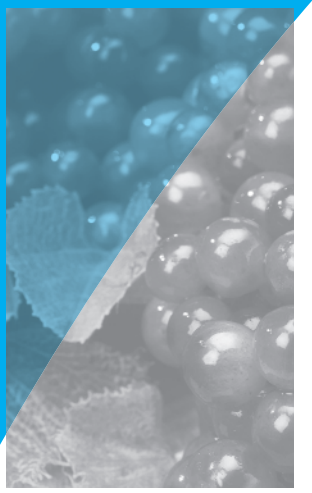
Illinois Council on Food and Agricultural Research

2003

A Partnership for Illinois Food and Agriculture



CELEBRATING 10 YEARS

C-FAR

1993-2003

OUR MISSION

The mission of the Illinois Council on Food and Agricultural Research (C-FAR) is to secure additional resources to adequately fund relevant and high-quality research and related outreach programs that lead to profitable, consumer-sensitive, and environmentally sound food and agricultural systems in Illinois and the nation. C-FAR will foster public confidence in food and agricultural research through public participation in planning and evaluating the process and impact of research activities.

Celebrating a Decade of Partnerships for Illinois Food and Agriculture

State of Illinois • Food, Agricultural, and Related Industries • Consumers • University of Illinois at Urbana-Champaign • Southern Illinois University at Carbondale • Illinois State University • Western Illinois University • Other Research Entities

The Illinois Council on Food and Agricultural Research (C-FAR) is a statewide coalition organized to support high-quality research and associated outreach programs relevant to Illinois' food, agricultural, and related systems. In 2003, C-FAR proudly celebrated the 10th anniversary of its founding in December 1993. During the past decade, a highly diverse coalition, representing virtually all segments of our food and agricultural sector and researchers, has worked together with the State of Illinois in an unprecedented partnership through C-FAR to secure the future of Illinois' number one industry.

C-FAR research funding is provided by the State of Illinois. C-FAR gratefully acknowledges the State of Illinois for these financial investments, which are enabling advancements for this important industry and contributing to the economic vitality of our state.

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Message from C-FAR

Greetings,

It is a pleasure for us to present this 2003 Annual Report to our membership, to our elected and appointed state officials, and to all interested citizens of Illinois and beyond. This 2003 report is special in that it marks the 10th anniversary of our organization, which is dedicated to ensuring the vitality of our state's food and agricultural research programs.

Together, with the State of Illinois and our research communities, we've forged new pathways never before seen in our nation. We of course are proud of this 10-year anniversary, but much more important is what our partnerships have meant to our food, agricultural, and related industries in Illinois.

Alongside our various partners, C-FAR is proud to have created an open forum for the research priority-setting process. Enabling the people of Illinois to be engaged in this process has resulted in a new dynamic. We are now able to identify and capture directly, from those whose livelihood depends on sound research outcomes, the challenges and opportunities that can be met through sound research and outreach initiatives.

We are proud that our research priorities span a myriad of opportunities that have spurred, and will continue to spur, our state's economy. With agriculture being our state's largest industry, its ability to significantly stimulate economic growth, enhance job creation, and foster a better life for every citizen of our state lies in the vibrancy of our research programs. Our membership stands ready to continue to work with Governor Blagojevich and the Illinois General Assembly in creating opportunities.

As we celebrate our past decade, we look with even greater enthusiasm to our second decade.

Alan Puzey
Chairman of the Board

Kraig A. Wagenecht
Executive Administrator

2003 Highlights

Livestock and Urban Waste Recycling Research Team (left to right): Kenneth Smiciklas, Robert Rhykerd, Williams Roy, Donald Holt (presenter of award), Duane Friend, Paul Walker, David Williams, Walton Kelly, Timothy Kelley.

Not pictured: Eberhard Morgenroth, Lutgarde Raskin, Patrick O'Rourke.

Annual Meeting

C-FAR held its annual meeting on February 18 at the Northfield Inn, Suites & Conference Center in Springfield. A record number of 200 members were in attendance to address key business matters and to review final reports for C-FAR-funded research initiatives that were completed in 2002. A meeting highlight was the presentation of the 2003 Donald A. Holt Achievement Award. State Representative Dan Reitz, chairperson of the House Committee on Agriculture and Conservation, joined Dr. Donald Holt in presenting this special award to the Livestock and Urban Waste Recycling research team. This interdisciplinary team of researchers was honored for their outstanding and innovative team research and outreach to develop and refine environmentally and economically sound livestock and urban waste recycling techniques that protect and enhance air, water, and soil quality.

C-FAR Board member Larry Fischer raises a glass of juice as he provides a toast commemorating the organization's 10th anniversary.

10th Anniversary Celebration at Semi-Annual Meeting

Members of C-FAR celebrated the organization's 10th anniversary at their semi-annual meeting, held on August 19 at the Northfield Inn, Suites & Conference Center in Springfield. Founded in December 1993, C-FAR has brought together a broad-based coalition of industry stakeholders that partner with state officials and researchers throughout Illinois to strengthen the state's food, agricultural, and related industries. A special celebration luncheon was held to commemorate this distinctive milestone. Highlights included remarks by Illinois Department of Agriculture Director Charles A. "Chuck" Hartke. A special presentation on C-FAR's origins and its impact on Illinois food and agriculture was graciously "voiced" by nationally renowned farm broadcaster Orion Samuelson. "It was really an honor for me to lead our 10th anniversary luncheon celebration," said Alan Puzey, C-FAR

chairman. "It reminded me just how hard our founders worked in structuring such a unique and distinctive organization. Their vision was phenomenal."

There are few, rare, precious moments in the course of human history when one has the opportunity to witness the birth of a vision. A vision so powerful, with the potential of creating a firestorm of positive change, that the person witnessing the event doesn't realize the cataclysmic change about to happen. Or, as Dr. Don Holt, a visionary researcher honored by many, told me at the time "Larry, you have no idea how you folks have just changed the process of food and agricultural research in the United States."

The concept proposed was simple and direct: To increase the public investment in food and agricultural research with increased accountability by soliciting more citizen input to identify needed research—and for that research to be conducted in a true collaborative effort between researchers. We are here today to celebrate the ten year anniversary of this vision—and you, the volunteers, all of you, who have nurtured this unique but practical concept. You should feel a sense of ownership and pride for your contributions. In this age of complexity—where we daily walk on quicksand and dance with electrons—it is refreshing to see the impact we have had on progress. So, to honor all of you here and all those who have traveled the C-FAR pathway, and to encourage those who will support this wonderful idea in the future, I ask you to join me in a well-deserved toast for 10 years of superb success. May we never forget the collective power of a diverse and unifie d group of volunteers who are committed to a vision that makes sense. Please join me in a sincere toast to the past and future success of C-FAR. Thank you.

—Toast provided by C-FAR Board member Larry Fischer at C-FAR's 10th anniversary celebration on August 19, 2003

C-FAR Day at Illinois State University

C-FAR held its third annual C-FAR Day on November 13 at Illinois State University's Farm at Lexington. This special event highlighted C-FAR-funded research initiatives taking place at the university. C-FAR Day provides an opportunity for C-FAR members, legislators, and other stakeholders to engage in discussions directly with researchers about their research activities. ISU faculty described key outcomes and impacts of their C-FAR research in areas including rural entrepreneurship, livestock waste management and composting, a grain entrapment life-saving device, remediation of crude oil-contaminated soil, Web-based agribusiness management tools, quality and safety of meat products, aquaculture, water quality, and animal welfare studies. Attendees engaged in discussions with researchers asking questions and providing input from their stakeholder perspective. Following the faculty presentations, attendees took a tour of the ISU farm and its research facilities.

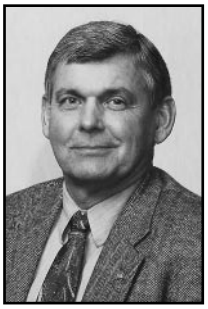
Paul Walker, professor of animal science, explains his research on vacuum bag ensiling of wet distillers grain to C-FAR members during C-FAR Day at Illinois State University's Farm at Lexington.

Who's Who

Illinois Council on Food and Agricultural Research

2003 Board of Directors

Alan Puzey
CHAIRMAN OF THE BOARD, FAIRMOUNT



David Downs
VICE CHAIRMAN OF THE BOARD, ALLERTON

Fred Bradshaw
SECRETARY-TREASURER, GRIGGSVILLE

Larry Fischer
RESEARCH CHAIR, QUINCY

Nels Kasey
RESEARCH VICE CHAIR, PARIS

Carol Keiser
MEMBERSHIP CHAIR, CHAMPAIGN

Karen Little
DIRECTOR, PLEASANT PLAINS

Staff

Kraig A. Wagenecht
EXECUTIVE ADMINISTRATOR

LeAnn M. Ormsby
COMMUNICATIONS DIRECTOR

Additional C-FAR Staff

Rhonda Hunter
ADMINISTRATIVE ASSISTANT

Gloria Buhrmester
SECRETARY

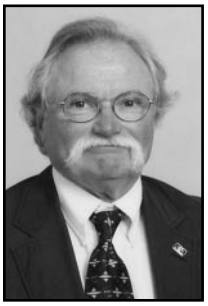
Arena Jackson
SECRETARY

Expanding Agricultural Markets

Dan Kelley
CHAIR, NORMAL

Phil Borgic
VICE CHAIR, NOKOMIS

Rural Economic Development



A.J. Harland
CHAIR, LAFAYETTE

Kevin Brussell
VICE CHAIR, CASEY

Agricultural Production Systems

Molly Ann Godar
CHAIR, ROCHESTER

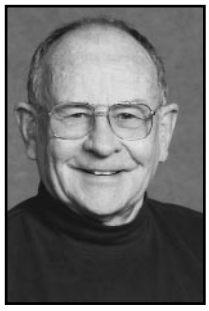
Anne Builta Crider
VICE CHAIR,
ARROWSMITH

Human Nutrition and Food Safety

Jeanne Harland
CHAIR, LAFAYETTE

Jim Fraley
VICE CHAIR,
COOKSVILLE

Natural Resources



Byford Wood
CHAIR, BREESE

Dale Crawford
VICE CHAIR, SULLIVAN

2003 C-FAR Members

Organizational Members

Association of Illinois Soil and Water Conservation Districts

Audubon Council of Illinois

Central Illinois Golf Course Superintendent's Association

Champaign County Farm Bureau

Dairy Management Inc.

DuPage County Farm Bureau

Environmental Law and Policy Center of the Midwest

Grain & Feed Association of Illinois

GROWMARK, Inc.

Hancock County Farm Bureau

Horsemen's Council of Illinois

Horseradish Growers of Illinois

Illinois Agri-Women

Illinois Association of Drainage Districts

Illinois Association of Meat Processors

Illinois Beef Association, Checkoff Division

Illinois Beef Association, Dues Division

Illinois Corn Growers Association

Illinois Corn Marketing Board

Illinois Dietetic Association

Illinois Farm Bureau

Illinois Farm Business Farm Management Association

Illinois Farm Credit Services

Illinois Farmers Union

Illinois Fertilizer and Chemical Association, Inc.

Illinois Forage and Grassland Council

Illinois Grape Growers and Vintners Association

Illinois Lamb & Wool Producers, Inc.

Illinois Landscape Contractors Association

Illinois Milk Producers' Association

Illinois Nurserymen's Association

Illinois Pork Producers Association

Illinois Pork Producers Association, Checkoff Division

Illinois Restaurant Association

Illinois Seed Trade Association, Inc.

Illinois Society of Professional Farm Managers & Rural Appraisers

Illinois Soil Testing Association

Illinois Soybean Association

Illinois Soybean Program Operating Board

Illinois Specialty Growers Association

Illinois State Beekeepers Association

Illinois State Grange

Illinois State Horticultural Society

Illinois State University Agriculture Alumni Association

Illinois State Veterinary Medical Association

Illinois Stewardship Alliance

Illinois Sustainable Agriculture Society

Illinois Thoroughbred Horsemen's Association

Illinois Turfgrass Foundation

Illinois Wheat Association

Institute of Food Technologists, Chicago Section

Kane County Farm Bureau

Kankakee County Farm Bureau

Knox County Farm Bureau

Lake Vermilion Water Quality Coalition

Macoupin County Farm Bureau

Madison County Farm Bureau

Mason County Farm Bureau

Mercer County Farm Bureau

Midwest Dairy Association

Organic Crop Improvement Association, Illinois Chapter

Orr Agricultural Research Center

Rural Partners

Southeastern Illinois Sustainable Agriculture Association

Southern Illinois University College of Agricultural Sciences Alumni Society

The Chicago Farmers

University of Illinois at Urbana-Champaign College of Agricultural, Consumer and Environmental Sciences Alumni Association

University of Illinois at Urbana-Champaign College of Veterinary Medicine Alumni Association

Warren-Henderson Farm Bureau

Affiliate Members

Central Illinois Agricultural Research Farms, Inc.

Greene Farm Management Services, Inc.

Illinois Crop Improvement Association, Inc.

Illinois Department of Natural Resources

Illinois Farm Development Authority

Illinois Forestry Development Council

Illinois Grape and Wine Resources Council

Illinois State Geological Survey

Illinois State University Department of Agriculture

Illinois State Water Survey

National Center for Food Safety and Technology

Sangamon County Soil and Water Conservation District

Shawnee Community College

Southern Illinois University at Carbondale Center of Excellence for Soybean Research, Teaching, and Outreach

Southern Illinois University at Carbondale College of Agricultural Sciences

Southern Illinois University at Carbondale Department of Agribusiness Economics

Southern Illinois University at Carbondale Department of Animal Science, Food and Nutrition

Southern Illinois University at Carbondale Department of Forestry

Southern Illinois University at Carbondale Department of Plant, Soil and Agricultural Systems

Southern Illinois University at Carbondale Fisheries and Illinois Aquaculture Center

Southern Illinois University at Carbondale Office of Economic and Regional Development

The Nature Conservancy in Illinois

University of Illinois at Chicago College of Pharmacy

University of Illinois at Springfield Institute for Legal, Administrative and Policy Studies

University of Illinois at Urbana-Champaign College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign College of ACES Information Technology and Communication Services

University of Illinois at Urbana-Champaign College of Veterinary Medicine

University of Illinois at Urbana-Champaign Department of Agricultural and Biological Engineering

University of Illinois at Urbana-Champaign Department of Agricultural and Consumer Economics

University of Illinois at Urbana-Champaign Department of Animal Sciences

University of Illinois at Urbana-Champaign Department of Crop Sciences

University of Illinois at Urbana-Champaign Department of Food Science and Human Nutrition

University of Illinois at Urbana-Champaign Department of Human and Community Development

University of Illinois at Urbana-Champaign Department of Natural Resources and Environmental Sciences

University of Illinois at Urbana-Champaign Department of Veterinary Biosciences

University of Illinois at Urbana-Champaign Department of Veterinary Clinical Medicine

University of Illinois at Urbana-Champaign Department of Veterinary Pathobiology

Western Illinois University Department of Agriculture

Western Illinois University Department of Dietetics, Fashion Merchandising, and Hospitality

Individual Members

In 2003, C-FAR had 119 individual members. These are individuals who, like the Organizational and Affiliate Members listed in the preceding sections, care about a vibrant food, agricultural, and related research program in Illinois.

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C-FAR Committees

Legislative Committee

The charge of this committee is to (1) monitor all legislative activity, state and federal, that may have an impact on C-FAR or its mission and objectives; (2) develop recommendations for Council or Board approval; and (3) implement and execute plans.

Committee members
Jack Erisman, chair
Fred Bradshaw
Constance Locher Bussard
David Downs
David Erickson
Wally Furrow
Carl Hopphan
Carol Keiser
Scott Lay
Karen Little
Alan Puzey
Stephen Scates
William Whiteside
Terry Wolf

Nominating Committee

The purpose and charge for this committee includes soliciting and receiving nominations for the board of directors from organizational members and presenting a slate of candidates to be voted on by the C-FAR membership at the annual meeting.

Committee members
Jack Erisman, chair
Jeffrey Adkisson
Shannon Allen
Bill Campion
Charlie Grotevant
John Huston
William McCartney
Bob Swires

Research Committee

The purpose and charge of this committee is to

- inquire into and prepare reports on current and planned research in Illinois on food and agriculture
- seek recommendations on research needs from (a) research professionals currently conducting such research at Illinois universities or elsewhere, (b) interested persons and groups, and (c) the public
- identify research beneficiaries
- prepare recommendations regarding research needs, processes, and impacts, and pursue their implementation as authorized
- foster public confidence in ongoing food and agricultural research by engaging public participation in planning and evaluating the process and impact of research activities

Committee members
Larry Fischer, chair
Nels Kasey, vice chair
Susan Adams
Bill Becker
Steve Calhoun
Pat Dumoulin
Paul Gebhart
Molly Ann Godar
Kae Hankes
A. J. Harland
Jeanne Harland
Karla Hart
Michael Herrin
Steve Kasten
Dan Kelley
Heather Hampton Knodle
Carl Neubauer
Lee Anne Roach
Wendell Shauman
Walt Townsend
Byford Wood

Ex-officio
Andrew Baker
George Fahey
Steven Pueppke
Randy Winter
Anthony Young

Rules and Procedures Committee

This committee, in consultation with the other committees, monitors C-FAR processes and develops proposals for improvements as needed.

Committee members
Dennis Thompson, chair
Rick Dean
Don Doehring
Paul Galligos
Pam Hansen
Gary Heichel
Bert Princen

Research Partners

University of Illinois at Urbana-Champaign

Robert A. Easter
Dean
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Steven G. Pueppke
Associate Dean for Research
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

George C. Fahey, Jr.
Assistant Dean, Research Leadership C-FAR
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

The University of Illinois at Urbana-Champaign carries out C-FAR-funded research in areas including

- agricultural and consumer economics
- agricultural engineering
- animal sciences
- crop sciences
- food science and human nutrition
- human and community development
- natural resources and environmental sciences
- specialty crops
- value-added agriculture
- veterinary medicine

Southern Illinois University at Carbondale

Robert D. Arthur
Interim Dean
College of Agricultural Sciences
Southern Illinois University at Carbondale

Anthony W. Young
Associate Dean for Research
College of Agricultural Sciences
Southern Illinois University at Carbondale

C-FAR recognizes with appreciation Dr. Anthony "Tony" Young, who retired as Associate Dean for Research for the SIUC College of Agricultural Sciences in 2003.

Southern Illinois University at Carbondale carries out C-FAR-funded research in areas including

- agribusiness economics
- animal sciences
- crop sciences
- food science and human nutrition
- forestry
- rural community development
- specialty crops
- water quality

Illinois State University

J. Randy Winter
Chair
Department of Agriculture
Illinois State University

Illinois State University carries out C-FAR-funded research in areas including

- animal sciences
- aquaculture
- crop sciences
- food safety
- horticulture
- rural economic development
- soil sciences
- water quality

Western Illinois University

Andrew J. Baker
Chair
Department of Agriculture
Western Illinois University

Western Illinois University carries out C-FAR-funded research in areas including

- alternative crops
- animal sciences
- crop sciences
- food safety education
- rural economic development
- sustainable agriculture
- value-added agriculture

C-FAR recognizes with appreciation Dr. Danny E. Terry, who retired as Chair of the WIU Department of Agriculture in 2003.

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Research Programs Fiscal Year 2003

In 1995 the Illinois General Assembly and then-Governor Jim Edgar passed the Food and Agriculture Research Act, the enabling legislation that provides the framework for C-FAR funding and research activity. In FY2003, Governor Rod R. Blagojevich and the Illinois General Assembly appropriated $6.968 million to C-FAR.

Funds are allocated to three C-FAR research programs:

Strategic Research Initiatives

The Strategic Research Initiatives (SRIs) are team-based research efforts that provide a targeted, multidisciplinary, and multi-institutional approach for addressing major issues and concerns of the Illinois food and agricultural industry and consumers.

University Internal Programs

These programs are supported by funds for food and agricultural research allocated directly to the University of Illinois at Urbana-Champaign, Southern Illinois University at Carbondale, Illinois State University, and Western Illinois University. Each university sponsors an internal competitive grants program to solicit creative, innovative, high-quality research that addresses C-FAR priorities. In 1999, the University of Illinois initiated its C-FAR Sentinel Program as part of the university's internal research program. The Sentinel Program's purpose is to take advantage of opportunities for performing creative, problem-solving research.

External Competitive Grants Program

C-FAR's enabling legislation stipulates that a minimum of 15% of the total appropriation be allocated to an external competitive grants program open to qualified researchers at nonprofit institutions, organizations, or agencies in Illinois. The C-FAR working groups evaluate and select the proposals for funding. Proposal review follows a two-step process. The first step is a request for and review of pre-proposals. C-FAR working group members evaluate pre-proposals based on relevance to C-FAR research focus areas, potential outcomes and benefits to stakeholders, and dissemination plans. The second step involves inviting principal investigators of top-ranking pre-proposals to submit full proposals. Full proposals undergo scientific review and evaluation.

Strategic Research Initiative Program

In 1998, the C-FAR membership established the Strategic Research Initiative (SRI) Program to implement a targeted, multidisciplinary, and multi-institutional team approach to addressing major concerns and opportunities for Illinois' food, agriculture, and related industries and consumers. This approach was unique and bold. Never before had such a program been tried for food and agricultural research at our state universities. While researchers from the same departments and possibly the same university had previously worked together, the degree of collaboration that the SRI program sought was a new approach. It was felt that bringing together the "best minds" from across the state to work together would result in a new dynamic of synergy not yet realized in the state. With five years of experience, the SRI program has proven that researchers can, and quite effectively, work together for a common cause.

