University of Missouri

CENTER FOR AGROFORESTRY

2003 Research Highlights
Research, Partnerships & Technology Transfer

"We see land as a community to which we belong ..."

UNIVERSITY OF MISSOURI CENTER FOR AGROFORESTRY • UMCA •

New market opportunities. Sustainable agriculture. Land stewardship. Habitat for wildlife. Improved water quality. Diversified farming. Successful entrepreneurship. In a nutshell, *agroforestry*.

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

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

UMCA Philosophy:

"A farm can be regarded as a food factory and the criterion for its success is saleable products. Or, it can be regarded as a place to live, and the criterion for its success is harmonious balance between plants, animals and people; between the domestic and the wild; and between utility and beauty." - Aldo Leopold

To practice our philosophy, UMCA:

- Conducts, coordinates and promotes research on agroforestry practices to improve the production and protection functions of agricultural and forest lands.
- Conducts, coordinates and promotes interdisciplinary research on the social, economic and market dimensions of agroforestry.
- Implements a technology transfer program that increases the awareness and adoption of agroforestry practices.
- Conducts, coordinates and promotes interdisciplinary research on the policy dimensions of agroforestry.
- Provides formal educational opportunities in agroforestry through the University of Missouri.
- Develops and carries out a collaborative international agroforestry program in the areas of instruction, research and outreach.

Goals for our efforts:

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

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

-- Aldo Leopold, *A Sand County Almanac,* 1949

To Our Friends

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

"We see land as a community to which we belong..."

From the Director:

Dear friends of UMCA,

We are pleased to present our 2003 review of research and current projects. As you will see, our fifth year as a University of Missouri big "C" center has been a groundbreaking and productive year for the Center for Agroforestry.

We continue to expand and enhance our efforts to establish agroforestry practices across Missouri and the Midwest as we seek to enable farm and forest land owners to remain profitable for generations to come, while conserving our precious natural resources.

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

The initiatives and accomplishments described in the following pages are only the beginning of what UMCA and its diverse group of associated partners and collaborators are striving to achieve.

At the Center for Agroforestry, we do believe land is a community to which we all belong. But with the privilege of land ownership comes a great responsibility - we must all contribute to the nurturing and stewardship of this land, working through financial and environmental challenges with determination and ingenuity.

As we move ahead to see the impacts of agroforestry come to fruition, we will continue to be inspired by our friends, our partners, and the innovative landowners we serve. Thank you for being part of our community.

Best regards,
Gene

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The Five Practices of Agroforestry

Agroforestry is a set of integrated land use practices that combines trees, shrubs, forages, grasses, livestock and crops using innovative and flexible combinations tailored to the landowner's needs. The goal of agroforestry is to optimize production and conservation benefits.

The University of Missouri Center for Agroforestry (UMCA),established in 1998, strives to initiate and coordinate agroforestry activities within the state of Missouri and to enhance the development of agroforestry within North America and the temperate zone worldwide. The Center is a leading institution for biophysical, economic and social research related to temperate agroforestry and its benefits to landowners and the environment.

Agroforestry practices can:

- Increase and diversify products, markets, and farm income
- Improve soil quality, reduce erosion, reduce nonpoint source pollution
- Improve water quality and reduce damage due to flooding
- Enhance wildlife habitat and improve biodiversity

The Five Practices of Agroforestry:

1. 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.

2. 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.

3. Silvopasture

Silvopasture is the intentional combination of trees, forage and livestock managed as a single integrated practice. 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. The trees also provide shade and shelter for livestock.

4. 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.

5. Windreaks

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, cereal, 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.

Paul Smith
20-acre alley cropping practice
Northwest Missouri, near Claremont

"In 1999 we seeded this field to orchard grass, and alfalfa. The first cutting this year produced about 3 ton per acre, and I feel that we benefit from the alley cropping because we have a short term benefit of the crops between the tree rows -- and eventually, my family or someone else will benefit from the tree crop."

Agroforestry Success Stories

Jim Wilson Operates a silvopasture practice with walnut and pecan trees near Nevada, Mo.

"Ever since we've been in nut production we've used cattle to control the height of the grass. We also benefit from the value of the beef that we sell in the fall in addition to the nuts that we harvest.

We chose cattle to run in here because we fertilize these trees with nitrogen and it causes the grass to grow. By grazing, it gives us extra profit from the beef. And it also helps where we don't have to mow as much.

Another thing that we like about the trees is that it's cooler on a hot summer day. It's at least ten degrees cooler down here, and the cattle are just scattered out everywhere grazing."

Ron Risdal - Corn soybean and alfalfa producer in Story County, Iowa. Planted riparian buffer in 1990.

"I don't think we've lost hardly any stream bank since 1993, where before, we were moving the fences about every year.

When it floods, the water stops at the buffer strip now instead of washing all over the bank. We don't have to move fences every year, and we don't have to haul rocks in the
gullies like we used to do years ago."

Partnerships

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

Internal Collaborations:

-College of Agriculture, Food and Natural Resources -- Partnerships with nine departments: Animal Science, Horticulture, Forestry, Agricultural Economics, Rural Sociology, Entomology, Agronomy, Plant Pathology and Fisheries and Wildlife.

-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.; and the Greenley Research Center, Novelty, Mo.

-University of Missouri Extension

External University Partnerships:

The Agroecology Issue Team, Iowa State University

Dusty Walter, Agroforestry Technical Training Specialist, talks with landowners about a plan for their forested areas.

Private lands initiatives/ Research Initiatives:

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

-USDA Forest Service State and Private Forestry Division: Collaborated to produce a Special Forest Product Production and Marketing Workshop to identify additional income sources for forest and landowners.

-U.S. DOE: Received Ameriflux site grant for carbon sequestration research.

-USDA ARS National Germplasm Resources Laboratory: Received awards to support ongoing research in the genetic improvement of eastern black walnut.

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

Federal and State Agency Partnerships:

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

Professional Associations:

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

Organizational Accomplishments: UMCA research dollars support research projects involving 100 individuals including university faculty, Federal and State agency research scientists, post-doctoral staff, research specialists, graduate research assistants, undergraduate students and support staff.

UMCA Key Accomplishments:

- Trains and supports an average of 12 Master's and 5 PhD students annually toward advanced degrees related to agroforestry, spanning 9 departments

- Initiated ground-breaking research toward the cultivation of the Black Perigord Truffle (gourmet European truffle), a high-profit potential crop for Midwestern landowners

- Supported dendrochronology research to begin the reconstruction of the climate record for the past 14,000 years; research will aid in understanding the impacts of climate change on the Midwest

- Created the most comprehensive long-term research program in the United States to develop Eastern Black Walnut into a horticultural crop

- Established the largest and most comprehensive research program in the United States to develop Chinese Chestnuts into a horticultural nut crop

- Conducted research that determined that trees planted 300 to 500 feet wide as buffers between the Missouri River and levees helped prevent levee failure during flood conditions; information of great value to U.S. Army Corps of Engineers

- In the past 5 years, UMCA researchers have published 54 refereed journal publications; generated an additional $1.1 million in spin-off funding; and leveraged an additional $434,000 from research partnerships

UMCA Faculty and Staff:

Harold E. "Gene" Garrett, Ph.D.
Director
Michael Gold, Ph.D.
Associate Director
Larry Godsey
Research Associate / Economist
Mark Coggeshall
Tree Improvement Specialist / Research Analyst
Julie Rhoads
Technical Training Specialist / Events Coordinator
Dusty Walter Technology Transfer / Research Specialist
William Reid. Ph.D.
Adjunct Associate Professor
Ken Hunt, Ph.D.
Post-Doctoral Fellow
Bonnie Beckett
Sr. Administrative Assistant
Rachel McCoy
Sr. Information Specialist

Associate Staff:

