in press).

Tree/Crop Interactions:

Ares, A. and D.K. Brauer. 2005. **Above ground biomass partitioning in loblolly pine silvopastoral stands: spatial configuration and pruning effects.** Forest Ecology and Management 219:176-184.

Stamps, W.T., T.L. Woods, R.L. McGraw, and M.J. Linit. 2005. **Arthropod communities in temperate agroforestry: Theory and reality.** pp. 1-6. In: Brooks and Ffolliot (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Alley Cropping:

[A]McGraw, R.L., W.T. Stamps, and M. Linit. 2005. **Yield and maturation of alfalfa in a black walnut alley-cropping practice.** pp. 1-5. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

[B]McGraw, R.L., W.T. Stamps, and M. Linit. 2005. **Alfalfa yield, forage quality, and maturation in a black walnut alley-cropping practice.** Agronomy Abstracts (CD-ROM), ASA Madison, WI.

Mungai, N.W., P.P. Motavalli, R.J. Kremer, K.A. Nelson. 2005. **Spatial variation of soil enzyme activities and microbial functional diversity in temperate alley cropping systems**. Biology & Fertility of Soils. 42(2):129-136.

Mungai NW. P.P. Motavalli, K.A. Nelson, R.J. Kremer. 2005. **Differences in yields, residue composition and N mineralization dynamics of Bt and non-Bt maize.** Nutrient Cycling in Agroecosystems. 73(1):101-109.

Nut Trees:

Hunt, K.L., M.A. Gold and M.R. Warmund. 2005. **Chinese Chestnut Cultivar Performance in Missouri.** Acta Horticulturae 693: 145-148.

Reid, W. 2006. **A fresh look at native tree spacing.** Pecan South 38(12):4-6.

Reid, W., M.V. Coggeshall and K.L. Hunt. 2005. **Black walnut cultivars for nut production**. Walnut Council Bulletin 32(3):1,3,5,12,15.

Reid, W. 2005. **Be prepared for success.** Pecan South 38(9):9-10.

Reid, W. 2005. **Blame it on the weather.** Pecan South 38(4):4,10.

Reid, W. 2005. **Focusing on natives.** Pecan South 37(12):4-8.

Warmund, M.R., K.L. Hunt, and M.A. Gold. 2005. **Removal of secondary burs increases average nut weight from primary burs of 'Armstrong', 'Orrin' and 'Willamette' Chinese chestnuts.** Acta Hort. 693:149-151.

Van Sambeek, J.W.; Garrett, H.E. 2005. **Ground cover management in walnut and other hardwood plantings.** In: Michler, C.H.; Pijut, P.M; Van Sambeek, J.W.; and four others. Black walnut in a new century (Proc., Sixth Walnut Council Symposium). Gen. Tech. Rep. NC-243. U.S. Department of Agriculture, Forest Service, North Central Research Station: 85-100.

Bottomland Restoration and Wildlife Habitat

Dey, D.C.; Kabrick, J.M.; Gold, M.A. 2005. **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-262: 3.

Kabrick, J.M.; Dey, D.C.; Van Sambeek, J.W.; Wallendorf, M.; Gold, M.A. 2005. **Soil properties and growth of swamp white oak and pin oak on bedded soils in the lower**

Missouri River floodplain. Forest Ecology and Management 204: 315-327.

Kabrick, J.M.., D.C. Dey and J.R. Motsinger. 2006. **Evaluating the flood tolerance of bottomland hardwood seedlings.** In: Buckley, D.S. and others, editor. Proceedings of Fifteenth Central Hardwood Forest Conference. Gen. Tech. Rep. SRS-___. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. (in press).

Navarrete-Tindall, N. and R. A. Pierce 2005. **2005 Final Report: Quail Cover Bundle Project.** Submitted to the Prairie Fork Trust. Williamsburg, Mo. 7 p. (Available from Navarrete-Tindall).

Vradenburg, J. 2005. **Distribution and abundance of anurans in southeast Missouri.** M.S. thesis, University of Missouri-Columbia, Columbia.

Riparian Forest Buffers and Water Quality

Anderson, S.H., R.P. Udawatta, T. Seobi, and H.E. Garrett. 2005. **Soil water content and infiltration in agroforestry buffer strips.** pp. 1-17. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Bailey, N., P.P. Motavalli, R.P. Udawatta, and K. Nelson. 2005. **Effects of landscape position and temperate alley cropping practices on soil carbon dioxide and nitrous oxide flux in an agricultural watershed**. pp. 1-14. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Herring, Joseph P. 2005. **Watershed planning in northeast Missouri: Identifying needs and opportunities for riparian forest buffers in the Mark Twain watershed.** MS Thesis, Iowa State University.