Original Strategic Research Initiatives End June 30, 2003

The C-FAR membership established five strategic research initiatives (SRIs), which focused on information systems and technology, rural community development, swine odor and waste management, food safety (functional foods was initially also part of this SRI), and water quality. These research initiatives have resulted in tremendous benefits for Illinois' food, agricultural, and related industries and for the citizens of Illinois. While several SRI components have received no-cost extensions to complete work, these five SRIs officially closed on June 30, 2003. SRI leaders provided final reports to C-FAR on the achievements and outcomes of their SRI, which are available on the C-FAR website at **www.ilcfar.org/research/index.html**. The executive summaries of those reports follow.

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Information Systems and Technology

Gary D. Schnitkey
SRI Leader,
University of Illinois at Urbana-Champaign

The Information Systems and Technology SRI (IT-SRI) began its work with a focus in three areas: (1) development of decision and analysis support systems, (2) development of activity, output, and outcome reporting systems for C-FAR-funded research, and (3) development of outreach information systems. Many outcomes contribute toward meeting objectives within each of these three areas.

Major outcomes of the IT-SRI are summarized in four areas. First, researchers developed comprehensive information systems that aid decision making in specific settings. Four comprehensive websites are now available:

- *Farmdoc,* available at **www.farmdoc.uiuc.edu**, addresses agricultural economics issues and has a goal of developing innovative and comprehensive programs to improve decision-making under risk through research and education. The *farmdoc* project provides seamless and integrated expertise in farm management, agricultural finance, commodity policy, and agricultural law. Usage of *farmdoc* has increased over the life of the IT-SRI. *Farmdoc's* requests increased from about 10,000 per month in 1999 to an average of 150,000 in 2003.

- *Illinois Integrated Pest Management (IPM) Online*, available at **www.ipm.uiuc.edu**, contains information on pest management for Illinois users. Information is available for field crops, fruits, vegetables, landscape and turf, greenhouse, home and gardens, and livestock. IPM Online's requests increased from an average of 4,039 per month in 1998 to an average of 66,612 per month in 2002. Preliminary data indicate a continued increase in 2003.

- *Illinois Interactive Agronomy Handbook (IAH),* available at **www.ag.uiuc.edu/iah**, builds on the popular printed version of the *Illinois Agronomy Handbook*. Electronic versions of chapters in the *Illinois Agronomy Handbook* are available at *IAH* and include chapters on climatology, corn production, soybean production, small grains production, cover crop production, alternative crop production, hay and pasture, seed, water quality, soil fertility, nutrient management, tillage systems, water management, weed control management, insect management, disease management, nematodes, and nutrient management.

- Illinois *TRAILL,* available at **http://traill.outreach.uiuc.edu**, provides integrated research information to the livestock industries. Species sites within *TRAILL* include BeefNet, DairyNet, HorseNet, PorkNet, PoultryNet, and SheepNet. Each species site provides a section for current topics, papers, events, and newsletters.

The second area of outcomes relates to decision support systems. IT-SRI researchers have made advances in developing decision and analysis support systems. Many of these decision support systems are included in the comprehensive websites just described. Additional support systems developed by the IT-SRI include the following:

• The *Enhanced Farm Research Analyst (EFRA)*, available at **www.farmresearch.com/efra**, is an extension to ArcView that aids researchers, consultants, and farmers in developing on-farm research by designing research plots and performing statistics on geo-referenced data. This tool aids in conducting research that will tailor recommendations for very specific situations. For example, use of this tool could allow for the development of fertilizer recommendations pinpointed to soil types and locations within fields.

• The *Online Evaluation Workbook,* is available at **www.community development.uiuc.edu/evalbook**, provides a step-by-step evaluation guide to help individuals design an evaluation strategy for economic development projects. The online version provides an interactive forum for conducting a project evaluation. The online version will be completed by December 2003. The online evaluation tool builds on the other tools available in the C-FAR sponsored Community Development Toolbox. In addition to strategic planning, needs assessment, and benchmarking, the evaluation tool works with the others to build a comprehensive economic development strategy.

• The *On-Machinery Information Manager* project has developed a prototype of an Agricultural Infotronics System (AIS) for remote monitoring. This prototype was developed for a Case MX-240 tractor with an attached cultivator. Based on results form this research, it was concluded that the AIS technology has the potential to increase the effectiveness of precision agricultural operations.

• *Prostar* is a Web-enabled agribusiness simulation of a retail fertilizer and chemical dealership. This simulator was designed to be used in college classes, in university outreach, and in agribusiness training environments to improve the learning, comprehension, and retention of knowledge relevant to making better business management decisions.

• The *Resource Management Mapping Service (RMMS)*, available at **http://space1.itcs.uiuc.edu/website/rmms**, is designed specifically to aid watershed management groups in planning projects by providing geographically information about their watersheds. RMMS also contains information of interest to other users across Illinois. *RMMS* is a geographical information system that currently has over 50 layers of information for Illinois. Layers include soil type information (where electronically available), watershed boundaries, streams, wetland boundaries, congressional districts, counties, Illinois Department of Natural Resource boundaries, towns, townships, highways, landfills, and roads.

The third area of outcomes relates to advances in information technologies. IT-SRI researchers have developed new and innovative methodologies for presenting information to users. As an indicator of this success, IT-SRI projects have won nationwide recognition in popular press outlets including *agricultural.com, Successful Farmer,* and *Farm Journal*. Moreover, results from these projects also have been presented as invited sessions at the meetings of American Society of Agronomy and the American Agricultural Economics Association meetings. *Farmdoc*, a project within the IT-SRI, also won the national team award for outreach from the American Agricultural Economics Association in 2002.

The fourth area of outcomes relates to the way individuals receive information within Illinois. Many individuals now receive information directly through websites that used to be obtained through written publications or through meetings. This is evidenced by the dramatic increase in use of the websites developed by IT-SRI researchers. Moreover, individuals who do not access information directly from websites are still impacted by the IT-SRI. Many information users, such as University of Illinois Extension, use information provided by the IT-SRI in conducting their programs.

These outcomes were obtained over the life of the project, which can be divided into three stages. The initiation stage spanned fiscal years 1999 and 2000. During this time period, over 30 projects were initiated, involving more than 60 researchers at the University of Illinois, Illinois State University, Southern Illinois University-Carbondale, Western Illinois University, Illinois Scientific Surveys, and American Farmland Trust. The second stage spanned FY2001 and FY2002 and represented consolidation. During this period, the 30 projects launched in the first stage were reduced to 11 projects. This consolidation allowed focus and increased visibility of individual projects within the IT-SRI. The third stage, refinement, occurred during FY2003. During this stage, projects were brought to fruition.

The project leader of the IT-SRI from FY1999 through FY2002 was Sally Thompson. Her leadership enabled much of the success of the project. Gary Schnitkey served as project leader for fiscal year 2003.

Researchers within the IT-SRI attracted over $2 million of funds that leveraged IT-SRI funds.

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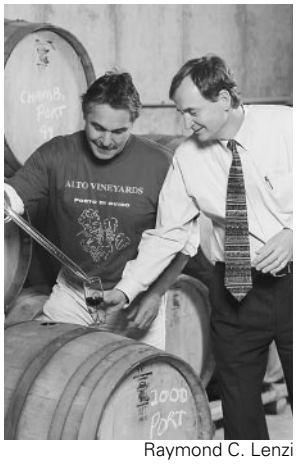
Rural Community Development

The Rural Community Development SRI (RCD-SRI), also known as I-FARRM (Illinois Farming Alternatives and Rural Revitalization Methods), has had enormous positive impact on the Illinois farm and rural economy. This SRI focused on technical assistance and research for value-added and alternative agricultural operations in niche and processed grains (corn, soybeans, etc.), grapes and wine, aquaculture (e.g., fish and prawns), organic crops and meats, other specialty crops, agritourism, and rural community foundations.



Raymond C. Lenzi
SRI Leader,
Southern Illinois University
at Carbondale

The project's combined economic impact on sales, payroll, capital investment, and leveraged project dollars equaled over $154 million. This included 88 new/expanded value-added agricultural enterprises, 457 new jobs, $18 million in new annual payroll, $45 million in value-added sales increases, $6 million in new capital investment, and $7 million in leveraged project dollars.

The SRI produced 156 new publications, including 64 business plans, 4 books, and 87 monographs or fact sheets and 63 journal articles or book chapters. Educational/outreach efforts reached nearly 500,000 through direct contact and research dissemination. Although the project no longer receives C-FAR funding, it has spawned a host of projects and programs that have generated their own funding bases. These continuing I-FARRM-incubated spin-offs include:

- The Illinois Cooperative Center, based at SIUC, which provides technical and business assistance to agricultural enterprises throughout the state
- The Southern Illinois Community Foundation, which has generated nearly $1 million in gifts and grants as well as generating funding for permanent staffing
- The Global Value-Added Project at the University of Illinois, which continues its important work both in Illinois and globally
- The Illinois Value-Added Rural Development Center, based at Western Illinois University
- The Agritourism Project and Union County Barnstorming Tour, which have become ongoing agritourism projects of southern Illinois tourism groups
- Aquaculture and grape/wine technical assistance based at SIUC's Office of Economic and Regional Development

In summary, the I-FARRM/RCD-SRI has had enormous positive impact and return on investment. It has met virtually all its goals and objectives, created a model performance metrics accountability system, and reached nearly 500,000 in its outreach effort, and it leaves a host of functioning Illinois programs and projects with ongoing impact.

Swine Odor and Waste Management

Michael Ellis
SRI Leader, University of Illinois
at Urbana-Champaign

Individual projects of the Swine Odor and Waste Management SRI (SO&WM-SRI) combined to focus on the initiative's primary objective: To support continued development of an environmentally sustainable, socially acceptable, economically viable U.S. swine industry through a broad, integrated research program addressing issues of swine odor and manure management.

A total of 29 projects, ranging in duration from one to five years, were conducted by scientists from 11 Illinois units, institutions, and agencies in the areas of odor measurement, control, and management; system design and management; nutrition; manure processing and handling; and community considerations and legal issues.

The initiative's 19 primary goals included

- new approaches to minimizing impacts of swine production
- proper methods for sampling, characterization, and identification of volatile organic compounds (VOC), odors, dust, and gas
- models on nutrient flow, production systems, and environmental determinants of odor emissions
- models to improve facility siting and manure application
- development of dedusters, wet scrubbers, and catalytic converters to reduce dust and gaseous emissions
- a center for testing and evaluating devices and processes in a simulated industry production setting
- various viable nutritional approaches to reducing excretion of phosphorus and other materials that contribute to manure mass and formation of VOC
- various viable manure-processing technologies to reduce manure volume; enhance odor control; reduce soil, ground, and water pollution; and develop a variable-rate slurry applicator
- a database on swine manure and odor
- efforts to understand public reactions to large-scale swine operations
- analyze and create a database of federal and state laws and court decisions governing swine odor and manure issues
- communication of up-to-date information and recommendations to various stakeholder clusters

Work under the SO&WM-SRI resulted in invention or development of numerous processes, devices, and recommendations for practical application. Many other products have also evolved. Some have been less tangible than others but are just as important, including establishment or formalization of enduring interdisciplinary and even interinstitutional scientific teams, $10 million in additional funding leveraged by the existence and results of C-FAR projects and research teams; and the establishment of continuing facilities and staffing for sample collection and analysis and for device and process evaluation and testing.

Odor Measurement, Control, and Management

In one project, a reliable method for sampling swine house air for dust, gases, and other VOC of interest was developed and modified after attempts to employ cotton-swatch adsorption were abandoned. Ultimately, the Tekmar-Dohrmann #6 trap at appropriate flow rate was used. Methods and instruments for chemically identifying VOC in swine facility air and dust were established and refined. These included high-resolution gas chromatography (GC) and GC-mass spectrometry. Results led to improving odor-control technologies in other C-FAR projects. Methods and instruments were refined so precise sampling and testing protocols for organoleptic VOC analysis via dynamic olfactrometry (DO) could be developed. Correlation between DO-determined odor offensiveness and total VOC concentration was low; correlations between DO offensiveness descriptors and concentrations of individual VOC were higher. DO tests were used as adjuncts in several Initiative projects.

A basic model having simple nutrient flows that performed reasonably was developed. A statewide nutrient flow model was designed to study implications of swine facilities at the state level. A system dynamics model of pig growth was developed to evaluate economic feasibilites of three approaches to pig-feeding system as related to nutrient excretion. A successful multiuniversity workshop on odor control technologies was held. The UITERM program was established to provide producers faced with pollution or nuisance complaints with consultation by UIUC staff.

The Illinois Swine Odor Control Proving Center was established. It completed evaluation of frequent facility cleaning on odor and dust emissions; a new wet air scrubber; contributions of pig manure to ammonia generation; refinement of the manure lagoon cover; and the effect of ozonation on pig house air quality and pig performance.

A dispersion model based on source strengths from published and archived meteorologic data was built for use as a prediction aid in facility siting decisions. The "Nanonose" instrument was invented and tested as a means of real-time quantitative measurement of specific VOC aerosols via size change under specific conditions surrounding aerosol particles as small as 20 nanometers. An approximately linear relationship exists between size change of an aerosol distribution and odor dilution.

Three prototype air dedusters were built. The laboratory prototype removed ~80% of airborne particles and ~55% of ammonia. The 5000-cfm vertical prototype performed almost as well in simulated production settings. With a new wet scrubber, ~50% of dust was removed from the exhaust of an 18" fan. A sequential development process showed that catalytic methods hold promise of being cost-effective ways to reduce exhaust gases from swine houses.

System Design and Management

Results of research projects and information from other sources were communicated to various stakeholder groups by several methods: accumulating an international database on swine manure and odor (>3000 citations on RefManager); website and CD-ROM systems potentiating easy, rapid future updating; newsletter; several trade-show exhibits; numerous speaking engagements; two workshops for scientists; and two field days for stakeholders. Illinois TRAILL is developing a website that will allow stakeholders to subscribe to an electronic newsletter, provide a searchable database of articles, and allow editors to upload their own content to the site.

Nutrition

Recommendations were developed for adding phytase to wheat middlings- and corn-soy-based pig diets while eliminating the need for supplementation with inorganic phosphorus and reducing excretion of phosphorus and calcium. Reduced dietary nitrogen and sulfur concentrations supported normal performance but decreased concentrations of odor-causing components in pig manure. Efficacy of a new *Escherichia coli*-based phytase product for dietary inclusion in improving phosphorus utilization efficiency and reducing excretion was demonstrated. A series of nutrition experiments led to several recommendations on nutritional approaches to increasing dietary phosphorus utilization in and decreasing phosphorus excretion by pigs and chicks.

Manure Processing and Handling

It was determined that any model of nutrient balance and flow in a swine-production system will need to be site-specific. Each facility will need to monitor its manure system frequently for guidance in management and regulatory compliance. It was demonstrated that composting manure according

to specific recipes of manure plus a carbon source (leaves, corn stalks, and so on) is a practical, economical, environmentally safe way for pork producers with small-, medium-, and large-scale operations alike to coexist with continuing urban sprawl. Compost can be used on-farm as a soil amendment or sold off-farm as a value-added product. The anaerobic sequencing batch reactor was found to be an effective way to remove and recover phosphorus from manure flows and hence reduce chances of environmental pollution. Three prototype systems for aerobic thermophilic microbial treatment of manure were demonstrated as effective means of using and thus removing manure from a swine production site. Because of the value of several co-products, this technology appears to be practically feasible. A high-temperature, high-pressure thermochemical means of converting pig manure into odor-free oil and char-like substance was developed as yet another means of removing manure from a swine farm. Covers were demonstrated to be effective in reducing odor emissions from manure lagoons. A variable-rate slurry applicator linked to the Global Positioning System (GPS) was invented and successfully developed as a means of controlling nutrient levels in crop-field soil. Experiments were conducted to determine optimum design, manure specifications, and operating requirements for a successful, practical gravity liquid/solids settling tank.

Community Considerations and Legal Issues

A random survey of Illinois newspapers revealed local arguments pro and con large-scale swine facilities (LSSF)—pro: farm/industry structure, economics, moral stance, minimizing environmental risks; con: environmental concerns, health risks, farm/industry structure, ethics of rural life. A book, with the working title *Pigs in Print*, is a product of this survey. Two more books are being written resulting from many interviews with various stakeholders in the Illinois pork production industry; working titles are *A History of the Hog in Illinois (1950–1980)* and *Citizen Reactions to Large-Scale Swine Facility Sitings*. A database available to all was developed to identify and analyze laws and court decisions related to swine odor and manure issues. A guide to important state and federal laws relevant to livestock facilities in Illinois, *How Environmental Regulation Affects Livestock and Poultry Production,* was produced.

The results of the SO&WM-SRI can be characterized as discovery and development, broad and deep, practical and theoretical. They have been described and disseminated to all stakeholder groups. They have thus fulfilled the mission of C-FAR. Many of the findings will be immediately applicable, others will serve as important links in the chain of scientific study destined to further come to grips with the real problems and opportunities associated with swine odor and manure management in the Land of Lincoln as well as around the world. Outcomes include less tangible matters such as the formation of interdisciplinary research terms and analytical and testing capabilities that promise to long survive the Initiative per se. Illinois scientists' focus on swine odor and manure management has been permanently enhanced.

Food Safety

Jeannette M. Endres
SRI Leader, Southern Illinois University at Carbondale

The constituency groups for the Food Safety SRI (FS-SRI) included all those involved with food production, handling, and preparation, from the producers on the farm to the families who consume the food. Other key constituency groups range from physicians who diagnose foodborne illnesses to educators and other researchers who work to identify the behavior of organisms and educate the consumers about how to avoid foodborne illnesses. Because of this broad scope, the research and outreach efforts of the FS-SRI are targeted to specific constituency groups. A complete description of these groups can be found in the *2002 C-FAR Annual Report.*

Promoting food safety in Illinois required a multilevel research and outreach effort. The food safety research agenda did not start with the SRI. The Governor of Illinois convened a Task Force on Food Safety prior to 1999 to study the food safety needs in Illinois. C-FAR participated in this task force as it was beginning to develop its own needs and priorities. About the same time, the President's Council on Food Safety planned for the National Food Safety Initiative. The Centers for Disease Control and Prevention released an infectious-disease control report titled *Food-Related Illness and Death in the United States* (www.cdc.gov/ncidod/eid/vol5no5/mead.htm), providing data on the frequency of the human foodborne diseases in the population.

Data show that since 1997 there has been an overall decline of 19% in the incidence of bacterial foodborne infections. Concurrent with this observed decline were implementations of mandated changes in meat and poultry processing plants, increased attention to good agricultural practices on farms, and increased consumer awareness of food safety; all areas addressed by this SRI. Data on *Campylobacter, Shigella, E. coli* O157 indicate a decrease in rate of infections in 1999, but the rate of *Salmonella* infections increased. However, *Salmonella typhimurium* and *S. enteritidis* have either stayed constant or decreased, while other *Salmonella* serotypes were associated with large outbreaks from unpasteurized orange juice, raw sprouts, and mangos. Recent data indicate there has been an average 10% per year increase in outbreaks of foodborne illnesses in the United States among one of the most vulnerable groups, children. The C-FAR organization was on target in addressing the food safety issues

in Illinois, since Illinois has ranked among the top three states in the nation in the number of foodborne outbreaks.

The overall goal of the FS-SRI was to focus attention on decreasing foodborne illnesses by promoting food safety strategies from farm to family, directed toward producers and veterinarians, the food-processing industry, and consumers. The initiative has included objectives and outcomes in three components: (1) pathogen detection and epidemiology, (2) Hazard Analysis Critical Control Point (HACCP), and (3) education/ outreach. The FS-SRI has consistently allocated approximately 60% of the funding assets to pathogen detection and epidemiology and the remainder to HACCP and education/outreach.

The FS-SRI has worked closely with members of the C-FAR Human Nutrition and Food Safety working group to identify a master list of specific food safety needs and the external consultants approved of the list in January 2000. These needs directed the management of the SRI for the duration of its tenure. Objectives to meet toward the overall goal of reducing foodborne illnesses tended to be redefined as the needs and research outcomes became available. The FS-SRI was not a static project but a continual process of redefining objectives, implementing the best strategies, and evaluating and marketing the results. The evaluation phase once again brought new objectives.

The SRI has had leaders of research teams from the University of Illinois, Southern Illinois University at Carbondale, Southern Illinois University Medical School at Springfield, Springfield Department of Public Health, Western Illinois University. and Illinois Institute of Technology to address the above needs during its tenure. Although the research focus has remained constant, there have been changes. For example, the need to address medical education was determined as CDC data indicated that cases of foodborne illnesses were underreported. However, it can be observed from the section addressing outcomes, highlights, and accomplishments that the researchers successfully addressed the needs identified by the constituents during the tenure of this SRI.

Not only did the FS-SRI team consult the working group for help in determining consumer and research needs, but it also formed an advisory committee made up of state and Federal agency representatives. These experts included representatives from Illinois Department of Public Health, Illinois Department of Agriculture, USDA Economic Research Service, and the National Restaurant Association.

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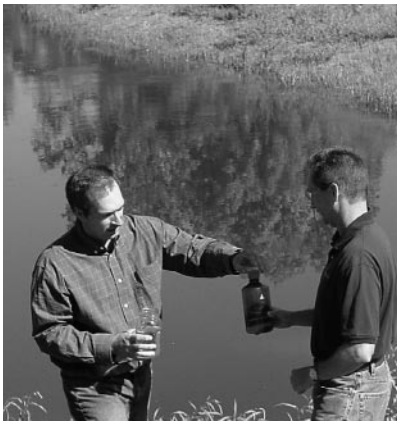
Water Quality



George F. Czapar
SRI Leader, University of Illinois
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The Water Quality SRI (WQ-SRI) was organized into three integrated research components: Best Management Practices, Mass Balance, and Modeling. Over 55 scientists, graduate students, and technicians from several universities and scientific surveys collaborated on 28 different projects. The following summaries briefly discuss these projects.