Ray Glendening - Farm Manger, HARC
Kenny Bader - Forestry
Wayne Bishop - Forestry
Nancy Bishop - HARC
Terry Woods - Entomology
Melissa Niedermann - Agronomy
Cory Schmidt - Forestry
John Thompson - Agronomy
Randy Thiessen - Horticulture

Associate Faculty, Staff and Collaborators:

Faculty:

Johann Bruhn, Ph.D. - Plant Pathology
Bruce Cutter, Ph.D. - Forestry
John Dwyer, Ph.D. - Forestry
Milon George, Ph.D. - Forestry
Richard Guyette, Ph.D. - Forestry
Mickey Heitmeyer, Ph.D. - Fisheries & Wildlife
Rob Kallenbach, Ph.D. - Agronomy
Monty Kerley, Ph.D. - Animal Science
William Kurtz, Ph.D. - Natural Resources
David Larsen, Ph.D. - Forestry
Marc Linit, Ph.D. - Entomology
Bob McGraw, Ph.D. - Agronomy
Jeanne Mihail, Ph.D. - Plant Pathology
Rose-Marie Muzika, Ph.D. - Forestry
Steve Pallardy, Ph.D. - Forestry
Bob Pierce, Ph.D. - Fisheries & Wildlife
Sandy Rikoon, Ph.D. - Rural Sociology
Mark Ryan, Ph.D. - Fisheries & Wildlife
Robert Sites, Ph.D. - Entomology
Chris Starbuck, Ph.D. - Horticulture
Corinne Valdivia, Ph.D. - Agricultural Economics
Michele Warmund, Ph.D. - Horticulture

Post-Doctoral Fellows:

Chung-Ho Lin, Ph.D. - Forestry
Terrell Stamps, Ph.D. - Entomology
Ranjith Udawatta, Ph.D. - Forestry

Collaborators:

Gary Bentrup - USFS/NAC
David Brauer, Ph.D. - ARS/USDA
Joe Colletti, Ph.D. - ISU Forestry
Dan Dey, Ph.D. - USFS
Michael Dosskey, Ph.D. - USFS/NAC
John Kabrick, Ph.D. - USFS
Rob Myers, Ph.D. - Jefferson Institute
Richard Schultz, Ph.D. - ISU Forestry
Michele Schoeneberger, Ph.D. - USFS/NAC
Jerry Van Sambeek, Ph.D. - USFS
Doug Wallace - NRCS
Gary Wells - NRCS/NAC

Technology Transfer and Outreach

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

Dusty Walter, UMCA Technology Transfer Specialist, talks with landowner Larry Harper about grafting improved black walnut trees. UMCA is conducting research to develop black walnuts as an orchard crop.

Technology Transfer Accomplishments, 2003:

Nearly 1,000 guests attended the first Missouri Chestnut Roast in October 2003, featuring Missouri nut and agricultural food products, educational displays and farm tours of the Horticulture and Agroforestry Research Center; nearly 2,000 guests are expected at the second annual Chestnut Roast on Oct. 16, 2004;

Four issues of Green Horizons, UMCA's newsletter, mailed to a subscription list of 3,700, and growing;

New publications have been produced, including a "NUTrition and Your Health" series on the health benefits of chestnuts, walnuts and pecans; and an Eastern Red Cedar Market Analysis and Directory;

New Agroforestry Training Manual was developed for use as an educational tool across the Midwest;

UMCA organized 15 technology transfer events or special, multi-speaker workshop or training sessions within larger conferences;

UMCA technology transfer staff coordinated, conducted or participated in 16 field tours;

UMCA technology transfer staff gave more than 40 presentations on various dimensions of agroforestry locally, regionally, and nationally;

UMCA exhibit traveled to 33 different agricultural events, targeting landowners and natural resource professionals;

Video production for new Forest Farming DVD has been completed in preparation for new DVD of the five practices of agroforestry.

"Just a note to let you know we appreciate your having a booth at the National Small Farm Trade Show & Conference for the past several years, and for giving a short course on agroforestry and silvopasture last year."

"Attendee surveys rated that talk as **one of the 10 most popular talks** at the Show (based on attendance and survey ratings)."

"I know farmers appreciate having agroforestry information available; your booth adds to the Show."

- ***Paul Berg, Managing Editor***
Small Farm Today magazine
Conference Attendance: 4,391

Landowners at the annual Small Farm Trade Show enjoy an informational video about silvopasture practices at the UMCA exhibit.

Missouri Chestnut Roast:
Connecting Missouri Families to the Land

Nearly 1,000 in attendance at first annual Chestnut Roast

Guided tours of 660-acre Horticulture and Agroforestry Research Center featuring diverse agroforestry practices

Educational booths from Missouri value-added agriculture vendors and University agricultural and environmental research programs

Showcase for Missouri's outstanding agricultural products, including wines; jams and jellies; pecan, walnut and chestnut products; locally-produced honey; cheeses and meats

Children's Tent, farm display, family activities and music

Set amidst the beautiful Missouri River Hills, the Roast serves to showcase 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, an emerging value-added crop for Missouri, and samples and displays of Missouri pecans and black walnuts

Photo: Jim Curley

A Chestnut Success Story
Julie Price, CEO
Taste of the Kingdom

Missouri-made food products,
Kingdom City, Mo.

"In continuing our mission of supporting Missouri niche agriculture through the production and sale of value-added, all natural, kosher certified products, we began work with the MU Center for Agroforestry in February to develop new value-added products using chestnuts for the Missouri Chestnut Roast. We were confident our new fruit line (using Missouri grown produce, of course) would sell, but ***we had no idea there would be so much interest in chestnuts!*** *Not only did our four chestnut sauces sell, but people wanted to buy our display chestnuts as well! We received absolutely no negative reactions to the new concept of chestnuts as a sauce ingredient, but rather were confronted with a myriad of questions (e.g. what is a chestnut?) which opened the door to educate the public on chestnuts as a new Missouri niche crop."*

Julie Price
- Oct. 6, 2003

Estimated Economic Impact of 2003 Chestnut Roast:

$9,504 from local visitors
$10,425 from out-of-town guests

* Figures estimated by Columbia Convention and Visitors Bureau

Current Research Initiatives

Since 2003, UMCA has been supported by and managed three significant USDA - ARS programs, representing more than 50 individual projects. The Center seeks to develop the scientific basis for designing and prescribing agroforestry practices within a "systems context," which allows technology to be used most effectively. To achieve this goal, our research efforts have been organized into eleven research "clusters" to enhance creativity and productivity among a range of investigators from many disciplines. UMCA research continues to serve as a catalyst for stimulating the development of agroforestry throughout the United States.

Clusters include:

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

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

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

4) Socio-economic-marketing research: The cluster's integrated approach responds to the need to facilitate adoption of new practices in agroforestry, which requires understanding of the social and economic relations of a given enterprise. These relations include institutions, networks, markets, technology, and environment. Research activities will provide an understanding of important factors that facilitate or constrain involvement in agroforestry.

Above: Aerial view of HARC showing the chestnut, black walnut and pecan research orchards. **Top:** UMCA researcher Ken Hunt speaks to a group about Chinese chestnut. **Below:** Tree Improvement Specialist Mark Coggeshall examines black walnut grown on a trellis system.

Aerial view of 12-channel Flood Tolerance Laboratory at the HARC farm. **Inset:** Researchers are testing the flood tolerance of several tree species, including oak.

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 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, pot-in-pot production, pine straw, woody and non-woody florals.

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

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

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

Aerial view of double- and triple-row silvopastoral plantings. **Below:** Cattle graze in a silvopasture research area.

Researchers are working on the development of pine straw as a profitable mulch industry for Missouri. **Right:** Pine straw is baled. **Far Right:** The pitch x loblolly pine research test at HARC. **Top Right:** The gravel bed is a tool for improving the survival of trees and shrubs in agroforestry.