Lin, C.H., Lerch, R.N. Kremer, R.J. Garrett, H.E. Udawatta, R.P. and George, M.F. 2005. **Soil microbiological activities in vegetative buffer strips and their association with herbicide degradation.** pp. 1-10 . In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Lin C.H., R.N. Lerch, H.E. Garrett, M.F. George. 2005. **Incorporating forage grasses in riparian buffers for bioremediation of atrazine, isoxaflutole and nitrate in Missouri.** Agroforestry Systems. 63(1):91-99.

Seobi, T., S.H. Anderson, R.P. Udawatta, C.J. Gantzer. 2005. **Influence of grass and agroforestry buffer strips on soil hydraulic properties for an Albaqualf.** Soil Sci. Soc. Am. 69: 893-901.

Udawatta, R.P, S.H. Anderson, C.J. Gantzer and H.E. Garrett. 2006 **Agroforestry and grass buffer influence on macropore characteristics: A computed tomography analysis.** Soil Science Society of America Journal. (in press)

Udawatta, R.P., S.H. Anderson, and H.E. Garrett. 2005. **Tree, grass, and crop root length densities and soil water content within an agroforestry buffer system.** pp. 1-16. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Udawatta, R.P., S.H. Anderson, P.P. Motavalli, and H.E. Garrett, 2005. **Calibration of reflectrometer sensors for claypan soils.** Agronomy Abstracts 2005. Annual Meetings. Salt Lake City, Utah, Nov. 6-10, 2005. American Society of Agronomy, 677, South Segoe Road, Madison, Wisconsin 53711.

Udawatta, R.P., P.O. Nygren, and H.E. Garrett. 2005. **Growth of three oak species during establishment in an agroforestry practice for watershed protection.** Can. J. For. Res. 35: 602-609.

Zaimes, G.N., R.C. Schultz, T.M. Isenhart, S.K. Mickelson, J.L. Kovar, J.R. Russell, and W.P. Powers. 2005. **Stream bank erosion under different land-use practices in Northeast Iowa.** pp. 1-10. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Socio-economics, Policy and Marketing

Arbuckle, J. Jr., C. Valdivia, A. Raedeke, J. Green, and J. Rikoon. 2005. **The non-operator landowner and agroforestry: An analysis of factors associated with interest in agroforestry practices.** pp. 1-14. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Flower, T., C. Valdivia and H. Dorr. 2005. **Habitus and interest in agroforestry practices in Missouri.** Selected Paper. American Agricultural Economics Association. Providence, Rhode Island, July 24-27. Published Electronically in AgEcon Search http://agecon.lib.umn.edu/cgi-bin/pdf_view.pl?paperid=16298&ftype=.pdf.

Gold, M.A., M.M Cernusca and L.D. Godsey. 2005. **Chestnut Market Analysis Producer's Perspective.** UMCA Publication 34 p. www.centerforagroforestry.org/pubs/chestnutmarketreport.pdf.

Gold, M.A., M.M. Cernusca and L.D. Godsey. 2005. **Competitive market analysis -- chestnut producers.** pp. 1-16. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Gold, M.A., M.M. Cernusca and L.D. Godsey. 2005. **Update on consumers' preferences on chestnuts.** HortTechnology 15(4):904-906.

Gold, M.A., L.D. Godsey and M.M. Cernusca. 2005. **Applying the five forces model to competitive market analysis of Eastern red cedar.** Forest Products Journal 55(12): 58-65.

Valdivia, C. and C. Poulos. 2005. **Factors affecting farm operators' interest in incorporating riparian buffers and forest farming practices in Northeast and Southeast Missouri.** pp. 1-14. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Valdivia, C., H. Dorr, J. Arbuckle, J. Love, S. Rikoon and M. Gold. 2006. **Profiles of Missouri rural livelihoods in four research regions: Social, economic, institutional, and ecological characteristics**. Agricultural Economics Working Paper 2006-2. Department of Agricultural Economics, University of Missouri Columbia. MO.

National Agroforestry Center

Bentrup, G. 2005. **Visualizing agroforestry alternatives or pixel this!** pp. 1-6. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Bentrup, G. M. Schoeneberger, M.G. Dosskey, G. Wells, T. Kellerman. 2005. **Tool time: Melding watershed and site goals on private lands.** pp. 1-8. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

Bentrup, G. 2005. **Getting the most out of riparian buffers.** BufferNotes. February.
Bentrup, G. 2005. **Visualizing buffer alternatives.** BufferNotes. April.