Best Management Practices

An experiment designed to evaluate the impact of rate and time of nitrogen (N) application and the use of a nitrification inhibitor on the environmental fate of N and corn yield was established in the 2001 crop year and continued through the 2003 crop year at a site in Douglas County, Illinois. A pattern tile field was selected that contained 54 tile lines that had been installed on 100-foot centers several years ago. Automatic samplers were installed on each tile line and programmed to record flow volume and to collect water samples systematically on a weekly basis for analysis for nitrate-N. Results of this study have shown that use of the best management practices, including application in the spring or as a side-dress treatment at the recommended rate, will minimize N loss from the field and optimize yield in most years. It is also evident from the data that application in excess of the optimum rate to corn will result in enhanced loss in the year following, when soybeans are grown. In addition, simulation models have been focused on this farm, and the model was tested using actual rainfall records. Tests of transient transport of nitrogen species were successful for these conditions. Work on the hydrologic portion of the model has resulted in several improvements to the original hydrologic model.

Another project was designed to improve the water and nitrogen mass balances for this field study. Researchers found that 75% to 90% of nitrogen coming out of tile lines is in the form of nitrate. The remainder of the nitrogen is primarily organic, with ammonium accounting for less than 1%. Two projects focused on reducing nitrogen loss through tile lines. In one study, shallow tiles placed closer together appeared to show positive water quality results. Peak tile flows and flow volumes were generally decreased with shallow tiles and delivered less nitrate-N compared to tiles installed 4 feet deep. The second project developed design criteria for field-scale subsurface bioreactors for removing nitrates from drainage water.

On-farm experiments were conducted in ten fields in 2002 and six fields in 2003, located throughout Illinois, to analyze the spatial variability of corn response to nitrogen fertilizer. Preliminary analysis of the data has shown that corn response to nitrogen fertilizer is not constant across fields but varies in a nonrandom manner. These results suggest that corn production functions vary among field sections and are probably related to site-specific soil characteristics and topographic attributes. A related project that was partially funded from the water quality SRI was the development of the Enhanced Farm Research Analyst (EFRA) software. The program is being used by farmers, consultants, and researchers for the demarcation of management zones in production fields, and also to determine site-specific response functions from producers' fields.

Mass Balance

To support the mass balance effort, stream-flow, sediment, and nutrient data were collected for quantitative analyses. The major findings of this study are that nitrate-N concentrations are significantly higher in Big Ditch than Big Creek, sediment is higher in Big Creek rather than Big Ditch, and the other nutrient concentrations are similar between the two stations. Quantification of N_2 fixation and N fertilizer usage by crops were needed to compliment soil, water, and atmospheric measurements being made as part of the Big Ditch

N cycle. Comparisons of nodulated and nonnodulated soybean plants and fertilized and unfertilized corn were used to determine estimates of soil N mineralization, N_2 fixation, and fertilizer uptake efficiency averaged over a three-year period (2000–2002).

Researchers measured organic carbon and total nitrogen concentrations of soil samples collected from fifteen fields in east central Illinois that had been previously sampled in either the 1901 or 1957 soil surveys. Their results suggested that soil N pools are not decreasing from current agricultural practices, and therefore net mineralization of N is not an important term in N mass balances.

Monitoring the concentrations and forms of nitrogen in streams and drainage tiles in the Big Ditch watershed helped researchers understand the role of in-stream denitrification. They found that the large nitrate loads (mainly from tile flow) found in all streams in east-central Illinois were relatively unaffected by denitrification within the stream environment, and only large reservoirs such as Lake Shelbyville would have a significant effect on reducing the nitrate load leaving Illinois. In order to account for the variability of nutrient loads of streams, existing data and new data sets were used to investigate how the frequency of data collection affects nutrient load calculations and how much variability existed in nutrient concentration in a stream cross-section. The main conclusions of the analyses were that more frequent sampling (weekly versus monthly) results in less error in estimating loads than less frequent sampling, and a data collection program with longer duration can collect data less frequently without losing accuracy of the load estimation.

In 2000, twenty-five face-to-face interviews were conducted with farmers in the Big Ditch Watershed regarding their use of N fertilizer, and the results were compared to previous surveys in the region. In 1995, the average N fertilizer application to corn was 40 lb N/ac, greater than specfied in the *Illinois Agronomy Handbook*, while in 2000, the average rate of over-application had decreased to 18 lb N/ac. It appeared that some progress had been made in reducing N fertilizer applications, but also that there was room for improvement.

Researchers also focused on shallow groundwater by monitoring water table depth, flow rates, and nutrient concentrations collected at a number of wells established for this study. Overall, N concentrations tended to be low in the groundwater, while phosphorus was rarely detected in groundwater samples. An analytical, steady-state groundwater flow model was developed and calibrated using water levels and stream flow data. Another project provided a detailed characterization of the hydrologic response of a tile-drained field over a several year period. The intense monitoring data provide the ability to calibrate and evaluate alternative models for flow and transport in small tile-drained watersheds.

Modeling

Linking water quality models and monitoring with economic processes and opportunities in watersheds was a major effort in southern Illinois. One group of researchers is developing a decision support system that helps a watershed optimize water quality and economic opportunities by evaluating alternative cropping systems across all farms in the watershed. Another group seeks to enhance water quality and farm income. This project included two intertwined components: (1) field-scale water quality monitoring of the benefits of riparian buffer zones and (2) a farmer/

landowner spatial decision support system for riparian buffer zone management. Existing models were evaluated for their applicability in Illinois watersheds, and to identify potential shortcomings. A model called ADAPT was found to simulate the monthly nitrate concentrations in the streams with reasonable accuracy, however, it appeared that the model overestimated N fixation by soybeans.

Researchers also investigated approaches for calculating riverine nitrogen loads, and in-stream sinks, as employed in the SPARROW model. They found a systematic error in the calculated loads, which produced an overestimation of nitrogen losses in rivers and streams by the SPARROW model. They proposed an alternative approach that uses actual river channel network data in conjunction with hydraulic geometry relationships to derive rates of N consumption by biogeochemical processes in sediments and stream waters.

The factors governing the hydrologic processes unique to tile-drained watersheds were investigated so that watershed water quality models can be improved or modified. Researchers found that DRAINMOD produced the best tile flow simulated results compared to AnnAGNPS (AGNPS 98) and RZWQM.

Finally, a Dynamic Watershed Simulation Model (DWSM) for storm events was developed to simulate surface and subsurface water, propagation of flood waves, upland soil and streambed erosion, sediment transport, and agrochemical transport in agricultural and rural watersheds. In addition, the following 11 watershed-scale models were reviewed and compared: AGNPS, AnnAGNPS, ANSWERS, ANSWERS-Continuous, CASC2D, DWSM, HSPF, KINEROS, MIKE SHE, PRMS, and SWAT. This review is very useful for selecting the most appropriate watershed model for an application.

A comprehensive website (**http://web.aces.uiuc.edu/sriwq**) details individual WQ-SRI projects, budgets, progress reports, and outcomes.

FY2004 Strategic Research Initiative Program

Recognizing that the five original SRIs would end in June 2003, C-FAR issued a request for pre-proposals in October 2002 for new SRIs that would address research priorities identified by the C-FAR membership or other initiatives that would benefit Illinois' food, agriculture, and related industries. Forty-one pre-proposals, requesting $43.4 million over the next five years, were submitted to the FY2004 SRI program, with $9.4 million requested for FY2004. The C-FAR membership identified three projects to be funded through the FY2004 program. The following SRIs officially began on July 1, 2003.

Biomass Energy Crops for Power and Heat Generation in Illinois: Diversifying Cropping, Improving Energy Security, and Benefiting the Environment

Dr. Stephen Long, University of Illinois at Urbana-Champaign, provides leadership for a multidisciplinary team of 12 researchers who are contributing to this five-year SRI. The research initiative aims to provide Illinois with the foundation and technology leadership for large-scale cultivation of biomass crops. Researchers will focus on the use of *Miscanthus*, a perennial rhizomatous grass, as a potential renewable energy source for Illinois and profitable alternative crop for Illinois producers.

Illinois First Livestock Focus Initiative

Dr. Michael Hutjens, University of Illinois at Urbana-Champaign, leads a multidisciplinary, multi-institutional team of nine researchers on this SRI, which focuses on addressing the economic and social challenges facing Illinois' livestock industry. The four-year initiative will focus on livestock facility siting in Illlinois; using Illinois byproduct feeds in livestock feeding programs; pasture-based forage systems to sustain Illinois livestock producers; and animal identification for enhanced food quality and monitoring livestock health.

Water Quality with a Focus on Total Maximum Daily Loads

This three-year initiative continues efforts of the former water quality SRI with a new focus on total maximum daily loads (TMDLs). Dr. George Czapar, University of Illinois Extension, leads a team of 15 investigators from across the state. SRI goals are to help develop the scientific basis for nutrient standards in the surface waters of Illinois and to assist in the appropriate development and implementation of TMDLs. The research team works closely with the Illinois Environmental Protection Agency, the Illinois Department of Agriculture, and the Metropolitan Water Reclamation District of Greater Chicago.

C-FAR Sentinel Program

Steven G. Pueppke, Associate Dean for Research at the College of Agricultural, Consumer and Environmental Sciences, University of Illinois at Urbana-Champaign

Introduced in 1999, the C-FAR Sentinel Program at the University of Illinois at Urbana-Champaign was initiated to take advantage of windows of opportunity to do research that address C-FAR priorities. Sentinel projects are multi-investigator and multi-departmental, with most crossing college boundaries and bringing together investigators from a variety of disciplines. In 2003, this program comprised seven creative, problem-solving research initiatives.

The Sentinel Program is the fourth component of the University of Illinois C-FAR research portfolio. It complements and extends the research efforts of the other components: the university's internal competitive grants program, External Competitive Grants Program projects, and the Strategic Research Initiatives (SRIs).

SoyFACE: Research and Discovery Program to Abate the Threats and Harness the Potential of Atmosphere Change to Benefit Illinois Agriculture

Principal Investigators

Stephen P. Long, Crop Sciences
Donald R. Ort, Crop Sciences and USDA-Agricultural Research Service
Evan H. DeLucia, Plant Biology

With assistance from sixteen investigators representing the Departments of Animal Sciences, Crop Sciences, Entomology, Food Sciences and Human Nutrition, Natural Resources and Environmental Sciences, and Plant Biology as well as the Illinois State Water Survey and USDA-ARS

The 2003 experiment on the 80-acre site was the largest experiment to date. Four 70-ft-diameter areas, known as FACE (Free-Air Concentration Enrichment) rings, elevating carbon dioxide (CO_2), four elevating ozone, and four elevating both gases in combination to predicted levels for 2040–2050 were operated in soybeans together with four further control rings. The facility successfully maintained these elevations to a high degree of precision from crop emergence to harvest. In the 2002 experiment, now fully analyzed, the 50% increase in CO_2 increased yield by almost 20%, and the increase in ozone decreased yield by 20%. If this loss is shown to be repeated in subsequent years, then it will confirm that a very significant loss of competitiveness on world markets is expected, given that ozone levels are not rising in South America, unless resistant germplasm is developed.

Ozone decreased photosynthesis, accelerated senescence and crop maturation, and resulted in fewer pods, fewer seeds per pod, and smaller seeds. CO_2 and ozone both decreased water loss by the soybean crop by 16% and 11% respectively, suggesting that by 2050 significantly less water will be lost to the atmosphere. This may benefit crops on well-drained soils. However, it would also affect regional climates by lowering water transfer to the atmosphere, leading to increased surface temperatures and drainage to rivers, in turn increasing the risk of flooding and nitrogen losses to the river system. Ozone lowered the yield of all soybean germplasm tested; although there was variation between genotypes, there was no evidence that recent cultivars were any more tolerant of ozone than the elite Chinese lines. In July 2003, a heavy hailstorm removed 90% of the leaves from the crop. However, the crop recovered to yield an estimated over 35 bushels per acre. Recovery of leaf area was more rapid and more pronounced in the elevated CO_2 treatment than in the controls and was weaker in the ozone treatment. It appeared that the hail damage amplified the difference between treatments. Elevated CO_2 provided some protection from leaf area loss caused by elevated ozone. Elevated CO_2 also increased photosynthesis and yield in corn, on average by 10%.

The project was featured in several local and national newspapers and TV stations during the summer of 2003, including *USA Today*, the *Washington Post*, and CNBC. Over 500 individuals visited the SoyFACE facility during 2003, ranging from high-school groups and two agritourism groups from Brazil to the Director of the National Science Foundation and the Deputy Director of the Illinois Department of Agriculture. Researchers from over 40 universities and research organizations in 15 different countries and four continents participated in SoyFACE research in 2003. Additional external funding leveraged to expand the project was provided in 2003 from Archer Daniels Midland (ADM), Pioneer Hi-Bred, BASF, Argonne National Laboratory, and USDA-ARS, DOE, USDA-NRI, and IALC. The estimated value of this additional external support in the past year is $560,000.

Developing an Agricultural Remote Sensing Program at University of Illinois

Principal Investigator

Lei Tian, Agricultural and Biological Engineering

Researchers continue to focus on individual projects sponsored by federal and private agencies to develop a requisite database for a major crop precision farming system based on remote sensing and novel ground truth data collection systems. A research focus is to increase remote sensing data quality. An unmanned aerial vehicle remote sensing data collection system was developed and tested in the Illinois Laboratory for Agricultural Remote Sensing (ILARS). To study the effects of natural lighting conditions and timing issues in agricultural remote sensing, a stand-alone real-time remote sensing system was implemented for a whole season of data collection. Sponsored by USDA and in collaboration with the industry, an autonomous data collection (plant-specific operation) system experiment project was initiated. Experiments have been carried out using commercial and University research farms to demonstrate new remote sensing based field operations. The AG 20/20 initiative project, funded by the NASA and United Soybean Board (USB), has been actively studying the applications of remote sensing-based herbicide application. Researchers from different departments and other institutes are working together on these projects.

With newly developed equipment, researchers provided unique remote sensing data collection and data processing services to researchers and producers. Researchers from ILARS presented papers and held displays in national and international conferences such as ASAE, ASPRS, ASA, Precision Ag, and ECPA. They are working closely with similar research labs at other universities and also with government agencies such as NASA and USDA. ILARS has also developed a very good co-operative relationship with other research institutes and private companies in Asia, Europe, and South America.

Transgenic Swine Program

Principal Investigators

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Sharon M. Donovan, Food Science and Human Nutrition
Walter L. Hurley, Animal Sciences

Progress has been made toward obtaining a patent for the IGF-I transgenic animals and further characterizing the α-LA and IGF-I lines of transgenic animals. Researchers have been working to obtain a new U.S. Patent, entitled "Animals Expressing Exogenous IGF-I in Their Milk." A divisional patent application was filed on September 30, 2003.

Four abstracts on IGF-I transgenic swine were presented at the 2003 Annual Meeting of the Animal Science and Dairy Science Association. Two abstracts focused on the mammary amino acid transport and mammary growth of the transgenic sows. Amino acid transport into the lactating mammary gland is critical for milk protein synthesis. Mammary overexpression of IGF-I did not affect lysine uptake, a sodium-independent transport system; however, the *maximal rate* of taurine transport was increased in sow mammary tissue of IGF-I transgenic sows. Because taurine is taken up by the mammary gland via a sodium-dependent process, these data suggest that IGF-I may regulate cellular sodium transport systems. IGF-I plays a critical role in mammary cell proliferation and apoptosis. Researchers investigated whether IGF-I regulated mammary development via changing rates in mammary cell death, which primarily occurs during the process of involution during weaning. Mammary secretions and tissue biopsies were obtained 4 days post-weaning (d25 postpartum). Overexpression of IGF-I resulted in increased IGF-I, IGFBP-2, and IGFBP-5 concentrations in mammary secretions during involution. Furthermore, mammary tissue from IGF transgenic sows had a significantly ($p<0.05$) lower percentage of apoptotic cells than nontransgenic sows (7.5+1.7 vs. 4.6+1.5 %, respectively) at d4 post-weaning. Taken together, these data show that the IGF-I that is overexpressed in the mammary gland of transgenic animals is bioactive and influences cell turnover and intracellular processes.

The other two abstracts compared the intestinal development of piglets suckling nontransgenic and IGF-I transgenic sows throughout lactation. Piglet intestinal samples were obtained on d3, 7, 14, and 21

of lactation. Jejunal mucosa weight was greater at d3 in IGF piglets than in controls ($p<0.01$), and ileal mucosal weight was greater in IGF piglets at d3, 7, and 21 than in controls ($p<0.01$). Jejunal and ileal lactase and sucrase activities were greater ($P<0.05$) on d21 in piglets suckling IGF transgenic than in piglets suckling nontransgenic sows. When data from all time points were combined, IGF piglets had greater jejunal lactase and sucrase activity ($P<0.0001$) as well as increased ileal sucrase activity ($P<0.0001$) than piglets suckling nontransgenic sows. Thus, increasing milk IGF-I content improved both growth (mucosal mass) and functional (enzyme activities) parameters in the intestine. The observation that the greatest differences between the groups was observed at day 21, suggests that piglets suckling IGF-I transgenic sows may have healthier intestines at weaning and would have improved production characteristics during the weaning transition.

An abstract on α-lactalbumin transgenic swine was presented at the 2003 Society for the Study of Reproduction meeting, and another will be presented at the International Embryo Transfer Society meeting in January 2004. Researchers have previously demonstrated that transgenic overexpression of a mammary-specific transgene, bovine α-lactalbumin (α-LA), increased milk production and piglet growth. However, in the previous experiments, all litters were normalized to 10 piglets per sow. It was hypothesized that α-LA transgenic animals had greater lactation potential than nontransgenic and would respond to increased suckling stimulation. Lactational response to increased suckling stimulation was determined by fostering piglets of either the same age as (d1) or seven days older than (d7) sow day of lactation to Yorkshire sows either nontransgenic (control) or transgenic for α-LA. Piglets that suckled α-LA sows, regardless of age of litter when fostered, grew significantly faster than piglets that suckled control sows for the entire 15 days of lactation studied ($P<0.05$), resulting in a cumulative average of 455 grams of additional gain per piglet. First parity α-LA sows are more able to respond to increased suckling stimulation by a resultant increase in milk yield than control sows under equivalent conditions. Similarly, piglets suckling α-LA sows gained weight faster than piglets suckling control sows. Overexpression of the bovine α-LA transgene in sows enhances mammary response to regulators of milk yield, such as level of suckling stimulation.

Illinois Center for Soy Foods

Principal Investigators

Barbara P. Klein, Food Science and Human Nutrition
Keith R. Cadwallader, Food Science and Human Nutrition

The goal of the Illinois Center for Soy Foods (ICSF) is to promote consumption of soy foods, thereby providing benefits to growers, processors, and consumers in Illinois. To achieve this goal, the Center is implementing several research, training, and outreach projects.

ICSF is developing innovative ways to increase usage of soy in the food service sector. Prototype soy-fortified foods are being developed. ICSF will work with food service providers and residence halls on the Urbana-Champaign campus of the University of Illinois to test these food products and evaluate consumer acceptance. Meanwhile, ICSF has completed development of improved prototype soy-fortified bakery products suited for American diets. Also, a new cookbook, *Baking with Soy,* has been published. This is the third in the cookbook series, *Soy in the American Kitchen*, on how soy products can easily be used in the American kitchen. To increase consumer awareness about new, high quality soy foods, the Center has started an annual Soy Foods Tasting event. Institutional food service managers, restaurant operators, food critics, dietitians, and leaders of community-based organizations are among those invited. Meanwhile, Soy Source, a retail "store" at the University of Illinois, continues to feature and test market new soy foods during the school year.

A high priority for the ICSF is its educational and outreach efforts. In the United States, short courses were organized to increase awareness about sensory and flavor issues related to soy (Soy Flavor Workshop: Sensory and Instrumental Methods); soy dairy analogs (Soy Milk and Dairy Analogues); development of soy foods (Product Development of Soy Foods); and nutritional benefits of soy (U.S. Private Voluntary Organizations [PVOs] Workshop). In addition, ICSF personnel spoke at schools, community organizations, and national and international food science and dietetics meetings about the health benefits of soy and the ease of using it, as well as research studies. Outreach activities were held in the field for international audiences on how to add soy to local diets. These included extension training in Honduras, Senegal, Botswana, Kenya, Tajikistan, and Zimbabwe. The ICSF undertook development of a prototype high-energy, nutrient-dense nutrition bar. The bar is meant to be the "first response" food during a refugee crisis caused either by natural disasters or wars. The ICSF also developed a high-protein, high-energy bun as a mid-day snack for vocational training programs in developing countries. In collaboration with Archer Daniels Midland (ADM) and the American Soybean Association, researchers organized a training course for schools lunch administrators and the World Food Program staff from Ivory Coast on improving protein content of their school meals. The Center has also provided research and technical services to several companies on problems related to extrusion and dairy analogs. A website at **www.soyfoods illinois.uiuc.edu** has been developed as a resource for consumers on how to use soy in their kitchens. The Center has received strong industry support for its research and outreach efforts, with more than $250,000 worth of soybean-processing equipment and research grants being received to date.