Environmental Protection Research

Non point source pollution of surface and ground waters linked to agricultural practices is a serious concern in the United States. Excess nitrogen and phosphorus runoff have resulted in the "dead zone" in the Gulf of Mexico, and through water runoff and soil erosion, agrochemicals from herbicides and other treatments may reach rural or urban water sources and generate millions of dollars in water treatment costs each year. UMCA researchers are investigating agroforestry practices, including alley cropping and riparian forest buffers, as environmentally beneficial solutions to non point source pollution that also provide economic benefits to landowners.

Riparian Forest Buffers Shown to Reduce Non Point Source Pollution and Runoff

Project: Agroforestry Practices, Runoff, and Nutrient Loss: A Paired Watershed Comparison. **Project Team:** Ranjith Udawatta; Harold "Gene" Garrett; Stephen Anderson; Tshepiso Seobi, M.S. candidate; Peter Motavalli; Neil Bailey, M.S. candidate

Study Methods:

The study is being conducted at the University of Missouri-Greenley Memorial Research Center in Knox County, Mo. Three adjacent north-facing watersheds designated as "east," "center," and "west" with land areas of 1.65, 4.44 and 3.16 ha, respectively, were instrumented with H-flumes and flow measuring and sampling devices in early 1991 (Fig. 1). Each watershed is drained by a grass waterway that leads into a concrete approach structure and an H-flume. The control (east) watershed is instrumented with a 0.91 m (3') flume while the other two watersheds are instrumented with 1.37 m (4.5') flumes. Treatments were randomly assigned and implemented in 1997.

Four and one half m (15') wide contour grass-legume strips consisting of redtop (*Agrostis gigantea* Roth), brome grass (*Bromus* spp.), and birdsfoot trefoil (*Lotus corniculatus* L.) were established at 36.5 m (some in lower slope positions were 22.8 m apart) intervals on the agroforestry (center) and contour strip (west) watersheds in June 1997 (Fig. 1).

Pin oak (*Quercus palustris* Muenchh.), swamp white oak (*Q. bicolor* Willd.), and bur oak (*Q. macrocarpa* Michx.) were planted 3 m apart down the center of the grass-legume strips of the agroforestry watershed in November1997. Trees had almost 100% survival rate in spite of deer damage and a severe drought in 1999. Five-cm mesh, one-m diameter welded wire fences were installed in 1999 to protect trees from deer damage.

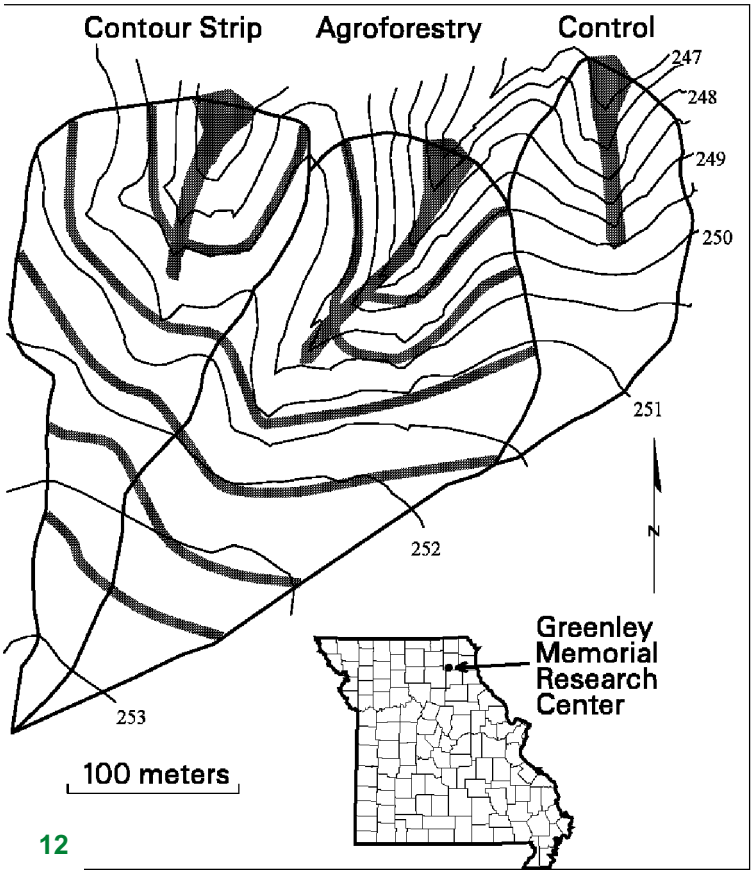

Figure 1: **(Left)** Study site location and 0.5-m-interval topographic maps of contour strip, agroforestry and control watersheds. Broad gray areas represent grass strips (contour strip), trees and grass strips (agroforestry), and grass waterways (contour strip, agroforestry and control).

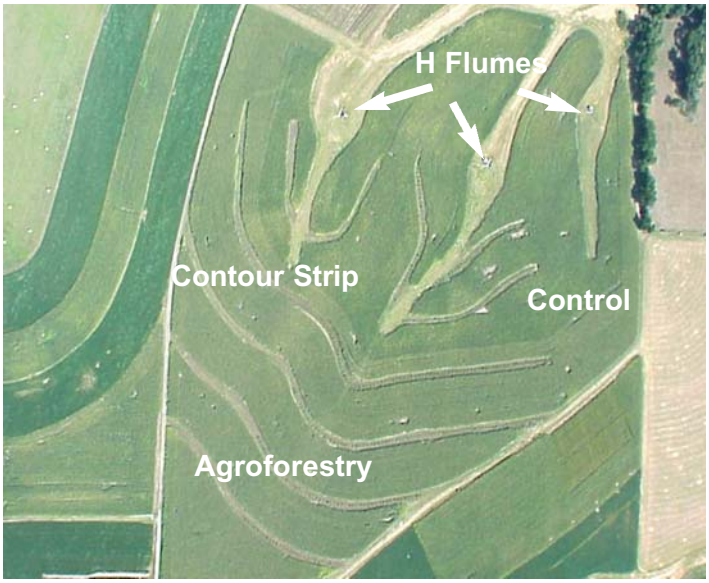

Figure 2: Photo taken in August 2002 (at 5,000 feet elevation).

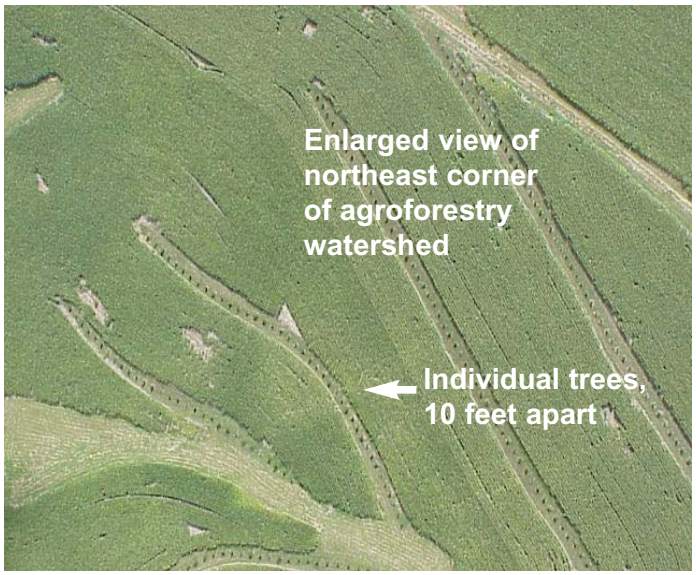

Figure 3

During the (1991-1997) calibration and subsequent three-year treatment periods, runoff was measured in 0.91 and 1.37 m H-flumes with ISCO bubbler flow meters. Composite samples were analyzed for sediment, total phosphorus (TP), total nitrogen (TN), nitrate and ammonium.

Key Findings:

1. Incorporation of agroforestry practices into row-crop agriculture has been shown to reduce runoff by 10% compared to a row-cropped watershed.

2. The contour strip treatment reduced erosion by 19% in 1999.

3. Treatments reduced total phosphorus loss by 8 and 17% on contour strip and agroforestry watersheds, compared to the control watershed.