Francis, C.A., M.L. Schneider, P. Skelton, M. Schoeneberger, and G. Bentrup. 2005. Methods for designing future food systems in peri-urban areas. Proc. Visualizing Food and Farm Meetings, Agriculture, Food and Human Values Society, Portland, Oregon. June 11. p. 48-49.

Tomer, M.D., M.G. Dosskey, M.R. Burkart, D.E. James, M.J. Helmers, and D.E. Eisenhauer. 2005. **Placement of riparian forest buffers to improve water quality**. pp. 1-11. In: Brooks and Ffolliott (ed.) 9th North American Agroforestry Conference Proceedings. (non-paginated CD-ROM).

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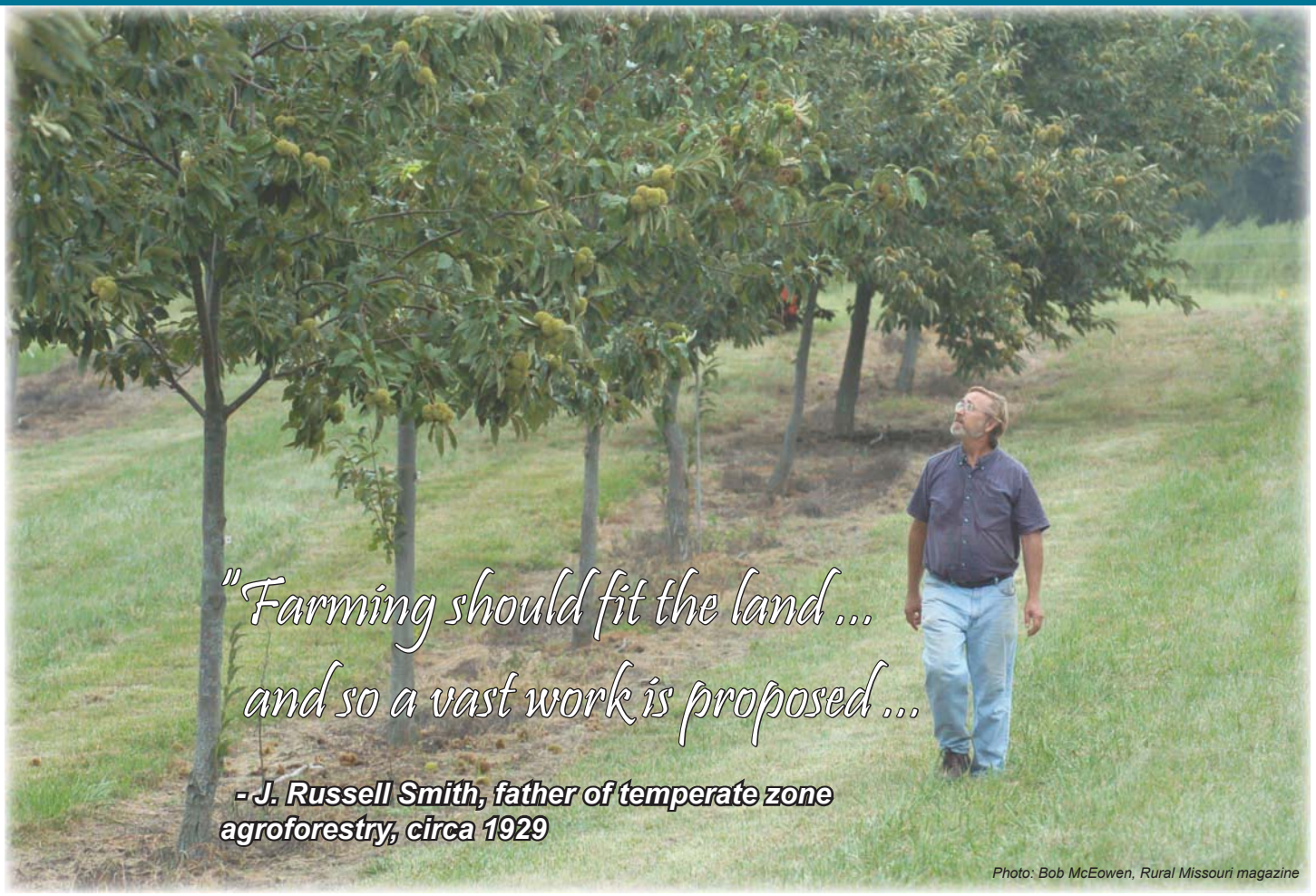
2005 Research Highlights: Research, Partnerships & Technology Transfer



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