Manipulation of Photoperiod to Enhance the Sustainability of Illinois Dairy Farms

Principal Investigators

Geoffrey L. Dahl, Michael F. Hutjens, David B. Fischer, Animal Sciences and U of I Extension
Richard L. Wallace, Veterinary Medicine and U of I Extension
Gary D. Schintkey, Agricultural and Consumer Economics and U of I Extension

Management of photoperiod (the duration of light a cow is exposed to each day) in dairy cattle is a profitable tool for producers in many economic situations. Properly implemented, photoperiod technology leads to immediate milk production responses, requires little capital investment, and has a quick asset turnover. These features make the investment particularly attractive to help producers meet the current challenges and improve

long-term viability of the Illinois dairy industry. This project emphasizes a combination of outreach education and applied research to demonstrate, optimize, and develop novel photoperiod management techniques and thereby facilitate widespread awareness and adoption of them on dairy farms in Illinois.

The first field study testing the viability of photoperiod management in Illinois was carried out the past two years on commercial farms. This study involved pairs of farms of similar production and management levels. Within each pair one farm installed lighting and is applying long-day treatment to the lactating herd, and the other farm's herd serves as a control of no treatment. Milk production, herd health, and implementation costs were followed for six months. Researchers are in the process of summarizing the results. Farms are now being enrolled for a second year in the study. A second study, examining the impact of photoperiod manipulation to speed heifer growth and eventual entry into the milking herd, has recently been completed, and results are being summarized.

Presentations were made at numerous industry sponsored events to at least 500 dairy producers and allied industry representatives in the Illinios-Iowa-Minnesota-Wisconsin region; at the Northeast regional meeting and Pacific Cow College, sponsored by Cargill, to over 125 technical service advisors; at the Western Canadian Dairy Seminar to 350 producers, veterinarians, and allied professionals; and at an invited presentation at the 42nd National Mastitis Council Meeting and the IVth International Dairy Housing Conference, co-sponsored by NMC and the American Society of Agricultural Engineers in Fort Worth, Texas. Information on photoperiod management is available at **http://il-traill.outreach.uiuc.edu/photoperiod**. The site includes data summaries, installation instructions, and worksheets for estimating installation costs and economic benefits.

Creating Niche Market Opportunities in Animal Feeding for Small Farmers with Soybeans

Principal Investigators

Neal R. Merchen, George C. Fahey, Jr., Animal Sciences

The central goal of this multi-year project is to identify soybean meal processing techniques that would add value to soybeans as a feedstuff for poultry and swine. Animal scientists at the University of Illinois are identifying soybean meal processing conditions, with the goal being to increase soybean meal amino acid digestibility and/or minimize meal phytate phosphorus content. The former result would allow for more nutrient efficient diet formulations for pigs and poultry. The latter would free up phosphorus already present in soybean meal but presently unavailable for digestion. This would require less feed supplementation and result in less phosphorus excretion by the animal to the environment. By developing soybean meal with benefits specific to swine and/or poultry feeding, it is anticipated that increased opportunities will arise for processing plants to furnish "species-specific" meal.

Work during the first two years has focused on two linked, yet different aspects of the project, animal science feedstuff modifications and feeding trials, and outreach activities. Animal scientists work with meal samples processed under tightly controlled conditions at a pilot plant at Texas A&M University. Soybean meal samples from beans processed with varying residence times during the desolventizing/toasting stage were analyzed to determine whether protein quality and growth and performance in pigs will be affected. The samples for examining phytate phosphorus variation were manufactured by varying extractor residence time and will be analyzed for composition and quality. These meals are currently being used in poultry and swine feeding trials to determine whether growth and performance of the animals are affected by the changes introduced in the meal quality. While the animal science research continues, the agricultural economics component is being actively developed. Animal enterprise models are being finalized and readied for use as recommendations from the animal trials are completed.

The second aspect of the project to receive considerable effort to date is the outreach component. Frazier Barnes & Associates provides linkages with soybean producer groups interested in possible advantages to producing specialized soybean meal products for animal feeding in small scale processing plants. As research results indicate potential advantages for swine or poultry feeding when using meal produced using modified processing conditions, these identified producer groups will be better prepared to capture the value of working within a niche market. The data resulting from the research will be best made available to the animal feeding industry and the public via the Internet. A website was developed and is gradually being populated with information ranging from general soy processing information to specific databases of soy nutrition information that will be of interest to the animal feeding industry.

The team is working in parallel efforts of research and developing outreach avenues to ensure better that this project will result in tangible outcomes. These outcomes will increase the awareness of how to

improve domestic marketing channels for soybeans while supporting and benefiting the swine and poultry industries with better information about soybean meal diets.

Plant Disease Molecular Diagnostic Initiative

Principal Investigators

Kris N. Lambert, Dean K. Malvick, Terry L. Niblack, Crop Sciences

In this project, funds were requested to purchase equipment to aid in the rapid detection of plant pathogens. The funds were used to purchase a Zeiss microscope that will speed the counting of soybean cyst nematodes; a microplate reader that can perform high-throughput immunological and DNA quantification assays, and two ABI sequence detection systems that can quickly quantitate pathogen DNA.

Researchers are currently using the Zeiss microscope to develop a rapid high-speed soybean cyst nematode counting system. The high-speed microplate reader has been used a great deal and has processed over 14,000 immunological assays that detect fungal toxins in plant tissues. The reader is also being used for high-speed determination of DNA concentration for DNA-based pathogen detection. The ABI 7900HT sequence detection system, which performs real-time polymerase chain reaction (PCR) to detect pathogen DNA, is now operational. In fact, it has been so heavily used that a second real-time PCR machine, an ABI 7000, was purchased. Researchers have used real-time PCR to detect fungal, nematode, and viral DNA in plant tissues. This instrument has been particularly useful because it greatly improves the sensitivity and speed of DNA-based pathogen assays. Several conventional PCR assays that detect plant pathogens have been converted into real-time PCR assays, called TaqMan assays, and the new assays have been found to be 100 times more sensitive. Researchers are now able to detect brown stem rot (BSR) of soybean, caused by *Philophora gregata; Aphanomyces* root rot (ARR) of alfalfa, caused by *Aphanomyces euteiches;* as well as *Fusarium solani* f.sp. *glycines*, which causes sudden death syndrome in soybean. The ability to detect these fungal plant pathogens allows for the investigation of the biology, ecology, and infection processes of these poorly understood pathogens. Such knowledge will be essential to improve integrated management of these diseases.

The real-time PCR machine has also been useful for research on detecting virulent soybean cyst nematodes (SCN). In these experiments, TaqMan assays have been used to detect SCN virulence genes. Researchers have determined the frequency of these genes in SCN populations growing on resistant and susceptible plants and have been able to predict some of the parasitic ability of SCN. This real-time PCR assay for SCN virulence will allow for the rapid prediction of SCN virulence to commonly grown resistant soybean varieties. The ability to predict SCN virulence quickly and monitor these populations over time will assist in advising growers on which SCN resistant soybean varieties to grow to control the nematode. The ability to rotate SCN resistant soybean will prevent the buildup of highly virulent SCN populations and help preserve SCN resistant soybean germplasm.

Internal and External Research Projects

In accordance with the Food and Agriculture Research Act (the C-FAR appropriation's enabling legislation), the majority of research funds are allocated on a percentage basis to Illinois' four food and agriculture research universities: University of Illinois at Urbana-Champaign (82%), Southern Illinois University at Carbondale (11%), Illinois State University (4%), and Western Illinois University (3%). Each university solicits requests for proposals (RFPs) as part of an internal competitive grants program to select innovative, high-quality research that addresses the needs of the Illinois food, agriculture, and related communities and consumers as defined by the C-FAR membership.

C-FAR's External Competitive Grants Program is designed to encourage and support research efforts from state agencies and organizations outside of the four universities. The program solicits RFPs from nonprofit research entities within the state. By legislation, a minimum of 15% of the C-FAR allocation is dedicated to support these research projects. Working group members review and select proposals submitted to this program.

Projects supported through the university internal programs and the External Competitive Grants Program are typically funded for one, two, or three years. No-cost extensions can be granted if additional time is needed to complete the project. Support is provided on a fiscal year basis that runs from July 1 through June 30. The following sections provide a report on the internal and external research projects that were completed in 2003, as well as a listing of the research projects that were funded in FY2004. Although projects are listed under given categories, they often span multiple research areas and interests.

Please visit the C-FAR website at **http://web.aces.uiuc.edu/c-far/cfarreporting/public.cfm** for more information about these projects.

Crops

A Selectable Marker for the Sugary Enhancer1 (*se1*) Gene in Maize

The sugary enhancer1 (*se1*) mutation, when homozygous in traditional *sugary1* sweet corn, has been shown to increase kernel sugar content at fresh harvest by 40%–100%, providing a superior product to consumers and extending postharvest maintenance of eating quality. The desirable attributes of *se1* sweet corn has lead the vegetable seed industry to attempt to develop and release new commercial hybrids carrying this mutation. The goal of this program is to attempt to identify DNA markers (AFLPs, SSRs, RAPDs, or transposable elements) tightly linked to *se1* that can provide a starting point for eventual cloning and characterization of the gene. An important application of this research is to provide DNA markers by which sweet corn breeders and researchers can more reliably select for *se1*, thereby leading to greater commercial utilization.

Three primary approaches were employed to generate DNA markers associated with the *se1* mutant allele. Initial efforts sought to utilize Robertson's Mutator stocks to introduce a transposon into the DNA sequence coding for the *se1* gene. After the screening of approximately 400,000 kernels over three years, no Mutator-induced *se1* mutants were detected. The next approach involved screening a sweet corn population segregating for the *se1* allele and previously mapped to saturation with RFLP markers for AFLP polymorphisms associated with sugar content. Although 20 polymorphisms were uncovered, only 10 polymorphisms provided data amenable to mapping, and none of these showed any linkage with *se1* or, for that matter, with any of the previously mapped RFLP loci. The final approach involved the tagging of 70 previously mapped SSR markers targeted to chromosomal regions previously associated with the *se1* phenotype onto another sweet corn F2:3 population generated from crossing two inbreds isogenic for *se1*. All loci were found to be monomorphic between the parents, although sugar analysis of the families in the population displayed clear segregation for the *se1* phenotype. Although this project identified no *se1*-linked markers, several populations were created with accompanying phenotypic data that will be useful for future attempts using other DNA markers (ESTs, cDNAs, etc.).

A C-FAR External Competitive Grants project

John A. Juvik, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Co-product Characterization from Dry Grind Ethanol Processing for Enhanced Value

The objective of this research was to determine nutrient content of process streams in dry grind (DG) ethanol processing plants to identify opportunities for increasing the value of co-products: distiller's dried grains (DDGS) and carbon dioxide. The DG process involves processing components of the entire corn kernel through fermentation. This process produces ethanol, carbon dioxide, and DDGS. The kernel components that do not ferment are concentrated into the DDGS co-product. Although most components are beneficial for animal nutrition, there can be a concern if these components are not bioavailable to animals or are fed in excess. In such cases phosphorus is excreted in animal wastes. Phosphorus has become a nutrient of environmental concern because it can be transferred from land surfaces into streams and lakes. The phosphorus content of DDGS is typically three times (approximately 0.8% dry basis) the concentration in corn (0.3%). It is anticipated that animal producers will be valuing co-products such as DDGS based on phosphorus content, since regulations for land application of animal wastes are expected to tighten. A large supply and high phosphorus content could reduce further the value of DDGS and hamper the economic sustainability of the dry grind corn processing industry.

This research involved the participation of two universities, a USDA research laboratory, and nine dry grind corn processing facilities. Through characterization of the process streams at 11 locations in each of the DG plants, researchers found that phosphorus concentrations in thin stillage and syrup streams were twice as high as in DDGS. This provides an opportunity to lower phosphorus concentration in DDGS by eliminating or reducing phosphorus in the thin stillage or syrup streams before they are processed into DDGS. Future work should focus on these two streams to lower phosphorus, which would improve DDGS value and reduce potential environmental impact.

A C-FAR External Competitive Grants project

Kent D. Rausch, Vijay Singh, Agricultural and Biological Engineering

College of Agricultural, Consumer and Environmental Sciences

M. E. Tumbleson, Agricultural and Biological Engineering and Veterinary Biosciences, Colleges of ACES and Veterinary Medicine

University of Illinois at Urbana-Champaign

David B. Johnston, Eastern Regional Research Center, ARS, USDA

Ronald Belyea, Animal Sciences

Thomas Clevenger, Civil Engineering

University of Missouri, Columbia

Fall Application of Nitrogen for Corn in Southern Illinois: Revisited

This project is an outgrowth of a need for more current information on the agronomic, economic, and potential environmental risks of fall nitrogen application to succeeding-year corn. Increasingly, farmers in the northern counties of the lighter-colored southern Illinois soils region are applying fall nitrogen (N) ahead of corn, mainly as anhydrous ammonia. The rate of conversion of ammonium-N to nitrate-N is much more rapid in southern Illinois soils than in northern Illinois soils, where fall N fertilization is an accepted practice. Consequently, not only is the nutrient lost to the environment but it is an economic loss to the producer, who will not get any yield benefit from the nitrogen that is applied. The goal of this research is to assess fall versus spring versus sidedress anhydrous ammonia application, with and without a nitrification inhibitor, on corn using current-day management practices, technologies, and hybrids.

Corn yield results observed in 2001 and 2002 experiments from two locations in southern Illinois suggest that fall anhydrous ammonia application is inferior to spring application, even if a nitrification inhibitor (nitrapyrin) is added to the fall N. Yields averaged 4 to 5 bushels per acre less with fall anhydrous (that included nitrapyrin) than with spring applications that did not include nitrapyrin. The value of the yield loss with fall ammonia application plus the cost of the nitrapyrin addition would mean a net profit reduction of about $15 per acre if the producer chose to fall-apply ammonia that included the inhibitor. The loss would be about $35 to $40 per acre if the producer chose to fall-apply ammonia that did not include nitrapyrin. A third year of harvest data has yet to be collected and analyzed. Once those data have been included, more definitive conclusions regarding the agronomic, economic, and environmental consequences of fall N application for corn in southern Illinois can be drawn.

Edward C. Varsa, Ronald F. Krausz, Plant, Soil and Agricultural Systems

College of Agricultural Sciences

Southern Illinois University at Carbondale

Stephen A. Ebelhar, Crop Sciences

University of Illinois Dixon Spring Agricultural Center

Identifying Resistance to Aflatoxin Contamination in Corn

The purpose of this research was to (1) screen 400 to 500 lines from a public corn germplasm collection for resistance to *Aspergillus flavus* infection and aflatoxin accumulation and (2) characterize the mechanism(s) operating in genotypes identified as resistant for subsequent development as an alternative selection tool for corn breeders.

Corn genotypes (n = 416) obtained from a public corn germplasm collection were screened in the laboratory for resistance to aflatoxin accumulation using *Aspergillus flavus* AF13 and *A. parasiticus* SK1. The latter isolate produces the aflatoxin intermediate norsolorinic acid (NOR) instead of aflatoxin, so human health hazards associated with screening are reduced substantially. Nonwounded corn kernels were inoculated with *A. flavus* to determine aflatoxin accumulation. A spectrophotometric assay to determine NOR concentration was developed using nonwounded kernels inoculated with *A. parasiticus*. A purified NOR sample was scanned (250 to 700 nm) in the spectrophotometer, and peaks were observed at 325 and 460 nm. All 416 lines were examined for NOR concentration after inoculation with *A. parasiticus*. In addition, visual data (number infected kernels, location and intensity of pigmentation) were collected 2 weeks after inoculation. NOR concentrations in these 416 lines ranged from 42.2 to 1132.3 ppm at 325 nm and 5.5 to 603.9 ppm at 460 nm. From these lines, 55 were selected to test whether NOR concentrations and visual data correlated with aflatoxin levels. Lines represented the full range of NOR concentrations and included GT-MAS: gk (resistant) and GT-119 (susceptible) as controls. NOR concentrations correlated positively with measured aflatoxin levels across all isolates. This exciting result indicates that we can use the NOR screen as an effective substitute for aflatoxin measurement in corn screening efforts. This is an important discovery with direct applications to human safety. The fact that aflatoxin levels correlated positively with NOR levels measured at 325 and 460 nm using both Pearson correlation and Spearman rank correlation shows flexibility in this procedure, because either wavelength can be used to predict aflatoxin production. Another positive result is that 14 additional corn lines were identified that support aflatoxin levels lower than those in GT-MAS: gk, which is the current standard for resistance.

John S. Russin, Salliana R. Stetina, Plant, Soil and General Agriculture

College of Agricultural Sciences

Southern Illinois University at Carbondale

In-Season Site-Specific Nitrogen Management for Corn

This research investigated the fundamentals for developing a multispectral sensor to detect corn nitrogen deficiency based on crop canopy reflectance. A background segmentation algorithm

was developed to filter the soil background out from the canopy images to eliminate the effects of background noise on leaf reflectance analysis. A dynamic calibration model was developed to compensate for ambient light factors to obtain consistent leaf reflectance with similar nitrogen deficiency level. Results obtained from field investigation indicated that there existed some approximate linear relationships between the corn's leaf reflectance (or vegetation indices determined based on such reflectance) and SPAD chlorophyll meter readings. The results also indicated that the reflectance from the near-infrared (NIR) channel alone was incapable of indicating nitrogen deficiency level, but it was the most sensitive channel to segment the background soil noise. This investigation found that the ratio NIR/G not only showed stronger correlations based on all leaf conditions (whole area, bright area, or shadow area) but also required less computation to perform the analysis. Based on the results obtained from this study, it can be concluded that it is technologically feasible to use a multispectral CCD camera on a nitrogen applicator to provide sufficient leaf reflectance information to assess corn nitrogen stress "on-the-go" during field operations.

Site-specific variable-rate nitrogen management technologies provide a promising way of increasing crop yield, reducing nitrogen input, and consequently reducing nitrate-nitrogen leaching. This research has verified the feasibility of implementing variable-rate nitrogen application by using a nitrogen stress detection sensor on a commercial nitrogen applicator. The verified results will lead to the invention of a "sensor-based variable-rate nitrogen management" technology implemented directly on commercial nitrogen applicators. Such an invention will make a usable tool to help the corn grower realize the benefits of technology advancements in site-specific variable-rate nitrogen management.

A C-FAR External Competitive Grants project

Qin Zhang, Beom-Soo Shin, Agricultural and Biological Engineering

Robert G. Hoeft, Emerson D. Nafziger, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Shufeng Han, Deere and Company

Remote Sensing Methods to Identify Nitrogen Deficiencies in Corn in the Low Organic Matter in Soils of Illinois

The goal of this study was to determine whether analysis of aerial images from a low-cost near-infrared camera can detect differences in corn canopy reflectance such that fertilizer nitrogen needs of corn can be estimated. It appears that nitrogen (N) recommendations can be adequately estimated from aerial images and that less nitrogen will be needed to optimize corn yields, but more information will be required than is provided by the aerial images alone, such as soil type and weather factors. The reduction in N needs was 27 to 31 kg per ha (24 to 28 lb/acre), which at a price of $0.14 per kg would save a farmer only an average of $3.75 to $4.30 per ha ($1.50 to $1.75/acre), which may not be enough to pay for the technology. However, decreased nitrogen use could translate to reduced environmental release of N.

A C-FAR External Competitive Grants project

Adam H. Anderson, Stephen A. Ebelhar, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Edward C. Varsa, Plant, Soil and Agricultural Systems

College of Agricultural Sciences

Southern Illinois University at Carbondale

Engineering Resistance to the Soybean Cyst Nematode

The goal of this research is to engineer novel resistance genes to protect soybean from the soybean cyst nematode. This project had three objectives: (1) to isolate genes that encode nematode intestinal proteins that can then be used as targets for engineering nematode resistance, (2) to optimize the expression of foreign proteins in nematode feeding cells using a rapid soybean hairy-root transformation method, and (3) to express nematicidal proteins and/or RNA in soybean roots using our optimized expression system and to evaluate these transgenic roots for resistance to the soybean cyst nematode.

Researchers cloned a cDNA for a target intestinal protein (adipokinetic hormone) that is thought to be essential for nematode feeding and fat digestion. When double stranded RNA (dsRNA) of a specific gene is eaten or internalized by a nematode, the specific gene's expression is often inhibited by a process called RNA inhibition (RNAi). Researchers used RNAi to disrupt the expression of the adipokinetic hormone gene and tested the effect of disrupting this gene on nematode parasitism. Data showed that RNAi of the target gene lowered nematode infection of the plant when the nematode was soaked in dsRNA. This result indicates this method of nematode control could work if the nematode internalizes the dsRNA. Unfortunately, researchers were unable to produce transgenic plants expressing dsRNA, so new SCN-resistant plants were not produced. This method of nematode control may work if a method can be devised to express dsRNA in soybean.

In parallel to this project, researchers tested transgenic soybean hairy roots for SCN resistance. These transgenic

roots were engineered to express proteins potentially toxic to SCN and were tested for resistance using an improved SCN bioassay. Using this assay, root lines expressing a proteinase inhibitor and a cholesterol oxidase for increased SCN resistance were tested. None of the root lines showed significant SCN resistance. However, researchers now have a rapid system to test transgenic soybean hairy roots for SCN resistance, and this will be a valuable tool for evaluating future transgenic plants for nematode resistance. There is very little direct impact of this work on SCN control, because the transgenic roots developed did not have significant SCN resistance. However, researchers continue to use the SCN bioassay developed in this project to evaluate transgenic roots in collaboration with companies and other researchers.

A C-FAR External Competitive Grants project

Kris N. Lambert, Jack M. Widholm, Gregory R. Noel, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Enhanced Production by Increasing Level of Disease Resistance in Soybean

The goal of this research was to enhance the productivity of soybean by introducing genes for disease resistance into commercially grown soybean cultivars so that these cultivars can be grown with reduced crops loss due to disease incidence. Researchers developed an efficient transformation system for soybean, based on selecting a strain of *Agrobacterium* and proper orientation of immature cotyledons of soybean on the culture medium. This system is reliable and applicable to multiple soybean cultivars. Moreover, transgenic lines of soybean carrying various antifungal protein genes have been developed. These have been confirmed to carry these transgenes. Future work to characterize the response of these lines to disease inoculation will be conducted.