4. The contour strip and agroforestry treatments reduced total nitrogen loss by 21 and 20%, respectively, during a large precipitation event in the third year after establishment.

5. During the third year of treatments, nitrate N loss was reduced by 24 and 37% by contour strip and agroforestry treatments, respectively.

Udawatta, R.P., J.J. Krstansky, G.S. Henderson, and H.E. Garrett. 2002. Agroforestry practices, runoff, and nutrient loss: A paired watershed comparison. *J. Environ. Qual.* 31: 1214-1225

Far Left: Tree buffers and agroforestry alley cropping on the agroforestry watershed.

Left: This photo, taken in 2004, shows a pin oak tree from the agroforestry watershed, seven years after planting.

Climate Change Research

Ancient oaks buried in Missouri streams reveal the benefits of riparian forests and document agricultural climate over the last 14,000 years

Research Team: Richard Guyette, Michael Stambaugh and Daniel Dey

Recent research at the University of Missouri has illuminated the hidden, long-term importance of riparian forests in understanding carbon sequestration, aquatic habitat and climate change.

Riparian Forests, Forest Buffers, and Carbon Budgets

Despite considerable knowledge of carbon storage in forests and soils, few studies have addressed carbon storage in riparian areas associated with lakes and rivers. Using tree-ring analysis and carbon dating, researchers evaluated the age distribution of carbon in large aquatic wood. This study revealed that large woody debris can reside and sequester carbon for a considerably longer amount of time when submerged in freshwater or riparian ecosystems, in comparison to above-ground land ecosystems.

Research studies were designed to examine the relationship between the age (residence time) and heartwood density of oak trees. Cross sections of oak wood were collected from streams and rivers in northern Missouri, with a sample of 40 white oaks and 5 red oaks. A density measurement was taken from the outermost section of the trunk using both a wet volume of the wood and its oven-dry weight. Dendrochronology methods were used to date the wood formed within the last several hundred years, and radio-carbon dating methods were used for wood formed before 1800 A.D. Four oak trees were carbon dated to show ages greater than 10,000 years and 25 trees greater than 1,000 years. One bur oak, dated to 12,320 years B.P., showed a density of 20 to 25 percent that of a living oak tree, and still retained bark samples, light colored sapwood, a discernable ring structure and its original circular shape (Guyette and Stambaugh, 2003). This type of wood may represent a distinct type of carbon sink that can be a critical source of habitat for **at least 9 orders of invertebrates**, such as leeches, crayfish, and chironomids.

Figure 1: *This large oak grew, died, and was buried within stream sediments for more than 7,750 years. In Missouri streams, trees like this store carbon for an average of 2,000 years making this one of the longest carbon cycles known. These unique trees, from the heart of the US agricultural region, could provide an annual record of climate variability that is over 10,000 years long.*

Key Findings:

1) Although riparian areas, including floodplains, represent about 15% of the landscape, they may sequester carbon in large woody debris **10 times longer** than the landscape as a whole (Guyette, et. al., 2002)

2) Large woody debris shows a mean residence time of 261 years in small lakes, but 350 to 800 years in a stream reach (Guyette, et. al, 2002)

3) Ancient oak submerged in streams may represent a distinct type of carbon sink that can be a critical source of habitat for **at least 9 orders of invertebrates**

Guyette, R.P., W.G. Cole, D.C. Dey, and R.M. Muzika. 2002. Age distributions of large woody debris in riparian carbon pools. *Canadian Journal of Fisheries and Aquatic Sciences* (593): 578-585

(Guyette and Stambaugh, 2003)

Climate Variability of the Agricultural Heartland: The Importance of Tree-Ring Records

by Richard Guyette, Ph.D., University of Missouri Forestry Professor and UMCA Research Collaborator

Tree-ring research of ancient oak wood indicates that the construction of tree-growth records thousands of years in length is very possible. These records are invaluable, containing long-term information about climate and plant growth variability for a region that is a global source of food commodities.

Tree-rings are one of the best sources of paleoclimate data because they are distinctively annual, climate sensitive, and can contain information about specific events such as periodicity of Dust-Bowl like droughts, the frequency of spring freezes, or the timing of extreme flooding. The potential for developing a long tree-ring record from ancient oak wood is excellent as it is relatively abundant (about 10 logs > 1000 years old per mile of stream reach) and very well preserved. For example, oak trees that are 12,000 years old have been found with bark still intact. No other climate record of this length and type exists in Eastern North America. Furthermore, long tree-ring chronologies are globally rare and proxies of long-term climatic variability are needed for understanding historic natural climate variation and future climate changes. The importance of the climate record from ancient oak trees is underlined by its geographic position within the most economically important agricultural region in the United States.

Much progress has been made on constructing the tree-ring record. Wood sampled in streams has been ^{14}C and tree-ring dated and range in age from modern to 13,818 years BP (before present). Oak samples in each 500-year period from present to 14,000 years BP have been found, suggesting the possibility of constructing a tree-ring chronology that is continuous through the Holocene period. Individual ancient trees have shown up to 290 annual tree-rings.

As cross-sections are accumulated from trees that grew contemporaneously, ring-width chronologies are constructed for use in climate reconstruction. The ring-width series from live trees was used to construct a chronology that covers the last 200 years and then began overlapping and extending the record back in time using wood taken from stream sediments. One hundred sixty oak trees have been collected and ^{14}C and/or tree-ring dated. Currently, the project team has constructed records for the period 1500 to 2003 AD and approximately 980 to 1540 AD. In addition, kernels for four additional oak chronologies within the last 14,000 years have been located. The tree-ring record is correlated with Palmer Drought Severity Indices (PDSI) and will provide a proxy of historic growing conditions. Tree-ring records are being analyzed for periodicity, such as El Niño, and other climate related information such as past evidence of abrupt climate change.

These records are invaluable as they contain long-term information about climate and plant growth variability for a region that is a global source of food commodities.

In the midwestern region, oak trees that are 12,000 years old have been found with bark still intact. No other climate record of this length and type is known to exist in Eastern North America.

References for further reading
(Dey et. al., 2003)

Missouri Tree-Ring Laboratory Website.:
www.missouri.edu/~guyetter

Extending the Value of Agroforestry

Silvopasture Grazing Research

The Center for Agroforestry is working to reduce hay costs and extend the livestock grazing season through silvopasture practices. Winter hay costs for feeding one steer can reach $91; the managed grazing practice of silvopasture can reduce this amount significantly. **Well managed silvopastures can reduce winter feed costs by approximately 20%** (Kallenbach et.al., 2003).

With more than 13 million acres of pasture lands dedicated almost entirely to beef production, Missouri is in a position to greatly benefit from the economic and environmental benefits of silvopasture.

Project Team: Robert Kallenbach and Monty Kerley

In this study, researchers tested the value of silvopasture in late fall/early spring forage production in a beef cattle operation. The forage production and performance of beef calves grazing annual ryegrass/cereal rye pastures in a silvopastoral system was compared to a pasture system without trees. A mixture of annual ryegrass and cereal rye were planted into an established pine/walnut alley cropping study (tree pasture), and the same forages were planted into pastures without trees (open grazing pasture). Silvopasture is best thought of as a component of an overall integrated grazing system. Animals were rotationally grazed between sub-pastures with a 1-3 day grazing period based on forage availability. Average daily gain (0.75 kg hd-1 d-1), animal days (607 d ha-1), and beef production (456 kg ha-1) for heifers was equal for both treatments.

Key Findings:

- Seasonal forage production was greatest from the tree treatment in early spring, while the open pastures produced more forage in late spring.

- The microclimate effect of the trees stimulated early spring growth in the tree treatment and would help livestock producers get cattle on pastures earlier in spring

- Silvopastures can be as productive as conventional pastures and beef producers could expect similar livestock weight gain using either system. However, because the silvopastures have the added benefit of producing wood products for future revenue, they show higher economic returns in the long term.