Schuyler S. Korban, Natural Resources and Environmental Sciences

Glen L. Hartman, Crop Sciences and USDA-ARS

Wayne L. Pedersen, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Identification of Soybean Genotypes with Resistance to Charcoal Rot

Charcoal rot of soybean caused by *Macrophomina phaseolina* is a disease of increasing importance in the Midwest. Currently, feasible management options do not exist for this pathogen. The goals of this project were to (1) develop protocols for the evaluation of host resistance and (2) identify host genotypes resistant to the disease. This project has led to the development of a field screening protocol. This protocol can be used reliably to identify varieties that hinder colonization by the pathogen. In addition, varieties were identified supported less fungal colonization and were less susceptible to the disease. Information gained in the field protocols is being used to develop a more economically efficient means to determine resistance.

John S. Russin, Jason P. Bond, Michael E. Schmidt, Plant, Soil and Agricultural Systems

College of Agricultural Sciences

Southern Illinois University at Carbondale

Improving Soybean Yield by Co-Inoculation

The intent of this research is to block or reduce the infection and nodulation of soybean roots by native (soil) bradyrhizobia via the presence of antibiotic-producing organisms (Streptomycetes) and induce infection and nodulation of soybean roots by developed strains of *Bradyrhizobium japonicum* efficient in nitrogen fixation and also resistant to the antibiotics that inhibit the native bradyrhizobia. These applied strains will have a competitive advantage over the native bradyrhizobia, resulting in enhanced nodulation by the desired inoculum with a potential increase in nitrogen fixation and yield.

Two field studies were conducted in 2001 and 2002 in Belleville and Carbondale, Illinois, and a demonstration field trial (2001) in Nashville, Illinois, evaluating the effects of co-inoculation on soybean yield. For the Belleville and Carbondale field trials, nine treatments were used: a noninoculated control, a *Streptomycetes kanamyceticus* treatment, and seven co-inocula of selected antibiotic-resistant strains of *B. japonicum* with *S. kanamyceticus*. Data were collected regarding early nodulation, nodule number, nodule occupancy, leaf nitrogen composition, yield, seed nitrogen composition, and accumulated seed nitrogen. For the Carbondale 2001 field study, significant differences between treatments were observed at the 5% level for early nodulation and nodule occupancy. The Belleville 2001 field data showed significant differences at the 5% level for nodule occupancy and leaf nitrogen content.

Soybean yield for the demonstration trial at Nashville, Illinois (Kurwicki Farm), displayed a 17% increase by co-inoculation versus the noninoculated control (32 by 825 ft harvest area). Due to the lack of timely rainfall, the Carbondale 2002 field study showed a significant difference only at the 10% level for early nodulation, while the Belleville 2002 study had a significant difference in nodule occupancy at the 5% level. However, a scanning electron microscopy (SEM) study showed that after 35 days of soybean growth, there were viable *S. kanamyceticus* filaments present on the soybean roots and nodule tissues. This work is being continued with field trials at Belleville and Carbondale for the 2003 growing season. It is hoped that these additional field trials will continue to show enhancement of nodule occupancy and increases in soybean yield/seed nitrogen content.

Brian P. Klubek, Edward C. Varsa, Plant, Soil and Agricultural Systems

College of Agricultural Sciences

Southern Illinois University at Carbondale

Soybean Cyst Nematode Interactions with Other Nematode Species and Tillage Effects on this Community

Researchers are evaluating the mechanisms behind sudden death syndrome (SDS) development and severity. One approach has utilized deep tillage to reduce soil bulk density and compaction. By increasing porosity and aeration of soil, the incidence and severity of SDS decreases. However, in plots that received the deep tillage treatment, soybean cyst nematode (SCN) populations were nearly double those observed in the no-till plots. Further complicating the problem is the fact that many weed species are favored in a no-till system. Many of these species, such as *Lamium purpureum* (purple deadnettle) and *Lamium amplexicaule* (henbit) are excellent hosts for SCN and other pathogenic nematodes. Many corn and soybean fields in Illinois are infested with both *Fusarium solani* f. sp. *glycines* and SCN. The question is: Should a producer use a no-till or a deep tillage system? The goals of this research are to (1) identify important nematode species in soybean and corn rotational systems, (2) evaluate the pathogenicity of these species alone and in combination with SCN, and (3) evaluate the direct and indirect effects of tillage on SCN and other pathogenic nematode species.

Throughout the past three growing seasons, over 500 soil samples, representing distinct production fields, were collected and processed. *Heterodera glycines* (soybean cyst nematode), *Helicotylenchus* spp. (spiral nematode), and *Pratylenchus* spp. (lesion nematode) were found with great frequency throughout southern Illinois. *Hoplolaimus galeatus* (lance nematode) and *Meloidogyne incognita* (southern root knot nematode) were detected, but at a much lower rate. The detection of southern root-knot nematode in soybean is a first for Illinois. Fields infested with this pathogen suffered great yield loss. Yield maps were obtained, and the fields were intensively sampled for nematodes.

Subsoiling conducted at DeSoto in the spring of 1999 resulted in a twofold increase in SCN populations averaging 20,200 eggs/100cc soil. In 2000, the field was planted to corn to follow standard rotation sequences. In the spring of 2001, sampling revealed that rotation had reduced SCN egg counts; however, there were still significant numbers of nematodes in the subsoiled plots. Populations of *Helicotylenchus* spp. and *Pratylenchus* spp. were not consistently affected by either of the tillage practices. At another site in Belleville, SCN populations were several orders of magnitude lower than at DeSoto. However, in plots that received subsoiling in fall 2000, there were significantly higher SCN counts than in no-till plots. A field that was under irrigation at Carmi also had SCN populations dramatically lower than at DeSoto. Subsoiling conducted in fall 2000 did not significantly affect any nematode populations in 2000, and lingering effects were not detected in the spring of 2002. Populations of SCN were extremely low (~150/100 cc of soil), and the combination of a wet year and irrigation at this site may have reduced the ability of tillage to increase porosity and O_2 exchange.

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Utilization of New SCN Resistance Genes from *Glycine tomentella*

The objectives of this research were to confirm the soybean cyst nematode (SCN) resistance level of *Glycine tomentella* backcross lines, map the locations of the SCN resistance genes that were transferred from *G. tomentella* into domestic soybean, and transfer these resistance genes into elite soybean backgrounds so they can be used by soybean breeders in both the public and private sector. Researchers initiated the project by retesting four soybean lines developed by backcrossing genetic regions from an SCN-resistant *G. tomentella*

accession. These lines were tested because previous work indicated that they were resistant to SCN. Initial replicated tests suggested that these lines carried partial SCN resistance, so crosses were made to initiate the development of genetic populations to map these resistance genes. However, when the resistance tests were repeated, it was not confirmed that these lines carried resistance.

Because these lines were not resistant in these repeated tests, researchers broadened their testing by evaluating the SCN resistance level of 88 additional *G. tomentella* backcross lines. Initial testing of the resistance in these lines was encouraging, and several lines appeared to carry resistance. However, analysis of data from the repeats of these tests showed that none of these lines were resistant. Although it was initially believed that a number of the *G. tomentella* backcross lines were SCN resistant, the final conclusion is that the lines tested were not resistant. Because researchers were unable to confirm resistance in the backcross lines, the resistance level of rooted cuttings from a hybrid plant from a new cross between soybean and *G. tomentella* was tested. Replicated tests of these cuttings showed that they were completely resistant, which demonstrates that resistance can be transferred from *G. tomentella* into hybrids with soybean. Funding is being sought to initiate the backcrossing of this resistance into soybean.

A C-FAR External Competitive Grants project

Brian W. Diers, Theodore Hymowitz, Crop Sciences

Glen L. Hartman, Crop Sciences and USDA-ARS

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Biology and Management of *Aphanomyces* and *Sclerotinia* Diseases of Alfalfa in Illinois

Alfalfa is a significant crop in Illinois. Diseases reduce yields, forage quality, and stand persistence. Two important diseases of alfalfa that have potential to be managed effectively but are poorly understood in Illinois are *Aphanomyces* root rot and *Sclerotinia* crown and stem rot. This research was directed at understanding the characteristics and management of these two diseases, which are caused by the fungal pathogens *Aphanomyces euteiches* and *Sclerotinia sp.,* respectively.

Races 1 and 2 of *Aphanomyces euteiches* can kill alfalfa seedlings and cause decline of mature plants in slowly drained soils, and *Sclerotinia* sp. can be devastating to alfalfa stands. The distribution and relative frequency of both races of *A. euteiches* were determined in Illinois for the first time. *Aphanomyces* was detected in soil from 19 of 19 counties sampled, which were concentrated in the primary alfalfa production areas of Illinois. Researchers determined that 60% of the isolates were race 1 and 40% were race 2. Both races were isolated from 67% of the counties, whereas only one race was isolated from 17% of the counties. In tests of molecular methods to detect and diagnose *A. euteiches*, it was determined that quantitative PCR is a much more sensitive method for detecting the pathogen than normal PCR is, and it may be a rapid and sensitive method for testing disease resistance in alfalfa. Studies were also initiated to investigate *Sclerotinia* crown and stem rot; however, weather was not favorable for this disease to develop in the two years this project was ongoing. Methods were evaluated for rapid identification of *Sclerotinia* species. Researchers focused on *Aphanomyces* root rot, and it was discovered that this disease may have a much larger impact on alfalfa production in Illinois than *Sclerotinia* crown and stem rot has. The results demonstrate for the first time that races 1 and 2 of *A. euteiches* are widespread pathogens in Illinois, and they probably cause extensive damage. This reveals the importance of managing *Aphanomyces* root rot in alfalfa, which could result in a minimal estimated $240,000 annual benefit to Illinois alfalfa producers, and demonstrates the potential benefits of alfalfa cultivars with resistance to both races of this pathogen in Illinois.

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Characterization of Nitrogen Use Efficiency in the Illinois Protein Strains

Inbred lines of corn were developed from the four Illinois Protein Strains. These inbred lines were crossed to an elite inbred and evaluated along with a commercial hybrid for grain yield, grain quality, and nitrogen use efficiency (NUE) in nitrogen titration field experiments during 2001 and 2002. Grain yields of the Protein Strain hybrids were reduced compared to the commercial hybrid, but grain protein concentration was nearly doubled in the Illinois High Protein (IHP) hybrid (15%), and the Illinois Low Protein (ILP) showed enhanced starch concentrations compared to the commercial hybrid. These grain compositions may be advantageous in value-added feed or processing applications. The IHP hybrid was superior to the commercial check

in nitrogen (N) uptake efficiency (amount of N taken by the plant from the soil) and remobilization to the grain, particularly at higher N rates. Conversely, the ILP hybrid was enhanced in N utilization efficiency (grain yield per unit N absorbed). The Protein Strains thus show promise as germplasm sources for improving both components of NUE.

In addition to collecting data on grain composition and NUE, samples were taken from vegetative and seed tissues of the Protein Strains and their hybrids throughout the grain filling period to profile gene expression changes in response to supplemental N in the field. These analyses are now in progress and will focus on genes associated with differences in nitrogen metabolism and grain composition. The study performed here indicates that it should be possible to increase NUE by 25% through directed breeding and biotechnology efforts. Current N fertilizer costs average approximately $30/acre. Reducing this by 25% would decrease input costs by nearly $7 per acre at current nitrogen prices; these savings are expected to increase with the anticipated rise in nitrogen fertilizer prices. Less N applied would also decrease N movement into water supplies.

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Comparing the Genotoxicity of Agrochemicals to Ubiquitous Food Additives

Many groups at the state and national level are now interested in how the regulation of pesticides is being conducted and want to ensure the fairness and accuracy of the regulation. The data presented as a result of this research will provide for the comparison of potential damage induced by agrochemical contamination with the potential damage induced by FDA-approved food additives. It is important, when faced with balancing human health versus agricultural economics, to have good data. To label a pesticide unsafe when it is really safe could have as devastating consequences as to label a pesticide safe when it is unsafe. Atrazine not only is a very effective herbicide but is also very economical for the producer to use. Taking atrazine off the market would force producers to turn to more expensive alternatives, thus making farming less profitable. Loss of atrazine would result in an estimated $28 per acre increase in cost. The overall goal of the research was to determine whether agrochemicals pose a greater threat to human health than chemicals approved for food additives.

The cytoxicity and potential to cause chromosome damage were examined in three sets of chemicals. Two of the sets were FDA-approved additives, one set consisting of artificial sweeteners and the other consisting of food preservatives. The third comprised three of the most commonly used herbicides used in the Midwest. Overall, a ranking of cytotoxicity places herbicides greater than preservatives, which are greater than sweeteners. However, it should be noted that glyphosate was not found to be toxic at any soluble levels. In addition, when exposure levels were examined, those for food additives were closer to cytotoxic levels than those of the public to herbicide contamination. With respect to cell cycle, food additives appeared to have more effect than the herbicides. Chromosome damage itself was more apparent in two of the herbicides, but at levels exceeding contamination. In summary, the general public does not appear to be at any higher risk from herbicides than from approved food additives with respect to the cell cycle modifiers. Herbicide applicators and farmers are possibly at risk for exposure to acetochlor and atrazine at concentrations that are clastogenic. The general population appears to be more potentially at risk from exposure to certain food additives at clastogenic concentrations than it is from agrochemicals.

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Competitiveness of Late-Emerging Waterhemp in Corn and Soybean

Common waterhemp has been a major problem for corn and soybean producers in Illinois. The specific research goals of this project were to (1) determine the competitiveness and seed producing capabilities of late-emerging common waterhemp in corn, (2) evaluate the competitiveness of late-emerging common waterhemp in soybean at two different row spacings (7.5 inches and 30 inches), (3) evaluate the shade tolerance of common waterhemp, and (4) provide this information to Illinois producers to help develop better common waterhemp management strategies.

Through this research researchers learned that common waterhemp interference with corn is greatly influenced by environmental conditions. Early-season common waterhemp competition in corn generally began when corn was at the V6 growth stage. However, precipitation greatly influenced the magnitude of corn yield loss. In high-moisture environments, corn was able to outcompete common waterhemp, but when precipitation was lacking,

corn yield was reduced by as much as 23%. This reduction in yield could result in over a $94 per acre reduction in net profit, stressing the importance of early-season weed control in corn. Common waterhemp interference from late-season emergence reduced corn yield when emergence was prior to V8 corn. Taking into account early- and late-season common waterhemp interference, the critical common waterhemp-free period was around V6 corn to optimize corn yield and net profit.

In soybean, common waterhemp interference reduced soybean seed yield when it was allowed to emerge at the VE, V2–V3, and the V4–V5 emergence timings. Row width affected the magnitude of yield reductions at these interference timings, with reductions being less in narrow-row soybean. Where reductions were observed with soybean yield, common waterhemp seed production was increased. In contrast to corn, this research suggests that growers may want to implement control measures if common waterhemp emerges at the V4–V5 soybean growth stage and earlier to reduce soybean yield loss and common waterhemp seed production. Shade and emergence time had a significant effect on common waterhemp growth and seed production. The later in the season that common waterhemp emerged, the less biomass and seed that it produced, stressing the importance for decreased row-widths, increased crop populations, and planting date as factors that should be considered to reduce the effects of this weed species in production agriculture.

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Evaluation of the Role of New Generation Pricing Contracts for Illinois Corn and Soybean Producers

The overall goals of the project were (1) to thoroughly evaluate the price performance attributes of known "new generation" cash contracts and combinations of pricing and insurance instruments for producers of corn and soybeans in Illinois, (2) to develop appropriate measures of producer attitudes towards and preferences for pricing and insurance instruments, and (3) to develop an outreach program that will help producers match their risk management philosophy to the appropriate portfolio of active and passive risk management strategies. A description of all known price indexing contracts was compiled and classified in three categories. Automated Pricing Contracts are least risky, follow predetermined rules for pricing grain, and generally give producers the average price over a set period. Managed Pricing Contracts are most risky and price grain according to the recommendations of an advisory service. Combination Contracts have moderate risk and price grain according to automated rules, but allow producers to share in gains generated by a professional hedging firm. Survey results from 170 Illinois producers show varying levels of preference for "playing it safe" in the corn and soybean markets. Producers can match their risk preference to the risk level of the pricing contract.

The historical performance of 11 contracts was simulated under three scenarios—rising, declining, and stable prices. Simulation results were compared to benchmark prices to determine performance of the contracts relative to the market in short, large, and normal crop years. Finally, an analysis of the historical marketing performance of Illinois corn and soybean producers indicated that over the period 1975 through 2001, producers underperformed the market in normal and large crop years and outperformed the market in short crop years. On average, producers underperformed the markets by $6 to $8 per acre, indicating that revenues could be increased by a change in marketing strategies to include averaging contracts.

Based on total production over the 27-year study period, Illinois corn producers underperformed the market by $2.9 billion to $3.7 billion, and soybean producers underperformed the market by $427 million to $697 million, depending on benchmark price used. These estimates are the upper bound on the increase in income that could be generated by marketing strategies that capture the average market price.

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Investigation of Failed Post-emergence Applications of Herbicides

Weed management in almost all soybean acres and numerous corn acres in Illinois relies on the effective use of postemergence herbicides. A common field observation is that weeds will temporarily cease growth after an herbicide has been applied, but then growth resumes shortly thereafter. Growers then have the option of either not taking any action to control the regrowing plants or applying another herbicide in an attempt to achieve complete control. The objectives of this research were to describe the potential of selected weeds to regrow after the death of the terminal shoot growing point and

to determine the influence of this regrowth on the efficacy of herbicides used as a possible control measure.

Common waterhemp, giant ragweed, and ivyleaf morning glory were the weed species analyzed in this research. Weeds were pruned to simulate tissue death of the terminal shoot. Different amounts of stem were pruned off to simulate a gradient of increasing shoot death down to the base of the stem. The extent of shoot pruning did not greatly influence the potential for weeds to regrow, as these plants commonly achieved growth and seed production that was observed for plants that were not pruned. Common waterhemp and ivyleaf morning glory had a slightly greater propensity for full recovery than did giant ragweed. The growth stage (height) of the weed was important in determining the potential for regrowth and full plant recovery. Giant ragweed was much less likely to recover fully if injury occurred at an early growth stage. Thus, if herbicides are applied on smaller weeds, a grower may dramatically reduce the risk of plant survival or the amount of regrowth possible. The influence of weed growth stage was less important for common waterhemp and not a factor at all for ivyleaf morning glory. Giant ragweed that regrew following pruning was more difficult to control with herbicides compared with plants that were not pruned. Plant regrowth had a variable effect on control of ivyleaf morning glory and common waterhemp with herbicides. Growers should reduce the risk of achieving incomplete control with postemergence herbicides and subsequent weed regrowth by targeting earlier applications of herbicides to smaller weeds. If weeds survive the herbicide application, the previously injured weeds have the potential to grow and produce seed to the same extent as plants that are not injured. In addition, control of weeds that survive a previous postemergence herbicide application may be more difficult with a second herbicide application.

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Pesticide-Free Crop Production on the Allison and Cooperative Farms

This project is unique in that organic and conventional farming experiments are being conducted on a 77-acre farm with 55 acres of the farm certified organic since 1998. Data is analyzed utilizing a systems approach, through several crop rotations, including agronomic and economic consequences. Researchers are producing data that is used to analyze the economic feasibility of these systems. While organic farming can increase return per acre, these methods expose growers to added risks in regard to obtaining adequate yields and meeting fertility needs. Overall goals are to develop systems that require fewer nutrient inputs, to improve efficiency of nutrient utilization, and to develop alternatives to pesticides, thus reducing any adverse effects that may result from excessive pesticide and nutrient inputs.

Researchers are demonstrating, on a farm scale, practical methods for producing marketable agronomic organic crops. The organic regions of the farm are certified annually, following OCIA standards. Experiments involve weed control, crop rotations, fertilizer methods, and tillage. For six growing seasons, field experiments were conducted comparing conventional to ridge-till production of corn and soybeans. Ridge tillage provided significantly better weed control than conventionally tilled fields. Yields in ridge-till production were not higher, but ridge tillage produced more economic return per acre than conventional tillage. Drilling organic soybeans has produced unreliable weed control and variable yields. Flaming studies demonstrated improved weed control with cultivation plus flaming, as opposed to cultivation alone, but corn yields were not improved with flaming. Flaming with no cultivation produced unsatisfactory weed control. Growing corn, soybeans, and wheat with conventional fertilizers, organic commercial fertilizers and cover crops, and hog manure supplemented with potassium sulfate and cover crops produced equivalent yields in all three fertility systems. Analyses in early summer revealed less soil nitrate in organic than in conventionally fertilized fields. Tissue analyses from organic versus conventionally fertilized fields exhibited similar levels of major nutrients, secondary nutrients, and micronutrients in corn leaves. Red clover cover crops interseeded into winter wheat provided good weed control and fixed enough nitrogen for the succeeding corn crop, so that the resulting corn yields were comparable to corn yields with conventional ammonia fertilization. A rye cover crop, following corn, suppressed weeds during the first five weeks of soybean production, and the resulting rye residue made the soil mellow so that cultivation of soybeans following the rye cover crop was much more effective than in comparable fields without a rye cover crop.