([A]Kallenbach et. al., In Review)

Importance of Silvopasture Research with Ryegrass and Cereal Rye:

Annual ryegrass/cereal rye pastures are becoming popular with beef producers wanting to extend the grazing season.

These forages have the advantages of rapid autumn growth rates and the ability to produce and maintain high quality forage when most other forages are dormant.

Annual ryegrass/cereal rye pastures are of interest to small scale farmers who wish to retain ownership of stocker calves through the backgrounding stage as calf gains often exceed 0.6 kg hd-1 d-1 in winter.

Annual ryegrass/cereal rye pastures fit well into a silvopasture system.

These forages grow primarily when most tree species are either dormant or not under heat or drought stress. As a result, they would be expected to compete only minimally with the trees.

Cattle graze in an open pasture setting at the Horticulture and Agroforestry Research Center.

Cattle graze in a pine silvopasture practice, which demonstrated economic benefits to landowners in this study.

Flood Research: Woody corridors along river levees can significantly reduce levee failure and save millions of dollars in repair costs

Project: Assessing the value of woody corridor buffers in levee protection along the Missouri River

Project Team: John Dwyer, Douglas Wallace, David Larsen and Liz Cook; Graduate Research Assistant: Stephen Allen

The wrath of the Mighty Missouri River burst from its banks in 1993 and became a roaring torrent that reclaimed its original boundaries. The river, then several miles wide in places, left behind a landscape scoured by erosion and inundated with sand deposits and covered with debris. These bottomland landscapes are some of the most productive and richest farmlands in the world -- **the economic losses from crops alone exceeded $235 million. Repair costs to U.S. Army Corps of Engineer levees reached $250 million.**

As the floodwaters receded, an aerial inspection and field evaluations appeared to indicate that woody tree corridors may have played a critical role in protecting levees from failure. Research efforts began in 1993 to find out if corridors of woody trees were instrumental in protecting levees from breaking. If this was true, then researchers needed to know if there was a "critical" width of tree corridor that would result in not only fewer levee failures, but also a reduction in the size of a levee break. If high-risk flood-prone areas along the river are protected by a buffer of trees between the levee and the river bank, potentially millions of dollars in taxpayer monies could be saved from the repair of damaged levee systems as well as the reclamation of hundreds of thousands of acres of rich farmland. Wildlife habitat, biomass and other value-added product opportunities are additional benefits of establishing woody corridors.

The Flood of 1993 destroyed some of the richest farmland in the world.
Photo: Jim Curley

Properly designed flood corridors using trees can play a vital role in accomplishing many important functions:

1) slow floodwaters and reduce floodwater energy
2) mitigate the scouring and shearing effects of floodwaters on levees
3) Increase levee stability and reduce the impacts of floods on farmland, roads, railways, water drainage structures and utilities
4) increase wildlife habitat and diversity
5) provide opportunities for production of profitable agricultural products, including woody biomass

The 1993 Missouri River levee pilot study of a 49-mile segment of the lower Missouri River revealed that when there is a woody corridor between the levee and the river, there are significantly fewer levee breaks. In fact, **if the woody corridor is at least 300 feet wide, then the chances that the levee will break are reduced by 80 percent.**

In 1997, the study was expanded to a 353-mile stretch of the river from Kansas City to St. Louis, and through detailed geographic information and aerial photography, researchers learned that **28 percent of the 1993 levee failures were associated with discontinuities in the woody corridor.** In fact, along the entire 353-mile study area, **the levee break length could be reduced by 50% with the presence of woody tree corridors.**

In terms of future floods, it will be very important to identify potential "nick points" in the levee system that can be protected with a woody tree corridor. These "nick points" or gaps in the woody corridor can make the situation significantly worse because the gap acts as a funnel for the water.

Key Findings:

1) 41% of levee failures in the studied segment occurred in areas with no woody corridor

2) 74% and 83% of levee failures occurred where woody corridor widths were less than 300 feet and less than 500 feet, respectively

3) Chances of levee breakage are reduced by 80% if the woody corridor is at least 300 feet wide

4) Median failure lengths with a woody corridor present were 50.3% shorter than median failure lengths with no woody corridor present

5) Discontinuities in woody corridors played a role in nearly 28% of levee failures studied

(Allen et. al, 2003)

Wildlife Habitat Restoration

Wildlife Habitat Restoration: Studying the Relationships Between Agroforestry and Wildlife

Project: Effects of agroforestry practices on wildlife species in major alluvial floodplains **Project Team:** Mickey Heitmeyer and Leigh Fredrickson (Principal Investigators), Shawn Papon, Shane Pruett, John Vradenburg, and Adam Warwick (Graduate Students)

This project is investigating the role of various types, sizes, and locations of forest patches in sustaining wildlife communities in the 100-year floodplain of the Mississippi River in southeast Missouri. Fifteen 4-square mile study sites were randomly selected to represent landscapes containing various amounts and types of forest, including agroforestry patches.

The study is investigating 6 primary wildlife communities (anurans, songbirds, birds-of-prey, bats, swamp rabbits, and waterbirds) and corresponding landscape mosaics on the study sites, and is also documenting relative comparisons among habitat types. Collectively, this is the **largest and most comprehensive landscape-level study of wildlife communities and agroforestry plantings** ever conducted on privately owned forest and agricultural lands in a major alluvial floodplain. Spin-off studies have begun with organizations including the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service/U.S. Geological Survey. In-kind support has been provided by organizations including the Natural Resources Conservation Service and the Missouri Department of Conservation. Future studies are attempting to understand nest success and mortality of songbirds in agroforestry patches and what specific resources wildlife species are utilizing in agroforestry settings.

Inset: Songbird species are benefitting from agroforestry plantings in alluvial floodplains along the Mississippi River in southeast Missouri.

Key Findings Among Wildlife Communities:

Songbirds: Songbird species richness was highest in habitats with the greatest structural complexity, highest plant species richness, most extensive forest patches, and widest range in hydroperiods including: 1) natural forest patches followed closely by agroforestry and strip cover (e.g., fence row, levee, etc. forest corridors); 2) landscapes with high amounts of forest cover; 3) abandoned channels of the Mississippi River; and 4) habitat outside of mainstem levees. Songbird species that prefer young forest patches, such as early successional native forest, were most common in agroforestry patches. Information gleaned on the birds' habitat in relation to levees will be very important to management and site selection for new agroforestry plantings (Papon 2002, Graduate Thesis, University of Missouri).

Bats: Through the use of mist nets and bat detectors, results indicated that bat abundance and diversity was higher in landscapes containing greater amounts of forest cover. Bat abundance and activity was similar in natural forest remnants and agroforestry patches (Warwick 2003).

Swamp rabbits: Distribution of swamp rabbit latrines indicated that areas with high forest cover were used most by swamp rabbits. More swamp rabbits were found in natural forest remnants and in agroforestry plantings located adjacent to natural forest patches, in comparison to other habitats and locations (Warwick 2003).

Waterbirds: To date, 96 biweekly aerial surveys of waterbirds on the study sites have been completed. Abundance, species richness, and distribution of waterbirds is strongly related to geomorphological setting and presence of remnant wetland basins on study sites. Generally, sites with more forest cover, including agroforestry plantings, have retained more natural topographic variation and remnant wetland basins, especially depressions that capture local runoff and create temporary and seasonal surface water. These sites attract the greatest number and abundance of waterbirds, especially wood ducks, mallards, great blue herons, and great egrets. During floods, forest patches including agroforestry are heavily used by wood ducks and mallards (Personal communication, M. Heitmeyer, University of Missouri Fisheries and Wildlife).