Gerald T. Vigue, Agriculture

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Scale-up of a High-Productivity Continuous Reactor for Butanol Production

The purpose of this project was to scale-up a continuous bioreactor for butanol production. Butanol, which can be produced from corn, is an excellent fuel that has more energy content (per lb or per gal) than ethanol. The development of a continuous bioreactor would allow economic production of butanol. In order to economize butanol production, researchers also attempted nutrient limitation. The microbial culture that was used to produce butanol from corn was *Clostridium beijerinckii* BA101, developed at the University of Illinois. As a result of this research, the bioreactor was successfully scaled up. In comparison to a laboratory bioreactor (25 days continuous operation) the scaled-up reactor was operated for 96 days. This would allow economic production of butanol. Nutrient limitation was not successful. It was concluded that a new culture (spo-) be developed before further studies are attempted.

Nasib Qureshi, National Center for Agricultural Utilization Research

United States Department of Agriculture

Hans P. Blaschek, Food Science and Human Nutrition

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Value Added Traits: Sustainability and Efficiency of Production Systems

The main objective of this research was the development of a reverse genetics tool that can be used to test and identify genes underlying economically important traits in soybean, in order to determine their function. The focus was on genes involved in seed protein and oil content. Researchers developed a Virus-Induced Gene Silencing (VIGS) vector using the pea early browning virus (PEBV); however, early experiments showed that the vector does not seem to be functional for gene-silencing purposes in soybean. Therefore, effort was shifted more toward developing an EMS seed library for TILLING (Targeting Induced Local Lesions In Genomes). It is based on the production and analysis of ethylmethanesulfonate (EMS)-mutagenized plant collections from soybean, for rapid systematic identification of mutations in the target sequences of genes underlying economically important traits in soybean. Researchers have been very successful in implementing the technology, identifying several important mutants that are being tested for their potentials.

Khalid Meksem, Plant, Soil and Agricultural Systems

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Animals

Economically Extending the Grazing Season for Cattle

This project focuses on ways to reduce production costs for Illinois cow-calf enterprises by fostering the sustainable use of natural resources in Illinois through alternative land management. Four different forage species plots were evaluated to ascertain growth patterns of the various forages throughout the growing season and thus allow producers to organize their pasture acreage so that a more uniform amount of forage is available each month. This will also allow them to begin grazing earlier than is normal, and to continue grazing past the time grazing is normally concluded in most west-central Illinois pasture. Another important aspect of this trial will be the establishment of peak forage production by the various species involved.

Four plots, each of two acres, were planted to each of four forage combinations: (a) fescue and bluegrass, (b) late-maturing orchardgrass and alfalfa, (c) white clover and perennial ryegrass, and (d) annual rye and sudax. These plots were grazed by a herd of commercial beef cows and their calves from May through November. All animals were weighed at the beginning of each month to estimate daily weight gains over the previous month. The number of days the animals were on a particular two-acre plot were recorded as to date in, date out, and number of animals. The rye/sudax plots produced the greatest grazing capacity in May, July, and October, while white clover and perennial ryegrass had the greatest grazing capacity in June, August, and November. Orchardgrass and alfalfa had the greatest grazing capacity in September. The data demonstrates that grazing capacity can be increased by a factor between 151 and 232% with rotational grazing of varied forage species, as opposed to constant grazing of traditional fescue and bluegrass pastures. By rotating animals through the non-fescue and bluegrass plots, the average animal units per acre averaged 0.91, whereas the average for the fescue and bluegrass plots was 0.42 animal units. Even more importantly, there was no "slump" in forage production in the warmer weather months with the non-fescue and bluegrass plots, while the fescue and bluegrass plots had virtually no grazing production in late July and throughout August. This project clearly points out the advantage in rotational grazing, as well as the advantages in seeding paddocks to different types of forage species.

A C-FAR External Competitive Grants project

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Evaluation of Ultrasound and Genetic Markers for Cattle in High-Quality Market

The purpose of this study was to determine the importance of marbling expected progeny differences (EPD) and rate and efficiency of gain on carcass value and profitability of early-weaned Simmental steers. Researchers also wanted to evaluate the effectiveness of a new DNA marker called GeneSTAR in predicting carcass marbling score and final value. Carcass value was correlated ($P<0.05$) with marbling EPD, yearling EPD, daily gain, feed efficiency, hot carcass weight, and yield grade. Carcass weight, marbling score, and yield grade accounted for over 79% of the variation in carcass value. Marbling score, dry matter intake, daily gain, yield grade, and carcass weight accounted for over 77% of the variation in profitability, explaining 30, 14, 12, 12, and 9% of the variation, respectively. Five-year average price data for individual feedstuffs, dressed beef, and grid premium and discounts were used to calculate carcass value and profits. The GeneSTAR marker had little effect on carcass value and profits.

A C-FAR External Competitive Grants project

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Paul M. Walker, Agriculture

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Illinois State University

Evaluation of Ultrasound and Genetic Markers to Enhance the Value of Feedlot Cattle for a High-Quality Market

The beef cattle industry is rapidly moving from a marketing system based on averages to individual carcass quality and yield grade. The objectives of this research were to (1) determine the effect of marbling deposition, rate and efficiency of gain, and cost of gain; (2) evaluate the effects of breeding selection for marbling EPD (MARB) and/or yearling weight EPD (YW) on feedlot performance and carcass characteristics; and (3) evaluate the relationship between final intramuscular fat percentage (% FAT) in the longissimus dorsi (LD) with feedlot performance and carcass characteristics.

Marbling EPD was negatively correlated with gain to feed ratio (*G:F*) and positively correlated with dry matter feed intake (DMI), quality grade, calculated grade based on ultrasound, marbling score (MS), and percent fat. The high-percentage Simmental steers used in this study had greater DMI and poorer *G:F* as marbling scores increased. Yearling weight (YW) was positively correlated with gain, *G:F*, DMI, and hot carcass weight (HCW) and negatively correlated with yield grade (YG). Data indicates a 1-unit increase in YW would result in a 0.76-kg increase in HCW. Additionally, a 10-unit increase in YW would result in a 0.4-kg/d increase in DMI and a -0.1 unit change in YG. Additionally, a 1% increase in percent intramuscular fat (% FAT) would result in a 0.12–0.19 unit increase in yield grade and less than a 40-degree increase in MS. Simple correlations between MARB and performance and carcass parameters were significant but weak, explaining only a small percentage of the variation. Selecting for greater MARB can improve carcass quality, but at the expense of greater DMI and poorer feed efficiency. The genetic effect of selecting for greater marbling can be overshadowed by other factors, such as management, nutrition. and environment. Correlations between YW and performance and carcass parameters were significant, but moderate to weak. Selecting for greater YW may increase HCW and improve YG with no effect on quality, but at the expense of greater DMI and poorer feed efficiency. Further research is needed to estimate the economic effect of these selection criterion on carcass value and enterprise profitability.

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Fescue Toxicosis Associated Reproductive Loss in Cattle

The aim of this study was to observe the effects of endophyte-infected fescue consumption on the estrous cycle and specific reproductive functions in heifers and to evaluate the efficacy of administration of a dopamine antagonist to block the dopaminergic effects of the fescue's endophytic compounds.

As part of the first experiment, three treatment groups were observed. Heifers fed an endophyte-free fescue diet, an endophyte-infected diet, and an endophyte-infected diet plus the dopamine antagonist, domperidone. Injection of domperidone ameliorated symptoms of fescue toxicosis, including restoring normal average daily gain, and estrous cycle duration. Domperidone restored circulating progesterone concentrations to near-control levels and produced markedly higher prolactin concentrations. In a second experiment, interspecies microarray analysis was performed using gene chips encoding for 10,000 rat genes and mRNAs isolated from heifer luteal tissue from the treatment groups in the first experiment. Approximately 4,000 genes were detected. A comparison of mRNA abundance revealed that 598 genes were downregulated and 56 were upregulated when tissues from control and endophyte-infected diet were analyzed. The drug treatment had a beneficial effect on the expression of genes evaluated in this study. A comparison of mRNA abundance between controls and endophyte-infected plus domperidone treatments had only 10 genes upregulated and 2 downregulated. These studies suggest that a dopamine antagonist may be beneficial for the treatment of fescue toxicosis in beef cattle. By doing so, beef producers should expect to regain the estimated $800 million yearly loss associated with fescue toxicosis.

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Influence of Bovine Viral Diarrhea on Cattle Production within Illinois

Bovine viral diarrhea (BVD), caused by BVD virus (BVDV), presents a major economic burden on the cattle industry. This virus can cause infertility, abortion, or the production of calves with congenital defects. The objectives of this research initiative were to (1) estimate the prevalence of BVDV PI cows in Illinois herds and assess factors associated with increased prevalence, (2) determine the incidence of postnatal BVDV infection in Illinois cattle herds, (3) identify herd-level and individual animal risk factors for postnatal BVDV infection, (4) determine the effect of vaccination strategies on the incidence of postnatal BVDV infection, and (5) determine the association between BVDV infection and herd production/reproductive parameters. This two-year study enrolled approximately 36 cattle operations in Illinois. Calves on each farm were sampled every 3 months through their first vaccination against BVDV.

In order to compare the performance of three diagnostic tests (IHC on skin biopsy, serum VI, and RT-PCR on

buffy coat) on the identification of BVDV PI cattle, to date, researchers collected 976 samples from 36 herds in the state of Illinois between April 2001 and February 2002. Herds studied included 32 dairy herds, milking between 25 and 300 animals, and four beef herds of 50 to 2,000 head. The number of animals sampled per herd ranged from five to 30 animals, and the ages from less than 1 month to cows. The three tests agreed on 892 (97.8%) samples that yielded a negative result and three (0.3%) animals that yielded a positive result. Comparison of IHC with PCR showed that 0.2% (2/956) of the samples tested positive by IHC and negative by PCR and 0.3% (3/956) tested negative by IHC and positive by PCR (proportion of agreement = 99.5%), most likely due to the ability of PCR to detect viremia from acute infections. Comparison of IHC with VI showed that 1.4% (13/925) of the samples tested negative by VI and positive by IHC, probably due to interference of colostral antibodies, and 0% tested positive by VI and negative by IHC (proportion of agreement = 98.6%). Researchers estimated an overall prevalence of PI in these herds of 1.3% (13/976) based on the animals from which they were able to confirm the PI status by retesting 4–6 weeks later. Improved and more realistic estimates of sensitivity (Se) of the assays to detect animals with PI or with acute infection and of specificity (Sp) were obtained using a Bayesian statistical method. These estimates are a first critical step for the evaluation of cost-efficient strategies for BVDV control.

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Innovative Finishing and Marketing Strategies for Small Beef Producers

Researchers sought to explore and create cattle feeding management and marketing strategies resulting in small beef feedlots (250 head) that are economically viable in a diversified farming operation. The focus was on cost competitive production systems and maximizing marketing premiums. One thrust was the development of a Feedlot SPA program. In addition to assisting individual producers with improving the viability of their operations, Feedlot SPA provides a database for researchers that allows them to explore profitability factors for small Midwest cattle feeders. Data collected for this program includes normal feedlot closeout information such as cattle gains, purchase and sale information, feed usage, and costs as well as information on the producer's operating expenses, capital costs, depreciation, labor, and investment. This allows for a more comprehensive analysis, tailored for the small producer, than was previously available.

Results of Feedlot SPA analysis demonstrated a wide variation in production costs. Because of the relatively consistent cost of corn throughout Illinois, it was not estimated that a large variation in feed cost would be seen in the feedlot analysis. However, significant variation was due to the utilization of forages and byproducts, along with dramatic differences in cattle performance. It was demonstrated that when actual costs were calculated, there was a large standard deviation around the $0.25 per head per day commonly used as a yardage cost figure. This indicates that custom feeders need to explore their own yardage costs further. The custom feeding industry generally charges on a feed cost plus yardage basis. This data would indicate that the average cattle feeder must find ways to lower costs or begin to budget yardage rates of 30 to 35 cents per head per day. The project team has been working with three noncompeting beef producer groups that have been working to develop direct ties with food retailers and promotion of their own branded product. The knowledge gained from these direct ties to producer efforts to get closer to the consumer will be used in the future to help Illinois livestock producers franchise such a model.

A C-FAR External Competitive Grants project

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Weaning Beef Calves on Pasture

The goals of this project are to develop, demonstrate, and document techniques for a pasture-based weaning system and to evaluate the practicality and profitability of such a system as a management alternative to conventional dry lot weaning. The profitability and practicality of pasture weaning compared to dry lot weaning were evaluated according to the following criteria: (1) health and performance of the calves during the weaning phase; (2) subsequent feedlot and carcass performance; and (3) economic analysis of feed, labor,

and management costs relative to calf performance and health.

A successful, simple, profitable, low-stress procedure for weaning beef calves on pasture was developed that provides producers with another option for the weaning process. Animal and economic performance is dependent upon high-quality pastures. This project involved a total of five direct comparisons of pasture (P) versus drylot (D)-weaned calves (a total of 243 calves from three herds) over a period of 3 years. P calves spent more time eating (grazing) and resting and less time vocalizing and walking the fence than D calves. There was no difference in the health status as measured by daily body temperature during the first week of weaning or treatment rates during the 28-day period. D calves gained 2.45 pounds per day with a feed conversion of 5.44 and total feed cost of $14.23. P calves gained 1.93 pounds per day with a supplemental feed cost of $4.61 for the 28 days. P calves showed more variation in performance with daily gains ranging from 0.63 to 2.74 pounds. This variation was directly related to pasture quality and quantity available. When pasture quality and quantity was good to excellent, daily gains ranged from 1.61 to 2.74 pounds with an average of 2.16 pounds. Stocking rates averaged 2.8 head per acre with a total of 78.4 calf grazing days per acre for the 28-day period. This resulted in a per acre gain of 135.6 pounds (with a net value of $105.42 above the supplemental feed cost when calves were valued at $80 per cwt) for the 28-day weaning period. Two groups of calves involving a total of 60 head were fed to market weights. There were no significant differences between P and D calves in finishing performance as measured by ADG, feed conversion, feed cost, quality grade, yield grade, rib eye area, or backfat.

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An Integrated Planning Tool for Dairy Systems that are EES Viable in Illinois

This research expanded upon a previous study that examined the impact of a declining dairy industry, assessed potential needs of purchasers of Illinois milk, and assessed community acceptance. The specific objectives are to evaluate the feasibility of three alternative dairy systems (intensive pasture, traditional, and feedlot systems) in terms of economic impact on the local and state economy, return on investment and community acceptance.

Whole farm budgets were developed for four alternative dairy systems (120-cow intensive grazing, 120-cow traditional grow feed, 120-cow traditional with all feed purchased, and a 600-cow concentrated feeding system with purchased feed). These systems were evaluated on how an individual farm would affect the Illinois economy, as well as the return on investment to the dairy owner. The systems were selected from a review of literature and consultation with dairy specialists. Values for total farm output for the four systems were $304,457, $478,120, $352,589, and $1,836,316, respectively. The corresponding output multipliers were 1.89, 2.16, 1.95, and 1.79, respectively. The 1.89 multiplier implies that for each $1 of farm output produced on an intensive grazing farm, an additional $0.89 of output is generated from other sectors of the Illinois economy. These multipliers are comparable to other industries such as mining (1.72) and construction (2.19). Employee compensation estimates for the farm types were $40,815, $80,036, $65,395, and $326,976, respectively. Employee compensation multipliers were 3.36, 2.77, 2.71, and 3.04, respectively. These multipliers were higher than other sectors reflecting lower wages paid on farms. Employee compensation multipliers were higher for the intensive grazing and concentrated feeding system than for the two traditional systems, a result that was likely due to the greater labor required by the traditional system in comparison to the other systems.

Differences in output multipliers between farms resulted because of differences in efficiency, types of purchases, and origin of purchase. More efficient use of resources results in lower multipliers. Purchasing resources from outside of Illinois also lowers multipliers. Multipliers at the county, state, and national level for the intensive-grazing farm were estimated to illustrate their potential range by changing the regional purchasing coefficients. The total output multiplier for intensive grazing ranged between 1.85 and 2.86. The employee compensation multiplier ranged between 2.23 and 5.27. Output multipliers do not imply profitability. Therefore, to assess willingness of farmers to adopt, internal rates of return on investment were estimated for each system over a 20-year period. For this analysis, milk yields for traditional and concentrated were comparable. Rates of return were estimated with and without Milk Income Loss Contract (MILC) payments. Investment amounts per cow for livestock, facilities, and equipment were $3,661 for intensive grazing, $5,163 for traditional, and

$4,139 for concentrated. Without MILC payments, rate of return on investment is respectively, 1.79%, 1.21%, and 4.13%. With MILC payments, rate of return is 7.87%, 6.62%, and 5.84% respectively. The limit on MILC payments resulted in a lower return for the concentrated system. Rate of returns are depended on assumptions productivity, outlook prices, investment costs, tax rates and government programs. From survey results community acceptance is higher for pasture systems and smaller dairy farms. Counties with dairy experience and counties with low nonfarm employment are more predisposed to accepting new dairies.

A C-FAR External Competitive Grants project

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Antibiotic Resistance in Dairy Herds: Assessment of the Risk to Food Safety

Bacterial resistance to antibiotics is increasing, and this development has resulted in human and animal disease-causing (pathogenic) bacteria that are refractory to many forms of treatment currently available. As the prevalence of resistant isolates continues to increase, the likelihood of transferring resistant pathogens between animals and humans will also increase. The current threat of antimicrobial resistance cannot be adequately determined strictly through a surveillance of bacterial pathogens. The majority of bacteria in the ecosystem of humans and animals do not cause disease and often exist in a commensal relationship with their hosts. Despite the concerns over rising antibiotic resistance, there is a considerable lack of data regarding the ecologic and epidemiologic forces that drive the spread and persistence of antimicrobial resistance determinants in agricultural settings. To understand better the basic biology and ecology of antimicrobial resistance determinants in commensal and pathogenic bacteria on dairies, as well as to develop methods for studying and monitoring trends in antimicrobial resistance, a field study was carried out on dairy farms with different demographics and management strategies.

Researchers sampled 203 cattle on four dairies, and many of these animals were sampled over four consecutive visits during the field portion of the project. It was hypothesized that individual animals that had been treated with antimicrobials would possess a higher proportion of antimicrobial-resistant *Escherichia coli* in their feces, and that these resistant *E. coli* would persist in the animal over time. It was also hypothesized that changes in the resistance levels in the *E. coli* of one animal would influence the *E. coli* populations of other animals in the same age cohort. The main factor associated with increased resistance levels was age. Young calves had a greater diversity of *E. coli* microbial resistance (MIC) phenotypes, and many of these *E. coli* isolates had elevated MICs to multiple antibiotics. However, regardless of treatment history, the animals had *E. coli* with lower MIC levels after 6 to 9 months of age. These results show that individual animal antibiotic treatments are not highly selective for resistant phenotypes over extended periods of time. Next, researchers used different multiplex PCR protocols that they optimized. They detected the resistance genes *flo*, which confers resistance against florfenicol; *cmlA,* which confers resistance against chloramphenicol; *cmy-2*, which confers resistance against third-generation cephalosporins; and various tetracycline resistance genes. Many of these genes were located on the same plasmids within the bacteria. The *E. coli* in which these genes were detected are of different DNA fingerprint patterns, suggesting that the gene has been transferred to multiple *E. coli* types. Finally, researchers completed the development and optimization of a *Salmonella* detection PCR from pooled bovine feces. The end result of this project is that the process of culturing for *Salmonella* from a large number of samples is now much more time- and cost-efficient.

A C-FAR External Competitive Grants project

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Assessing Needs for a Viable Illinois Dairy Industry

The purpose of this research was to assess the needs for a viable Illinois dairy industry. The research team addressed three research questions: What is the economic impact on the state and local economy under the current scenario of declining

production, and an alternative scenario with increased milk production to balance fluid milk production and consumption? What are the needs of milk purchasers in the state or surrounding regions in terms of quantity, quality, and delivery of raw milk? What are the perceptions of local residents toward dairy in their community?

Economic impact: If past trends until 1997 continue through 2007, it is projected that dairy farm numbers will decline by about 50% to slightly more than 1,000 farms, cow numbers will decline by 25% to approximately 100,000 head, but milk production will decline by only 4% because of the increase in cow productivity. Despite the small decline in milk production, the value of dairy farm products in constant dollars (1997) will decline by 29% to $179 million because of lower projected prices. The overall impact on economic output of the projected decline for the Illinois economy will be a decline of $126 million. Overall employment will decline by 890 jobs, or a loss of $19 million in employment compensation.

Needs of milk purchasers: Fifteen companies who purchase milk directly from Illinois dairy producers were surveyed to determine their future volume, quality, and delivery needs for milk. The seven that responded account for the majority of the milk purchased from Illinois producers. Projected purchases for 5 and 10 years from 2002 were 7.7 billion lb in year 5 and 8.7 billion lb in year 10. They expect Illinois producers to provide 19% of volume in year 5 and 18% of volume in year 10. The results suggest that opportunities are available to Illinois milk producers to expand production within the existing distribution system for their milk. A difference between an 18% share and a 20% share of the current milk market translates to supporting an additional $42 million of economic output and 292 jobs.

Resident perceptions of a dairy: Residents, community leaders, and farmers from 14 Illinois counties were surveyed in addition to dairy farmers and other groups as to their perceptions of dairy in their community. Rural residents preferred dairy over a variety of other possible neighbors. They preferred dairy to a car wash, coal mine, hog farm, or chemical plant, but preferred grain farms, churches, golf courses, or a subdivision over a dairy. Residents from a dairy county, with a farm background, or experience with dairy were much more willing to live closer to a dairy. Residents who were nonfarm rural, from nondairy counties, or from counties with higher percentage of nonfarm employment preferred to live greater distances from a dairy. Perceived benefits of a new dairy were jobs and expanded tax base. Perceived detractions were odor and water pollution.