Wildlife Habitat Restoration: Reforesting Bottomland Crop Fields With Oak to Restore Wildlife Habitat

Project: Assessment of regeneration methods for establishing oaks in floodplains **Project Team:** Dan Dey (USFS), John Kabrick (USFS), Josh Millspaugh (MU)

Millions of acres of Missouri bottomland forests have been cleared for agricultural production, producing some of the state's most productive farmland. There are areas that are only marginal for agricultural production due to flooding, but these can still be very productive using agroforestry practices. This project provides landowners with methods to establish oak in floodplains to diversify native forests; combine timber, acorn production and the management of wildlife habitat for recreational operations; and restore waterfowl habitats using agroforestry practices.

Above: Redtop grass is an excellent cover crop for oak. **Right**: Rabbit chewing damage to oak seedlings can be extensive if competing vegetation is not controlled.

Key Research Findings: Bottomland Oak Reforestation

- Oak can be established in former bottomland crop fields by planting large container grown oak seedlings with a cover crop of redtop grass, producing a 98 percent survival rate after 4 years.

- Rabbit damage, a major cause of regeneration failure, was greatly reduced in the redtop fields as the wildlife habitat became more open to rabbit predators (raptors).

- **Acorn production in large container seedlings of swamp white oak that were only 18 to 24 months old is phenomenal** compared to production in natural oak stands, which often do not produce acorn crops for 20 to 30 years. This is a major benefit to landowners who want acorn production for wildlife purposes, and it is important in providing a local seed source that makes possible natural regeneration of oak in the future (Dey et. al., 2003).

(Dey et. al., 2003)

Songbird Reforestation in Missouri River Bottomlands

Project Team: Dirk E. Burhans (MU), (GRA) Brian G. Root (MDC), and Daniel C. Dey (USFS), Maria A. Furey, Graduate Student

Songbirds represent an increasingly popular recreational activity. **In 2001, U.S. wildlife recreationists 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. As part of the larger oak restoration study, a research project was developed to examine songbird use of planted oak habitats in Lower Missouri River bottomlands. Comparisons were made between 40-acre blocks of land planted in oaks with a covercrop of redtop grass (*Agrostis alba*); land planted in oaks with no cover crop; and a control block where natural vegetation was unmanipulated. Early results suggest these planted Missouri River bottom land habitats may 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 landuse.

Surprising Songbird Findings:

- Where redtop grass is successful, invasive vegetation and weeds are reduced, and grassland songbirds have colonized abundantly. They have used the redtop plots for breeding **year after year,** whereas in other grasslands, many of these species would quickly drop out with increased vegetation growth.

- A startling low frequency of cowbird parasitism is recorded at these bottomland sites. Brown-headed Cowbirds are a native brood parasite (they do not build nests or feed their own young but lay their eggs in other birds' nests) that has increased greatly with human alteration of the American landscape.

- Rates of nest predation by various predators, like raccoons and snakes, are comparable with rates elsewhere in Missouri; yet because cowbird parasitism is low, nests at these bottomland sites experience higher success and lower mortality than many elsewhere in the region.

(Personal communication, D. Burhans, University of Missouri; and B. Root, Missouri Department of Conservation)

New Market Opportunities

From Trash to Cash: Eastern Red Cedar

A major objective of the Center for Agroforestry's research efforts is to identify and explore new market opportunities for products that can be produced through agroforestry -- resulting in increased profits for landowners and environmental benefits to the landscape. One of these market opportunities is eastern red cedar *(Juniperus virginiana)*, which generates nearly $60 million in annual sales in the eastern U.S. Once considered a "trash tree" to be removed from pastures and fences, the list of products produced from red cedar is diverse and growing, including scented hangers and closet liners; pet bedding; mulch; building lumber; home decor and novelty items.

There are approximately 3.14 billion red cedar trees in the U.S., with 1.67 billion of these trees found in Missouri, Arkansas, Kentucky and Tennessee. Missouri alone has an estimated 384 million eastern red cedar trees.

The University of Missouri Center for Agroforestry's 2003 red cedar market research study had two major objectives: to develop a basic understanding of the eastern red cedar market (who are the participants in the market, what kind of products are currently being marketed, what are the general trends for supply and demand); and to analyze the competitive forces that coordinate and control the market, enabling necessary relationships to be identified for success in the eastern red cedar market.

Above: Cedar logs are ready for cutting and curing at Blair Cedar and Novelty Works. **Right:** Raw cedar logs have been rough-cut (3-sided) in preparation for further processing.

"Would you please send me as much information on red cedar as you can? We have almost 1,000 acres and lots of good red cedar. We need a market! Thank you!"

Maraget Duncan, Landowner,
Cuba, Mo.

"Many landowners don't like cedar because they see it as a nuisance," said Michael Gold, associate director of the University of Missouri Center for Agroforestry, who led the study with colleague Larry Godsey. "It's a very invasive, competitive species that's hard to control. Even though we knew cedar was bought and sold, we didn't have the data to tell landowners about profits to be made and existing markets for cedar, so the market analysis was designed to answer these questions."

The Eastern Red Cedar market generates nearly $60 million in annual sales.

During the development of the eastern red cedar analysis, the agroforestry team surveyed red cedar businesses in 16 states, ranging from small operations with annual sales less than $10,000 to large firms with sales more than $16 million.

Key Findings from Red Cedar Market Analysis:

- Nearly 40 percent of survey respondents indicated that demand for red cedar products had increased in the past 5 years
- Approximately 50 percent felt it would continue to increase over the next 5 years
- Missouri is undercapitalized and not yet taking advantage of the opportunity to add value locally to red cedar products
- The market is growing for primary and secondary manufacturers, including sawmills, mulch producers, lumber companies and parts manufacturers --areas where Missouri is in a position to capture more of the value chain

(**Eastern Red Cedar Market Analysis and Directory** available at www.centerforagroforestry.org; or request copies by phone at (573) 882-9866.)

Blair Cedar and Novelty Works: Adding Value to Missouri Cedar

John Blair is quite familiar with the delightful aroma of Missouri red cedar. As a child, he spent hours in the factory where his grandfather, the late John H. Blair and his sons, grew a salt-and-pepper shaker business into the world's leader in the production of cedar souvenirs and novelties. The business, Blair Cedar and Novelty Works, has been a staple in Camdenton, Mo., since 1930 and continues to provide a value-added market for Missouri red cedar logs.

The plant processes 750,000 board feet of lumber each year, all from Missouri trees. Blair Cedar novelties are shipped to gift retailers and novelty shops in all 50 states through an active sales force, with approximately one million pieces shipped from the facility annually.

The family-owned and operated facility can process a raw log into a souvenir plaque, bank, screenprinted box or even a slingshot -- one of their top sellers -- in four to five weeks. Maximum value is added to the logs through careful curing, cutting, printing and lacquering from an experienced team of crafters.

"We're always developing new souvenir items using red cedar, which is usually an impulse buy for shoppers," said Blair. "Staying on top of the market can be challenging, but it's a good feeling, too."

Blair said the business plans to expand into online sales soon.

Left: Missouri red cedar lumber is cut, sanded and stacked in preparation for souvenir boxes, then a photographic image is applied. **Below:** Keepsake cedar plaques are lacquered with a special material for many years of enjoyment. A box of screenprinted cedar souvenir boxes are ready to be shipped.

Red Cedar Next Steps

To assist with future growth of the Missouri red cedar market, the following actions are recommended:

- Establish marketing board to coordinate supply and demand, connect buyers and sellers, and lobby for management practices that benefit the growth of cedar

- Develop an industry infrastructure to regulate quality and quantity standards, landowner production plans and further university research

- Develop low cost propagation methods for male cedar trees that will not produce seed

- Develop red cedar management handbook in collaboration with the U.S. Forest Service Central Hardwood Research Unit

Horticulture & Agroforestry Research Center

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

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

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

- The midwest's most significant pine straw, eastern black walnut and Chinese chestnut research initiatives are conducted at HARC
- The farm is the site of the nation's most comprehensive programs for developing the eastern black walnut and Chinese chestnut into profitable orchard crops
- Extensive bioremediation, non-point source pollution and flood tolerance studies
- A research project for producing gourmet mushrooms, including morel and the European black truffle, has been developed

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

Examples of Current HARC projects:

Pitch x Loblolly Pine and Black Walnut Winter Forage Alley Cropping Study: This is the oldest agroforestry study on the farm and serves several purposes, including exploring the effects of row spacing on tree growth and tree/forage interactions in an alley cropping practice. Pitch pine / loblolly pine hybrids and black walnut planted in single, double and triple rows are grown to examine the effects of row configuration on these species, emulating an alley cropping practice. **(See photo, page 11)**

Riparian Buffer BioFilter Livestock Trial: Assesses the value of riparian buffers in filtering nitrates and phosphates out of runoff from adjacent livestock fields.