A C-FAR External Competitive Grants project

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Photoperiodic Effects on Immune Responsiveness in Transition Dairy Cows

Previous research has shown that photoperiod manipulation of cows during the dry period between lactations can improve production efficiency in the subsequent lactation. In addition, there is evidence that photoperiod alters immune responsiveness in many species. Because cows are at the greatest risk for new mastitis infection and other diseases during the periparturient period, manipulation of the light environment (photoperiod) may offer a novel approach to improve animal health at a critical time in the production cycle.

Researchers confirmed that short-day photoperiod (SDPP) increases lymphocyte proliferation and chemotaxis relative to long-day photoperiod (LDPP) in dry cows. Treatment with SDPP decreased circulating concentrations of prolactin but increased prolactin sensitivity by stimulating prolactin-receptor expression; this shift in sensitivity to prolactin is likely the mechanism causing greater ability to resist new infection. Cows on SDPP experienced fewer incidences of parturition-related disease events relative to those on LDPP, despite the lack of general health differences between the groups before calving. It was also found that when SDPP and LDPP cows were challenged with mammary infusion of *Streptococcus uberis* to cause mastitis, SDPP cows became sicker than LDPP cows, suggesting that SDPP treatment caused greater sensitivity to pathogens.

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Economic Optimization of Wean-to-Finish Pork Production Systems

Arguably, the major technical development that has occurred in swine production in Illinois over recent years has been "wean-to-finish" production. With this system, piglets are weaned into a single building, where they remain until they are removed for slaughter. Traditional approaches involved weaning piglets into nurseries and then moving them into growing-finishing accommodations. Wean-to-finish production is being widely used in the swine industry in Illinois because of its practical and economic advantages. At the initiation of this research there was little if any objective, research-based information from which to establish optimum design and management approaches to maximize the output and profitability of wean-to-finish systems. Because of the dramatic differences between wean-to-finish and conventional approaches, historical data from traditional systems could not be used as the basis for advocating optimum management strategies.

To address these issues, a research collaboration was formed between University faculty and commercial producers, who, as well as providing facilities for the research studies, were intimately involved in setting the objectives and designing the studies carried out in this project. The specific objectives of this project were (1) to develop facility design and management approaches for wean-to-finish production systems that maximize the output from each facility, and (2) to develop an economic computer simulation model that allows producers to decide on the optimum design and management strategies for their facilities at any point in time.

This research project involved a total of 21 experiments (with over 19,000 pigs) that were carried out on four different commercial wean-to-finish systems. Important outcomes and impacts for the Illinois swine industry include

- Swine producers are applying these research findings to make critical management decisions regarding the management of wean-to-finish systems. Specific areas affected include the use of double-stocking buildings, housing pigs in large group sizes (i.e., 100 pigs/pen), optimizing floor and feeder space allowances, minimizing body weight variation, improving post-weaning performance through feeding and management, and optimizing pig removal strategies at market.
- The formation of a group of collaborators, including producers, associated industry personnel, and researchers, bringing together research expertise with the facilities and extensive experience and expertise of the commercial team. This group has continued to function beyond this specific research project, focusing on facility design and management issues having an impact on the future competitiveness of Illinois swine production.

A C-FAR External Competitive Grants project

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Effects of Alternative Strategies for Handling Swine Slurry—I

This project was designed to evaluate the use of unprocessed liquid swine manure and the liquid phase of separated swine slurry as soil amendments and their subsequent effects on subsurface water quality and pathogen transfer.

Polymer-assisted separation decreased the phosphorus (P) concentration of swine slurry 80% and the nitrogen (N) concentration 50%. The reduction in these two elements allows greater amounts (more gallons per acre) of swine slurry to be applied per acre, or result in fewer pounds of N and P being applied when the volume of slurry applied remains constant. Separated effluent also had significantly lower sodium (Na) concentrations than unprocessed slurry, resulting in less Na buildup in the soil. Compared to control with zero fertilizer application, soils amended with inorganic fertilizer, unprocessed slurry, and separated effluent had significantly higher P, potassium, and zinc concentrations. Corn grain yields were similar on soils amended with slurry, separated effluent, and inorganic fertilizer, being 185, 183, and 182 bushels per acre, respectively. Separated effluent contained lower concentrations of pathogen indicator microorganisms (fecal coliforms, *E. coli*, etc.) than unprocessed slurry. While indicator microorganisms were detected in the soils amended with slurry or effluent, no pathogens were detected in corn, grain, or soybean samples grown on these soils.

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Effects of Alternative Strategies for Handling Swine Slurry—II

The purpose of this project was to evaluate the solid/liquid separation efficiency of raw unprocessed swine slurry using a lower-cost static gravity screen-roll press separator and a higher-cost chemical flocculant (polyacrylamide, PAM)-assisted gravity belt thickener system alone and in combination under production scale conditions. The data generated was compared to determine the feasibility of using these treatment systems alone or in combination to reduce nutrient concentrations in liquid swine manure prior to additional treatment or discharge into the environment. Results generated by this study indicate that the PAM-assisted gravity belt thickener (PAM-GB) was significantly more effective at achieving solids separation than the static gravity screen-roll press (GS-RP). The GS-RP did remove 59.1% of the settleable solids (SS) but only 9.1% of the suspended solids (TSS), 17% of the phosphorus (P), and 20.3% of the nitrogen (N). The PAM-GB removed greater than 99.0% SS, 94.8% TSS, 92.2% P, and 79.5% N. Because the GS-RP did produce a slurry with uniform solids concentration (about 3.0%), operating the GS-RP and the PAM-GB in tandem reduced the labor required to operate the PAM-GB. The cost to separate was 1.13 cents per gallon of unprocessed slurry. The cost to land-apply unprocessed slurry with a tractor-operated injector drag line system is 0.80 cents per gallon. To be cost-competitive, separation flow rates must be increased 83%, which is very possible.

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Feeding Conjugated Linoleic Acid to Improve Bone Health and Meat Quality of Growing Finishing Pigs

Based on previous research in animals, the planned rationale for this study was to examine the effects of conjugated linoleic acid (CLA) supplementation on the bone mineral density, bone mineral content, and growth and carcass characteristics of the pig during the high-growth phase of finishing. Furthermore, researchers chose to remove the supplement 30 days prior to animal harvest to determine whether physiological changes occurring from CLA could be maintained. Conjugated linoleic acid is a naturally occurring product, manufactured from safflower or sunflower oil, that could potentially offer an economic benefit to swine producers if it could improve live pig growth performance and decrease carcass trim loss.

In concurrence with previous research, a comparative advantage was observed for specific growth and carcass characteristics in the growing pigs. Gilts fed CLA exhibited higher ($P < 0.05$) average daily gain compared with gilts fed the control diet (0.84 kg/d vs. 0.80 kg/d). All pigs fed CLA had lower ($P< 0.04$) last-rib fat depth compared with pigs fed the control diet (2.54 cm vs. 2.31 cm). However, Dexascan measurements of bone mineral density (BMD) and bone mineral content (BMC) of the femur revealed no differences ($P = 0.23$ and $P = 0.38$, respectively) when comparing all pigs fed CLA with all pigs fed the control diet. While some advantages in performance and carcass traits were realized in this trial, the removal of CLA in the diet 30 days prior to harvest negated some of the expected growth performance and carcass trait improvements reported in previous studies. It also appears that the time on CLA supplement needs to be longer to affect bone tissue growth or that the removal of the CLA 30 days prior to harvest allowed changes in bone growth to return to the non-CLA-supplemented equivalent. Based on these results, one could conclude that improvements in growth performance and certain carcass traits can be realized only if CLA is supplemented throughout the grow-finish phase of market pig production until the time of animal harvest. At the current time, CLA has not been listed as an approved feed additive for livestock in the United States. Until such time, the economic value of feeding CLA to livestock species cannot be assessed.

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Irradiation of Processed Pork Products to Increase Profits in the Pork Industry

The purpose of this project was twofold. First, researchers wanted to assess the eating quality and shelf-life of processed pork products that were subjected to electron beam irradiation. Secondly, they wanted to estimate the cost, using an economic model, of using electron beam irradiation as a food safety tool. Processed meat

products are currently not approved for irradiation according to FDA regulations.

In assessing the eating quality and shelf-life attributes of irradiated frankfurters and ham, researchers evaluated factors relating to color and odor. Regarding color, irradiated ham was lower ($P<0.05$) for Hunter L* color, indicating a slightly darker product. Color analysis of franks revealed no changes in external or internal color between irradiated and control samples over a shelf-life of 60 days in the package. The analysis of product odor showed an increase in "cooked odor" when comparing irradiated with control ham samples. Similar results were evident in odor data for franks. Panelists did not rate the irradiated samples as undesirable for odor. Regarding the safety of the products, the total aerobic plate counts for ham were fivefold less than those of the control ham samples. Theses data indicate that electron beam irradiation significantly slows the growth of spoilage bacteria present on fully cooked, ready-to-eat ham.

Commercial ham production was chosen as the business model for the cost analysis portion of the study. The cost analysis model included net present value, internal rate of return, break-even point, and unit costs for four rates of throughput under the three scenarios. X-ray irradiation was profitable at volumes over 51 million pounds annually. Cobalt-60 irradiation showed the greatest profitability, with an internal rate of return almost twice that of capital cost. Contracting irradiation services was advisable for volumes of 150 million pounds or more annually because irradiation and transportation charges combined would exceed net income before interest and tax for lesser volumes. Total costs per pound ranged from $0.04 (50 million pounds) to $0.01 (200 million pounds) for X-ray, $0.02 (50 million pounds) to $0.008 (200 million pounds) for cobalt-60, and $0.07 (50 million pounds) to $0.05 (200 million pounds) for contracting irradiation services. The rate of return ranged from 15% to 71% for X-ray, 27% to 100% for cobalt-60, and up to 196% for contracting irradiation services.

A C-FAR External Competitive Grants project

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Tetracycline Resistance in *Salmonella* Isolated from Illinois Swine

The emergence of multiple-drug-resistant (MDR) *Salmonella* is a serious problem as the worldwide increase of MDR *Salmonella* infections narrows the therapeutic options, considerably adds to the cost of treatment, and increases the mortality rate. The overall goal of this research is to characterize the phenotypic and genotypic components of antibiotic resistance in *Salmonella* isolated from marketed pigs in Illinois.

Researchers developed and used methods to describe the phenotypic and genotypic components of tetracycline (TC) resistance of *Salmonella* from swine production systems. Phenotypic analysis indicated that *Salmonella* from swine mesenteric lymph nodes isolated at slaughter from 141 farms indicated that 61% express resistance to at least one antimicrobial tested. Resistance to more than two antimicrobials was found in 38% of isolates. Resistance to six antimicrobials was found in less than 1% of isolates. Resistance was detected to five or more antimicrobials among 43% of herds. *Tet* genes, designated A, B, and C, were detected in 18.6%, 66.4%, and 1.6% of isolates, respectively. Tetracycline resistance was observed in 50.1% of isolates, with 1.4% intermediate. When broken down by genetic pattern, resistance/intermediate resistance was found in the following proportion of isolates: A-, B-, C-, 23.0%; A+, B-, C-, 93.1%; A+, B-, C+, 94.7%; and A-, B-, C+, 69.7%. The two most commonly used antimicrobials at therapeutic doses were tetracyclines, 38.5%, and tylosin, 20.2%. Among subtherapeutic regimens, the most common were bacitracin, 51.0%; tylosin, 42.3%; and tetracycline, 15.4%. Use of these antibiotics was not significantly correlated with phenotypic resistance or the prevalence of any of the three genes studied. It is concluded from this that current antibiotic use is not significantly associated with the proportion of *Salmonella* resistant to tetracycline. However, tetracycline use, genes, and phenotypic resistance are common. At the group level, and among farms with *Salmonella* isolates, use of antimicrobials in feed at therapeutic doses was not associated with a change in the number of antimicrobials with detected resistance. However, reported subtherapeutic use was associated with an increased risk of detecting resistance to five or more antimicrobials. Subtherapeutic use was also associated with an increased number of antimicrobials against which *Salmonella* were detected to be resistant.

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Evaluation of Central Ram Testing Records

The objective of this trial was to develop adjustment factors for ultrasonically measured ribeye area and ribfat and scrotal circumference in rams. With increased use of ultrasonic measurement to evaluate breeding stock, there is a need for standard adjustment factors for differences in age and weight of the rams when they are ultrasonically scanned. Currently, producers must basically guess at what the effects of age and weight are for these traits when comparing animals varying for age and weight. The derived adjustment factors can be used to account for differences between rams in both central test stations and in on-the-farm testing programs, thus increasing the accuracy of genetic selection and improving efficiency of food production.

Data were collected on 100 rams of the Corriedale, Dorset, Suffolk, Hampshire, and Polypay breeds. These rams were tested in either the 2001 or 2002 Illinois ram tests. Rams were ultrasonically scanned for ribfat and ribeye, and measured for scrotal circumference, every 28 days over the last 84 days of the test. The results of the analysis show that scrotal circumference can be adjusted to common age and weight bases using 0.114 as the weight deviation coefficient, 0.030 as the age deviation coefficient, and –0.002 as the weight squared deviation coefficient. For ribeye area the weight deviation coefficient is 0.014, and for ribfat the weight deviation coefficient is 0.0026. These adjustments will allow scrotal circumferences, ribfat, and ribeye areas measured in animals over a varied weight range to be compared on an equal basis.

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Use of Stockpiled Forage for Winter Sheep Grazing

Extending the grazing season for sheep through utilization of unharvested forages was the proposed objective of this trial. If such forages can be used, resources can become more sustainable. Dependency on fossil fuels will be reduced since forages will not require harvesting. Profitability for individual producers can increase through decreased machinery, labor, and fossil fuel costs. Funds were received for the first year of this project, which allowed the first-year activities of re-establishing the pasture with fescue varieties and late-maturing orchardgrass. However, due to a reduction in the C-FAR appropriation by the State of Illinois, funding was not received for years two and three. Thus, there are no results.

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S-Methylmethionine (Smm): A New Source of Sulfur Amino Acid Activity

The purpose of this research was to quantitate the level of S-methylmethionine (SMM) in corn and soybean and test the efficacy of SMM as a precursor of methionine (Met) and choline (Cho). Results indicate the levels of SMM in corn gluten and soybean meals are about 0.5 and 1.65 mg/g, respectively. In diets singly deficient in either Met or Cho, the addition of SMM produces a significant growth response in chicks. Thus, SMM in foods and feeds contain both Met- and Cho-sparing activity. This means that SMM could reduce the amount of Met and Cho presently added to swine and poultry feeds if strains of corn and soybean could be found or made that overproduce this compound.

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The Post-Antibiotic Era of Food Production

The goal of this two-year project was to explore the novel hypothesis that proinflammatory cytokines, which are reduced in antibiotic-fed animals, inhibit the major regulator of postnatal animal growth and productivity, IGF-I. Researchers focused on skeletal muscle myoblast satellite cells due to their critical role in increasing lean muscle mass. IGF-I promotes protein synthesis in myoblasts and ultimately the fusion of myoblasts into muscle fibers.

Researchers discovered that proinflammatory cytokines act on muscle cells indirectly by reducing the sensitivity to IGF-I. In primary porcine myoblasts, IGF-I induces a more than 50% increase in protein synthesis. When porcine myoblasts are treated with physiological concentrations of a major proinflammatory cytokine from the immune system, TNF, IGF-I-stimulation of protein synthesis is significantly impaired. TNF alone does not affect basal protein synthesis in porcine myoblasts. These data are important because they strongly indicate that the detrimental effects of proinflammatory cytokines from an activated immune system occur by impairing action of a major hormone that promotes postnatal growth, IGF-I. Additionally, it was confirmed that IL-1 also blocks IGF-I-stimulated protein synthesis in porcine myoblasts. Therefore, this discovery points to the idea that there could be a common mechanism by which proinflammatory cytokines impair the growth of lean muscle mass in growing livestock. This phenomenon is generally referred to as crosstalk between immune and hormone receptors. A thorough understanding of exactly how proinflammatory cytokines target intracellular proteins to block the actions of growth-promoting factors such as IGF-I is likely to provide alternative strategies to the use of antibiotics in feed. Indeed, substantial progress has been made toward understanding the mechanism by which TNF and IL-1 act at the cellular level to impair IGF-I-stimulated protein synthesis. Targeting cells of the immune system, and their proinflammatory cytokine products, would represent a major advance that could lead to the efficient production of livestock in the absence of antibiotics.

A C-FAR External Competitive Grants project

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Effects of Fumonisin on Atherosclerotic Disease

Cardiovascular disease, especially atherosclerosis, is a major cause of death in adults. The mycotoxin, fumonisin B_1, causes cardiovascular disease and hypercholesterolemia in several animal species. Since Illinois is second in corn production in the United States and fumonisins are commonly found in Midwest corn, it is important to determine the mechanism of fumonisin-induced cardiotoxicity to protect human health. The goal of this project was to investigate the mechanism of fumonisin B_1-induced cardiovascular toxicity. Studies were based on the researchers' previous findings in swine that fumonisin B_1 induces a decrease in mean aortic pressure and an increase in mean pulmonary arterial pressure that results in left-side heart failure and pulmonary edema. These cardiovascular changes are accompanied by increased serum concentrations of sphinganine and sphingosine that result from fumonisin-induced alterations in the sphingolipid biosynthetic pathway.

The effects of fumonisin B_1 on vascular rings obtained from swine and heart cells in culture were evaluated to further our understanding of the cardiovascular toxicity of fumoninsin B_1. To prove a causal relationship between the vascular changes and elevated serum concentrations of sphinganine and sphingosine, researchers examined the in vitro effects of sphinganine, sphingosine, and sphingosine-1-phosphate (S-1-P) on relaxation and contraction of porcine thoracic aorta and pulmonary artery vascular rings. Fumonisin-induced systemic arterial hypotension is mediated by increased serum sphinganine and sphingosine concentrations; this suggests that pulmonary artery hypertension is mediated by increased serum S-1-P. The disparate response of thoracic aorta and pulmonary artery to sphinganine, sphingosine, and S-1-P probably reflects relative influences of L-type calcium channels and alpha-1 receptors in different vascular beds. Similar results were found in vascular rings obtained from Sinclair minipigs fed 10 to 30 ppm fumonisin B1 for 6 months.

To determine the roles of sphingosine and sphinganine in producing cell injury, the cytotoxic effects of exogenous sphinganine and sphingosine were evaluated in rat embryonic cardiomyocytes (H9C2[2-1]) and hepatocellular carcinoma cells (HepG2), using the MTT assay. Sphinganine was a more potent cytotoxic agent than sphingosine for both H9C2[2-1] and HepG2 cells. Thus both sphinganine and sphingosine may play a role in fumonisin B_1-induced cardiotoxicity and cell death. This information will assist the risk assessment of fumonisins for human health.

A C-FAR External Competitive Grants project

Wanda M. Haschek-Hock, Veterinary Pathobiology

Peter D. Constable, Veterinary Clinical Medicine

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College of Veterinary Medicine

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Mycobacterium paratuberculosis Thermal Inactivation and Incidence in Fluid Milk

There are two objectives of this program: (1) to collect information on the prevalence and concentrations of *Mycobacterium paratuberculosis* (MpT) present in raw milk as delivered to Illinois milk processors, and (2) to apply this data to assessing the safety of milk pasteurization time-temperature conditions as employed during commercial practice. MpT is an obligate intracellular pathogen and the causative agent of paratuberculosis, or Johne's disease, occurring primarily in cattle and other ruminants. Excretion of MpT in feces and milk occurs as the course of the infection progresses. It is one of the most widespread bacterial diseases of domestic animals throughout the world; annual losses for the U.S. cattle industry alone are estimated as in excess of $1.5 billion. Crohn's disease is a chronic inflammatory, granulomatous, and ulcerative process that occurs in the deep layers of the small and sometimes large intestine. The clinical pictures of Johne's disease in cattle and Crohn's disease in humans are remarkably similar. Momentum seems to be gaining to support the conclusion that MpT plays a role in at least a proportion (estimated as approximately 30%–50%) of Crohn's disease cases. It is necessary to understand the prevalence and concentrations of MpT (initial bioburden) in raw milk in order to be able to evaluate the effectiveness of pasteurization.

Samples of commercial raw milk tankers received by Illinois milk processors were evaluated for MpT by culture on Harrold's egg yolk medium and in BACTEC 12B radiometric medium. A double decontamination procedure was used during the isolation of MpT. Decontamination was necessary because no selective medium is available for MpT, MpT is nutritionally fastidious and requires rich media, and MpT cultures are easily overgrown by the mixed population of competing microorganisms found in milk. Results are currently available for analyses performed on a total of 405 tanker raw milk samples. Of the samples tested, 32 (7.9%) were positive by either of the two culture methods. The recovered numbers of MpT in

positive samples ranged from 1 to approximately 37 CFU when 50-mL and 125-mL milk samples were assayed. The maximum concentration of MpT observed in this study was less than 1 CFU/mL (0.8 CFU/mL).

Tests were also performed to evaluate the effect of the decontamination procedure on the recovery of *M. paratuberculosis* ATCC 19698, since one laboratory has suggested that decontamination may produce significant losses in MpT viability. The results showed from no loss to an approximately 46% loss in recovery from the decontaminated samples and confirm that minimum detection limits are only lower than those using samples not processed by decontamination. The results provide an understanding of the prevalence and concentrations of MpT in raw milk. This information on the initial MpT bioburden in raw milk is essential to estimating the effects of thermal processing (pasteurization) and assessing the risk posed to the consumer. The very low concentrations of MpT found in raw milk in this study suggest that the risk from commercial pasteurized milk is low. Questions regarding the pathogenicity of MpT and its infectious dose remain.