Pitch x Loblolly Pine Progeny Testing: Pitch/Loblolly hybrid pines offer a market to Missouri landowners for both wood and pine straw, a multi-million dollar landscaping mulch crop in the southern states.

Mushroom Trials for Forest Farming: Researchers are evaluating Eurpean truffles, morels, shiitakes and other gourmet mushrooms for landowner profits.

Cottonwood Clonal Trial: Landowners may see a need for production alternatives to row crops and forage that offer potential for income and environmental benefits. This project seeks to identify poplar clones that are well-adapted to the climate of the lower Midwest and that produce substantial wood crops for fiber, chips or energy over short (4-5 year) rotations. The project also will provide estimates of total carbon sequestered by such plantations, data that will be useful in determining potential economic returns from carbon credit programs that may emerge. Cottonwood clones are being evaluated for their growth response and adaptibility to Missouri conditions. The best cultivars will be used in agroforestry to produce biomass and for pulp and paper production.

Cherrybark Oak Spacing Study: Cherrybark oak has market potential north of its native range, which extends south from the Missouri Bootheel and the USDA cold hardiness Zone 6. Seedlings have been planted at different spacings to establish uniform shade conditions for field testing promising agroforestry forages from the forage shade study laboratory **(see photo p. 24)**.

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

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 pitch x loblolly genotypes in the plantation are hardy, fast growing, long-needled pines, suitable for commercial pine straw in Missouri.

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.

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.

National Arboretum / NC-7 Trials: The purpose of this planting is to serve as a germplasm repository and evaluation site for newly introduced and rare woody plants with potential ornamental value. A cooperative agreement in 1996 designated HARC as the U.S. National Arboretum Midwest Research and Education Site. Since then, many National Arboretum introductions have been planted, including red maples, alders, disease resistant elms, 'Green Giant' arborvitae, viburnums and many others. The National Arboretum/ NC-7 trial plantings provide a unique opportunity for Missouri nursery producers, landscapers and interested individuals to observe mature specimens of new and unusual plants.

Forage Shade Study: In 1994, researchers began this project by examining 27 forage species (native and exotic legumes, warm season and cool season grasses) for the effect of shade on dry weight production and nutritional value. During the intervening years, additional species have been studied. All species are evaluated under 3 shade levels: 0% (full sun), 55% shade and 80% shade. The goal is to determine their growth and development under different shade levels when grown as companion crops in agroforestry practices or for savanna and woodland restoration.

Evaluating the MDC quail cover bundle shrubs: Bare root seedlings of false indigo, wild plum, fragrant sumac and dogwood were established in 2001. These shrubs were chosen for their potential to provide quality escape cover and food for bobwhite quail. The main objective is to compare their growth and development with moderate management under field conditions.

Flood Tolerance: A Flood Tolerance Laboratory was constructed along Sulphur Creek in the Missouri River floodplain at HARC. This facility provides a unique field laboratory for studying the response of plant species to the periodic flooding common to mid-western floodplains. The laboratory has 12 channels, each approximately 20-ft wide by 600-ft long. Each channel can be independently adjusted for water depth, standing or flowing water, and duration of flooding. Selected grasses, legumes, and tree species are being evaluated for flood tolerance. The flood tolerance of hardwood planting stock and genetic variation in ecotypes from seed collected from bottomland and upland stands is also being evaluated.

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

Tree Improvement: The tree improvement program focuses on identifying and testing selections of black walnut (*Juglans nigra*), pecan (*Carya illinoensis*) and chestnut (*Castanea mollissima*) for incorporation into agroforestry plantings. Major components of this research include (1) testing cultivars on various sites; (2) identifying superior rootstocks for grafting; (3) developing improved vegetative propagation techniques; and (4) creating a breeding program to develop improved selections. A significant component of the tree improvement research program at HARC is nut tree repositories, which serve as germplasm collections to study the adaptation and commercial potential of various cultivars of nut bearing trees to Missouri. Repositories at HARC include walnut (*Juglans nigra*), pecan (*Carya illinoensis*), Chestnut (*Castanea mollissima and Castanea hybrids*), and Hazelnut (*Corylus hybrids*). UMCA is conducting the nation's most extensive programs to develop the northern pecan, Chinese chestnut and the eastern black walnut as profitable agroforestry orchard crops.

Ongoing studies for developing the Chinese chestnut (top) and eastern black walnut (top and right) are underway at HARC.

Toward New Horizons

> Make no little plans. They have no magic to stir men's blood ...
> - Daniel Burnham

No little plans are made at the University of Missouri Center for Agroforestry. During the years to come, the Center plans to continue to lead the Midwest and the nation in the scientific understanding of agroforestry practices that protect our environments and provide sustainable income for forest and agricultural landowners. We know everything we do to protect and preserve our natural landscapes and resources will impact not only this generation, but also many generations to come.

Outreach and Education: The Center is working to develop an online agroforestry distance education course that can be accessed from virtually any location in the world. A completed set of educational videos on all five agroforestry practices will be available soon on DVD.

Fully restored window, 1819 Thomas Hickman house.

Preserving a Missouri treasure: One of Missouri's oldest intact brick houses, the Thomas Hickman House, was built in 1819 and stands on the property of the University of Missouri Horticulture and Agroforestry Research Center. This 1,800 square-foot house represents the southern "Georgian" cottage design, a distinctive architectural style that hallmarks the early development of the Boonslick region of Missouri. Thomas Hickman, one of the original settlers of Howard County, was a local businessman who bought the land on which the home rests, just two miles from Old Franklin - the site where William Becknell and his party began the legendary Santa Fe Trail in 1821.

The goal of this project is to restore the house to its historic condition and to develop it as a visitor center for the Horticulture and Agroforestry Research Center. The Hickman House will hold permanent educational displays of local archeological, geological and historical interest, in addition to period artifacts from the early 1800s. Botanical collections will focus on the natural heritage of the Boonslick region. Exhibits will also introduce visitors to current research projects at the Center. Period gardens will be established to reproduce an early nineteenth-century landscape, and the grounds will be developed to accommodate a picnic area, parking facilities and restrooms. The Hickman House will be open to all to enjoy.

The 1819 Thomas Hickman House is being restored for use as a visitors center at the UMCA research farm.

International Research and Education Center: The Center for Agroforestry is actively seeking financial partnerships to establish a world-class international research, education and training facility at the Horticulture and Agroforestry Research Center. This will be the only facility of its kind in the United States.

Expansion of Research Center: UMCA plans to purchase additional land near the Horticulture and Agroforestry Research Center to accommodate rapidly expanding research needs.

Groundbreaking Mushroom Research

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

Research is also being conducted to develop morel and other gourmet mushrooms into profitable agroforestry crops for landowners. The first specialty mushroom workshop in Missouri will be hosted by UMCA in December, bringing together researchers, niche-product experts and landowners to explore the outstanding potential of the specialty mushroom crop. Markets for this specialty product are expanding as more chefs feature locally-grown mushrooms on the menu. Demand for specialty mushrooms is also increasing at farmers' markets and retail grocers.

2003 Publication Highlights

Riparian Buffers and Water Quality

Allen, S.B., J.P. Dwyer, D.C. Wallace, and E.A. Cook. 2003. **Role of woody corridor width in levee protection.** *J. of the Am. Water Resources Assn* (394):923-933.

Bentrup, G., M.M. Schoeneberger, M.G. Dosskey, and G. Wells. 2003. **Beyond patterns: tools to balance production and environmental goals on private lands.** Proceedings of the 6th International Association of Landscape Ecology World Congress. Darwin, Australia, July 13-17.

Dey, D.C. J. M. Kabrick, J. Grabner and M.A. Gold. 2003. **Restoring Oaks in the Missouri River floodplain.** IN: Proc. 29th Annual Hardwood Symp. Hardwood silviculture and sustainability: 2001 and beyond. May 17-19, 2001. French Lick, IN. *National Hardwood Lumber Assoc*. p. 8-20.

Dugger, S., D.C. Dey and J.J. Millspaugh. 2003. **Vegetation cover affects mammal herbivory on planted oaks and success of reforesting Missouri River bottomland fields.** In Proceedings 12th Biennial Southern Silvicultural Conference. 25-27 February 2003. Biloxi, MS. *General Technical Report SRS-. U.S. Department of Agriculture,* Forest Service Southern Research Station. Asheville, NC. (in press)

Grossman, B.C., M.A. Gold and D.C. Dey. 2003. **Restoration of hard mast species for wildlife in Missouri using precocious flowering oak in the Missouri River floodplain,** USA. *Agroforestry Systems* 59: 3-10.

Hall, D. L., B. S. Bergthold, and R. W. Sites. 2003. **Macroinvertebrate communities of prairie streams in Missouri: The influence of adjacent land uses.** *J. Freshwater Ecology* 18(1): 55-68.

Lin, C.H., R.N. Lerch, H.E. Garrett, M.F. George. 2003. **Degradation of isoxaflutole (Balance) herbicide by hypochlorite in tap water.** *Journal of Agricultural & Food Chemistry.* 51(27):8011-8014

Lin, C.H., R.N. Lerch, H.E. Garrett, W.G. Johnson, D. Jordan, M.F. George. 2003. T**he effect of five forage species on transport and transformation of atrazine and isoxaflutole (balance) in lysimeter leachate.** *Journal of Environmental Quality.* 32(6):1992-2000.

Tufekcioglu, A., J.W. Raich, T.M. Isenhart, and R.C. Schultz. 2003. **Biomass, carbon and nitrogen dynamics of multi-species riparian buffer zones within an agricultural watershed.** *Agroforestry Systems.* 57(3): 187-198.

Silvopasture and Forages

[A]Kallenbach, R.L., M.S. Kerley, and G.J. Bishop-Hurley. **Forage accumulation, quality and livestock production from an annual ryegrass and cereal rye mixture in a pine-walnut silvopasture.** (In Review, Agroforestry Systems).

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

McGraw, R.L., F.W. Shockley, and T. Elam. 2003. **Effects of temperature on germination of ten native legume species.** Native Plants Journal 4:5-9.

Navarrete-Tindall, N., L. Mechlin, and J.W. Van Sambeek. 2003. **Shade tolerance of Festuca paradox Desv., a cool-season grass native to North America.** In: Proceedings, 18th North American Prairie Conference. Kirksville, MO: Truman State University: In press.

Wildlife and Agroforestry

Furey, M.A., D.E. Burhans, H. He, M.A. Gold and B.E. Cutter. 2003. **Effect of vegetation structure on breeding territory selection by red-winged blackbirds in a floodplain forest restoration project.** p. 211-212. IN: Van Sambeek, J.W.; Dawson, Jeffrey O.; Ponder, Felix, Jr.; Loewenstein, Edward F.; Fralish, James S., eds. Proceedings, 13th Central Hardwood Forest Conference; 2002 April 1-3; Urbana, IL. *Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.* 565 p.

Warwick, J. A. 2003. **Distribution and abundance of swamp rabbits and bats in fragmented wetland forests of southeastern Missouri.** M.S. thesis, University of Missouri, Columbia, MO.

Socio-economics, policy, marketing

Godsey, L. 2003. **Funding Incentives for Agroforestry In Missouri.** University of Missouri Center for Agroforestry. Agroforestry In Action. Columbia. MO. 24 p.

Raedeke, A.; J. Green; S.S. Hodge; C. Valdivia. 2003. **Farmers, the Practice of Farming and the Future of Agroforestry: An Application of Bourdieu's Concepts of Field and Habitus.** *Rural Sociology.* 68(1):64-86.

Alley Cropping

Kirk, S.D, C.J. Starbuck and J.W. Van Sambeek. 2003. **Comparing the growth of *Gymnocladus dioicus* in a pea gravel medium amended with calcined clay or expanded shale.** *Proceedings of the International Plant Propagators Society.* In Press.

Gray D., S.G. Pallardy, H.E. Garrett and G.E. Rottinghaus. 2003. **Effect of Acute drought stress and time of harvest on phytochemistry and dry weight of St. John's wort leaves and flowers.** *Planta Medica* 69:1024-30.

Gray, D.E., S.G. Pallardy, H.E. Garrett and G.E. Rottinghaus. 2003. **Acute drought stress and root age effects on alkamide and phenolic acid content in purple coneflower roots.** *Planta Medica*. 69(1):50-55.

Van Sambeek, J.W. 2003. **Legume ground covers alter defoliation response of black walnut saplings to drought and anthracnose.** In: Proceedings, 13th Central Hardwood Forest Conference. *Gen. Tech. Rep. NC-234. USDA Forest Service North Central Research Station.* p. 556-565.

Dan Dey, United States Forest Service and UMCA research collaborator, talks with a group of landowners at a bottomland reforestation workshop co-sponsored by the Center for Agroforestry. Dey is researching the benefits and methods of reestablishing oaks in floodplains.

Biomass

Pallardy S.G., D.E. Gibbins and J.L. Rhoads. 2003. **Biomass production by two-year-old poplar clones on floodplain sites in the Lower Midwest, USA.** *Agrofor. Syst.* 59:21-26.

Pallardy S.G. and D.E. Gibbins. 2003. **Branch morphology in young poplar clones on floodplain sites in Missouri.** In: Van Sambeek, J. W. Dawson, J. O., Ponder, F. Jr., Loewenstein, E. F., Fralish, J., Eds. Proc. 13th Central Hardwood Forest Conference; 2002 April 1-3; Urbana, IL. *Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.*

Carbon Sequestration

Guyette, R.P. and M.C. Stambaugh. 2003. **The age and density of ancient and modern oak in streams and stream sediments.** *IAWA Journal (International Association of Wood Anatomists).* 24:345-353

Dey, D.C., R. Guyette and M. Stambaugh. 2003. **Ancient wood uncovered.** *Missouri Conservationist* 64(1):4-7

Forest Farming

Bruhn, J.N., Mihail, J.D., Wetteroff, J.J., Jr., and Clark, T.A. 2003. **Evaluating management practices for log-grown shiitake production in midwestern agroforestry.** In: Van Sambeek, J.W.; Dawson, J. O.; Ponder, F., Jr.; Loewenstein, E. F.; Fralish, J. S., eds. Proceedings, Thirteenth Central Hardwood Forest conference; 2002 April 1-3; Urbana, IL. *Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.* p. 88-100.

Garrett, H.E. 2003. **Roles for agroforestry in hardwood regeneration and natural-stand management.** (Keynote Address). In: Van Sambeek, J.W.; Dawson, Jeffrey O.; Ponder, Felix, Jr. Loewenstein, Edward F.; Fralish, James S., eds. Proceedings, Thirteenth Central Hardwood Forest conference; 2002 April 1-3; Urbana, IL. *Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.* 565 p.

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The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired in value ... - Theodore Roosevelt

University of Missouri
CENTER FOR AGROFORESTRY
203 ABNR
Columbia, MO 65211
(573) 882-9866
umca@missouri.edu
www.centerforagroforestry.org

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