A C-FAR External Competitive Grants project

Joseph Dunn, National Center for Food Safety and Technology

The Illinois Institute of Technology

Effects of Soybean-derived Phytostanols on Serum Cholesterol Levels

Elevated levels of cholesterol in the serum (hypercholesterolemia) is a major risk factor for coronary heart disease (CHD). Fifty-eight million Americans have CHD, and 960,000 die from this disease yearly. The healthcare and lost productivity costs of CHD are $286.5 billion. A 10% reduction in serum cholesterol level is associated with a 5% reduction in mortality from coronary heart disease. Soybean and corn oil contain phytosterols that lower serum cholesterol levels when ingested. Hydrogenation of phytosterols produces stanols, which lower serum cholesterol levels more than phytosterols do. Certain microorganisms have the ability to produce stanols by hydrogenating phytosterols. The goal of this study was to develop a microbial fermentation process for conversion of soybean phytosterols into stanols.

Microorganisms were used to convert soybean phytosterols to stanols. The stanols were produced using a 12-liter fermenter. The stanols were recovered from the fermentation medium and purified by saponification and solvent extraction. Characterization of the chemical structure of the stanols by gas chromatography-mass spectrometry showed that the double bond in the A ring of the sterols had been reduced (hydrogenated) and that the orientation of the hydrogen atom at position C5 was in the beta configuration. Rats fed cholesterol and the stanols for two weeks had lower average serum cholesterol levels than control animals, though the effect was not statistically significant. The stanols were safe, as no adverse health effects were observed in the rats. Soy-derived stanols would increase the supply and should reduce the cost of cholesterol-lowering foods. Reduced cost to the consumer would promote increased consumption, which would lower serum cholesterol levels in the population and decrease CHD and deaths. Use of soybeans to produce stanols would increase the demand for soybeans.

John D. Haddock, Microbiology

College of Science

William J. Banz, Todd A. Winters, Animal Science, Food and Nutrition

College of Agricultural Sciences

Southern Illinois University at Carbondale

Impact of Soy Components on Quality of Life During Aging

Diets rich in soybean components have been reported to prolong life, prevent cancer, and protect oxygen-related damage from aging. Soybeans contain estrogenic compounds, and there is recent evidence that estrogens can protect the brain from age-related loss of nerve cells and thus could prevent dementia and Alzheimer's disease. In this project, researchers proposed that soy proteins and soy phytoestrogens can improve quality of life in aging individuals by delaying the age-related decline in learning and memory, the onset of age-related diseases, and the endocrine changes that normally accompany aging. Long-living Ames dwarf mice, short-living growth hormone transgenic mice, and normal mice were fed diets containing no soy proteins (casein controls), soy protein with low phytoestrogens, or soy protein with high phytoestrogens, starting at weaning. Specific objective of the research are to determine the effects of these diets on (1) longevity parameters such as mean and maximal lifespan; (2) age-related changes in learning and memory (as measured by passive avoidance test); (3) plasma levels of corticosterone, insulin, and glucose, as well as and insulin tolerance; and (4) blood lipid profiles.

Soybean diets tended to normalize plasma cholesterol levels in dwarf and transgenic mice, while a low-isoflavone diet reduced plasma triglycerides in most of the

examined genotypes. The effects of low-isoflavone diet and high-isoflavone diet on the levels of free radical and esterfied cholesterol in the liver were strongly genotype dependent. Fasting blood glucose levels were reduced, and glucose tolerance was improved, by both low-isoflavone and high-isoflavone diets in growth hormone transgenic mice and in their normal siblings. Glucose tolerance was improved by high-isoflavone diet also in growth hormone receptor knockout mice. Lifespan data was also analyzed for the effects of diet, genotype, and the interaction. The expected genotype effects on longevity were statistically significant in each of the genotypes studied. The effects of diet were significant in two of the four stocks (long-lived Ames dwarf and short-lived MT-hGH transgenic), and no significant interaction was detected. Compared to casein diet, soy diet with low isoflavones extended life in normal, Ames dwarf, and MT-hGH mice, while soy diet with high isoflavones did not affect longevity. The effect of diet on longevity of normal mice was strain dependent and, within strains, sex dependent. In mice fed low-isoflavone soy diet, memory retention after 24 hours appeared to be better than in animals fed casein diet in each of the four groups tested, and memory retention after seven days was similarly improved in three of four groups. In most groups, these apparent effects reached statistical significance. Highisoflavone soy diet had no consistent effects on performance in this task.

In summary, positive effects on quality of life were seen in animal models fed the low-isoflavone soybean protein-based diet when compared to casein protein-based control. In addition, the experimental diet that was high in soy isoflavones and was also soy protein based had inconsistent benefits on quality of life. The low-isoflavone soy-based diet was calculated to represent the isoflavone intake similar to human consumption, whereas the high-isoflavone soy based diet was chosen to test the effects of pharmacological (high) levels.

Andrzej Bartke, Physiology

School of Medicine

Southern Illinois University

Medicinal Genes and Healthful Dietary Choices

The goals of this research were to determine the potential therapeutic effects of American ginseng and work on identifying genes involved in the therapeutic efficacy of ginseng and overall plant health. Moreover, the project was used to train students in the areas of biomedical research and plant genomics. In addition, the grant served to enhance collaboration between the College of Agricultural Sciences and School of Medicine, which would open avenues for funding at the national level.

Fresh 7-year-old, wild-simulated American ginseng plant material was obtained from an Illinois ginseng farmer near the Springfield area. Plant materials (i.e., leaf, stem, root) for RNA extraction were quick frozen in liquid nitrogen. Additional plant materials were maintained at room temperature before water extraction and lyophilization, and the extract's effects were tested in a human breast cancer MCF-7 cell proliferation assay. It was determined that both leaf and root extracts were potent inhibitors of cancer cell proliferation, with leaf producing the more potent inhibitory effect. Researchers were unable to obtain pure RNA from ginseng root, but successfully extracted RNA from leaf material. A recent study has demonstrated that ginseng leaves synthesize the biologically active components in ginseng, the ginsenosides, which are then transported and stored in the root. Researchers obtained DNA sequences of the plant material corresponding to sequences found in a number of different types of plants and found one novel sequence, which has yet to be identified.

Laura L. Murphy, Physiology

School of Medicine

Khalid Meksem, Plant, Soil and Agricultural Systems

College of Agricultural Sciences

Southern Illinois University at Carbondale

Neonatal Intestinal Function and Resistance to Diarrhea: Impact of Soy Fiber

Diarrhea is a leading cause of morbidity and mortality in infants. The goal of this project is to understand how the addition of fermentable fiber to the diet of newborn infants affects the mechanisms regulating *Salmonella*-induced gastroenteritis. It is our central hypothesis that addition of fermentable fiber to infant formulas promotes the development of the gastrointestinal (GI) tract in newborn infants, thus enhancing host defense against *Salmonella* infection. The rationale for the proposed research is that if the role of fermentable fiber in modulating the infectious susceptibility of infants to *Salmonella* is understood, nutritionists will be better able to design formulas to optimally meet the nutritional needs of infants during normal and compromised states.

Two-day-old piglets were randomized to receive formula alone (control) or containing methylcellulose (MCEL), soy polysaccharides (SPS), or fructo-oligosaccharides (FOS) for 14 days. On day 7, piglets were further randomized to receive an oral gavage of *Salmonella typhimurium* or serve as

noninfected controls. *S. typhimurium* infection produced diarrhea in control and MCEL groups, but not in SPS and FOS groups. Postinfection physical activity was lower ($p = 0.0001$) in the controls than in all other groups. Ileal lactase activity was reduced ($p < 0.05$) following infection in the control group but not in the MCEL, SPS, and FOS groups. Mucosal barrier function, measured as resistance, was impaired in the ileum by infection ($p < 0.05$) in the control and SPS groups but was unaltered in the jejunum and colon. Total ion transport and basal short-circuit current were higher ($p < 0.05$) in jejunum than in ileum and colon, irrespective of diet or infection. SPS and FOS increased ($p < 0.05$) ileal glutamine transport relative to piglets fed MCEL, irrespective of infection. Fermentable fiber enhances intestinal function and reduces the severity of *S. typhimurium* infection-associated symptoms and thus may be a cost effective way to reduce the severity of pathogenic infection-associated symptoms in infants.

Kelly A. Tappenden, Sharon M. Donovan, Food Science and Human Nutrition

H. Rex Gaskins, Animal Sciences

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Soybean Isoflavones as Modulators of Neonatal Intestinal Development

Approximately 15% of all infants, or 600,000 infants in the United States, are fed soy-based formulas. Concentrations of isoflavones in soy formulas range from 32 to 47 milligrams/liter (mg/L) (approximately 65% as genistin or genistein), compared to about 6 micrograms/liter in breast milk. Based on an average formula intake of 900–1000 mL/day, a 4-month-old infant fed soy formula consumes 28–47 mg/day, or 6–9 mg/kg body weight, of isoflavones. Therefore, the gastrointestinal tract of infants fed soy formula is constantly exposed to a very high concentration of genistein, the impact of which was unknown. Researchers have previously shown that genistein at concentrations present in infant formulas inhibited the proliferation of cultured intestinal cells by causing cell cycle arrest at the G2/M transition. This block in cell cycle progression was associated with a reduction in the protein abundance of cyclin D1. In contrast, genistein at 1 mg/L induced intestinal cell proliferation, which was mediated via the interaction of genistein with estrogen receptors located on intestinal cells. Although these data were compelling, extrapolation of observations from cultured cells to anticipated effects in human infants is problematic, therefore, the objective of this research was to determine the impact of ingested genistein on intestinal structure and function of neonatal piglets.

Piglets were fed sow milk-replacer (MR), MR + 1 mg/L genistein (LG), or MR + 14 mg/L genistein (HG) for 10 days. There were no differences in any parameter assessed between piglets consuming MR or the LG formula. Formula intake, body weight gain, and intestinal length and weight were similar in all groups. The average serum genistein concentration in the HG group was similar to that reported in human infants fed soy formula, validating the appropriateness of the level of genistein fed. No significant effects of genistein on lactase and sucrase activities, glucose or glutamine transport, or barrier function were observed in either jejunum or ileum, suggesting that overall digestive and absorptive capacity was unaffected by genistein. Researchers next investigated intestinal cell turnover by measuring enterocyte proliferation, migration and cell death (apoptosis). Jejunal and ileal villus heights were not significantly different, but the percentage of jejunal crypt cells expressing proliferating nuclear cell antigen (PCNA) in the HG group was reduced 50% compared to piglets consuming MR and LG diets (12% vs. 25%; $p = 0.001$), indicating decreased proliferation. The drop in proliferation did not appear to be due to diminished levels of activated protein tyrosine kinase, c-src. There was no effect of genistein on apoptosis. However, enterocyte migration distance in the HG group was 20% less ($p = 0.1$), but this slowing of migration was not attributable to a change in intestinal trefoil factor (TFF3) mRNA expression. Thus, consumption of formula containing HG for 10 days reduced enterocyte proliferation and migration but not other growth or functional parameters. These data show for the first time that genistein is bioactive in the neonatal small intestine. Further, soy isoflavones did not markedly alter intestinal development of neonates, however, longer-term studies are needed to determine whether continued consumption of soy formula could compromise intestinal structure and function.

Sharon M. Donovan, Kelly A. Tappenden, Food Science and Human Nutrition

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Mark A. Berhow, National Center for Agricultural Utilization Research

United States Department of Agriculture

Acyl Carrier Protein's Role in the Regulation of Fatty Acid Biosynthesis in Plants

The long-term goal of this research is to obtain a better understanding of the critical factors regulating the composition of the oilseed storage components carbohydrate, lipid, and protein. Information attained can be utilized to enhance the overall value of oilseeds, both as a nutritional resource and as a food ingredient. The objective of this project was to clarify the functional role of ACP isoforms in plant lipid and fatty acid biosynthesis in vivo using Arabidopsis thaliana as a model oilseed.

Transgenic lines of *Arabidopsis* plants containing constructs designed to alter expression of different ACP isoforms were generated; researchers expressed additional ACP isoforms to collect ACP protein for crystallization experiments (structural analyses). One set of plants investigated was transformed with an antisense construct designed to reduce expression of the major ACP isoform in leaf (ACP-4). There was a dramatic reduction in ACP-4 and reduction of leaf lipid content (22%–60%) based on fresh leaf weight. Additionally, there were varying degrees of bleaching of the plants and reduced photosynthetic efficiency. Also, fatty acid composition was affected. There was a decrease in 16:3 as a percentage of total fatty acid. There were no changes observed in leaf lipid class distribution; however, there was a decrease in 16:3 in monogala ctosyldiacylglycerol (lipid associated with chloroplast membranes and critical to photosynthesis). Results suggested that ACP-4 plays a major role in biosynthesis of fatty acids for chloroplast membrane development. Also, alteration in the ACP profile of *Arabidopsis* leaf resulted in an alteration of flow of fatty acids between the prokaryotic and eukaryotic pathways for galactolipid assembly.

Additional plants were generated from antisense manipulation of ACP-1 and ACP-2 using seed-specific promoters. Lipid content was reduced 5%–40%, without affecting fatty acid composition. Alterations in carbohydrate and protein in response to reduced lipid accumulation in seeds were anticipated; however, they were not significantly affected. Seeds were lower in weight. Researchers have extended these informative studies into soybean plants. Dramatic reductions in oil content may be achieved through manipulation of ACP levels; this may be used to decrease oil content of agronomically important crops. This may be achieved without major adverse effects on other storage components.

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Dietary Protein Control of Insulin Action and Blood Glucose

This research is part of a systematic program to evaluate the potential for diets with increased levels of high-quality protein and reduced levels of refined carbohydrates to help adults achieve and maintain a healthy body weight. A moderate protein diet has been found to be effective for weight loss and targets loss of body fat while maintaining muscles, improving blood lipid levels, and enhancing regulation of blood sugar. A unique relationship has been demonstrated between the levels of dietary protein and carbohydrates and how the body regulates synthesis of muscle protein and levels of blood glucose. The traditional view is that after a meal, carbohydrates are absorbed and insulin is released, stimulating use of blood glucose and increases in protein synthesis. However, this relationship may not be accurate. First, insulin is effective only in two tissues: muscle and fat. In fat tissue, insulin stimulates deposition of excess carbohydrate energy as body fat. In muscle, insulin stimulates growth and use of blood glucose as a fuel. For growing children, the role of insulin in muscle is beneficial, but for nongrowing, sedentary adults insulin does not stimulate muscle protein synthesis, and use of glucose as a fuel is minimal. Researchers have discovered that the action of insulin in muscle is mediated by the presence of the essential amino acid leucine. The actions of insulin occur through a signal pathway that influences diverse metabolic processes including glucose uptake, protein synthesis, storage of fat, and production of molecules used to make glucose. New research reveals that the amount of leucine present in the cell (and the diet) modulates the role of insulin in each of these processes.

This research explores the fundamental molecular roles of leucine in muscle metabolism, in regulation of the action insulin, and in control of mechanisms the body uses to regulate changes in blood sugar (glucose). These studies provide evidence that dietary substitution of protein for carbohydrates reduces the wide swings in blood levels of glucose, insulin, and glucagon associated with high-carbohydrate meals by shifting the mechanism for control of blood glucose from the peripheral regulation by insulin to central regulation by the liver. In diets that are high in refined carbohydrates, the body is required to dispose of

large quantities of glucose rapidly in muscle and adipose after each meal. In sedentary adults, muscle is relatively ineffective in use of glucose, suggesting that high-carbohydrate diets increase storage of energy in fat tissue. These studies show that lowering the amount of dietary carbohydrates while increasing protein reduces the levels of insulin, increases use of body fat for energy, stimulates protein sparing in muscle, and enhances the body's ability to stabilize blood sugar. This shift in the mechanism the body uses to control blood sugar appears to correct abnormal symptoms associated with obesity and type 2 diabetes. This research provides critical new mechanistic information about the importance of high-quality protein in the adult diet.

Donald K. Layman, Food Science and Human Nutrition

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Refining Soybean Oil Using Supercritical Fluids and Membrane Technology

The purpose of the research was to develop a combined supercritical fluid and membrane processing system to purify food oils, such as the crude oil extracted directly from corn or soybeans, so as to produce a more efficient, less costly, and more environmentally friendly oil purification process. Membrane technology has been investigated extensively as an alternative to traditional methods of processing vegetable oils. Membranes have several advantages: lower energy requirements, higher yields, fewer chemicals, less effluents, and potentially higher-value co-products such as oil-free lecithins and free fatty acids in their native state. However, with today's membranes and organic solvents (e.g., hexane), a primary limiting factor has been the low flux (throughput through the membrane) and poor membrane lifetime due to incompatibility of the membrane with solvents and the high viscosity of the miscella.

Supercritical carbon dioxide is an excellent solvent for fats and oils. It has additional advantages, such as a viscosity that is nearly a hundredfold lower than the viscosity of organic solvents, nontoxicity (an important element in complying with the 1990 Clean Air Act, which restricts operation of hexane-based soybean oil plants), nonflammability, low cost and ready availability (CO_2 is a byproduct of the fermentation of corn to ethanol, and it is either discarded or sold for ~$0.01 per pound). In addition, oil-processing plants that use hexane or some other organic extraction solvent produce large amounts of volatile organic compounds, which would be lowered with supercritical fluid membrane technology.

The technology in this research project, when fully developed, will allow Illinois soybean and corn oil processors to remain competitive by reducing the cost of processing. They face the emergence of less expensive oils, particularly palm oil, which are produced in countries with less restrictive air quality standards. It will also help many corn-based dry-milling ethanol plants that do not recover the carbon dioxide they produce and instead vent it to the atmosphere or are paid less than a penny a pound when they can find buyers. These ethanol plants are in urgent need for more value-added co-products in order to be economically viable when the ethanol subsidy expires in 2007.

William E. Artz, Munir Cheryan, Food Science and Human Nutrition

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Value-Added Initiatives and Specialty Crops

GROW ILLINOIS AG: An Expansion

The purpose of this initiative is to identify, assist, and promote Illinois alternative agricultural enterprises and to assist rural communities in developing strategies for retaining and expanding their businesses. Towards this end, an inventory of Illinois alternative agricultural enterprises was developed and made available on the GROW ILLINOIS AG website at **www.siuc.edu/~illinois.** Prospective customers, investors, developers, and other producers now have access to more than 435 Illinois alternative agricultural enterprises. Visitors to the website can find more than 440 different products and services among 294 different townships throughout 96 Illinois counties.

GROW ILLINOIS AG investigators assisted rural communities and groups of agricultural businesses by conducting Business Retention and Expansion (BR&E) programs, which involved collecting information and suggestions from local business people to find out what is needed to improve their business. Follow-up assistance and feedback analyses were then provided to help communities formulate plans for acting on the needs identified in the studies. The core participants of the project are orchard owners who have developed on-farm markets. The objective of the project was to identify ways the businesses could work cooperatively to attract more tourists to the area. Information and opinions were collected from businesses among the Jackson County communities of Murphysboro, Carbondale, and Makanda, and the Union County communities of Cobden, Alto Pass, Anna, and Jonesboro. A business in Buncombe of Johnson County also participated in the study. Additional participants included motels, restaurants, antique shops, bed and breakfasts, a museum, an historical site, wineries, vineyards, rustic resorts, outdoor recreation facilities, a bait shop, a convenience store, golf courses, theaters, and parks. Among the respondents, 69 percent reported they would be interested in working cooperatively to market their products, services, activities, or events. In all, 19 rural communities are represented among the businesses that participated in GROW ILLINOIS AG BR&Es.

A C-FAR External Competitive Grants project

Susan Kohler, Sharon Schumacher, Office of Economic and Regional Development

Southern Illinois University at Carbondale

An Evaluation of the Potential Market for Hybrid Striped Bass Produced in Illinois

The specific goals of this study were to (1) determine potential demand for hybrid striped bass from supermarkets and full-service restaurants in the North Central Region and (2) assess consumer perceptions of hybrid striped bass. Of the 208 full-service restaurant fish buyers that participated in the survey, exactly one-half indicated that they did not know that farmers raised hybrid striped bass as a food fish, and an additional 8% indicated that they were not sure. Of the 147 supermarket fish buyers that participated in the survey, 73% of single-unit supermarket buyers and 47% of chain buyers indicated that they were not aware that farmers raised hybrid striped bass as a food fish. An additional 16% of single-unit buyers and 17% of chain buyers indicated that they were not sure. When compared to restaurant buyers, single-unit supermarket buyers quoted offer prices that were 39% lower for whole hybrid striped bass and 37% lower for hybrid striped bass fillets. Supermarket chain buyers quoted offer prices that were 13% lower for whole fish and 18% lower for fillets.

A focus group with 10 Illinois fish consumers consisted of a sensory evaluation of hybrid striped bass fillets and a discussion of participants' perceptions of fish and their fish purchasing activities. The sensory evaluation allowed participants to taste and evaluate three cooking methods and two recipes found on the Internet. The overall results indicated that participants generally liked hybrid striped bass, but that the preparation method was an important factor in determining the degree to which participants liked or disliked the fish. The focus group discussion revealed that participants were unfamiliar with hybrid striped bass as a food fish, and they commonly associated the words "striped bass" with sport fishing. The results of this study suggested that the success of large-scale marketing of hybrid striped bass in the North Central Region would depend on extensive product promotion and education of both retailers and consumers. Full-service restaurants were more likely than supermarkets to offer prices that covered farm production costs.

Kerry W. Tudor, Agriculture

College of Applied Science and Technology

Illinois State University

Bioavailability of Micro and Macro Minerals from Normal and Low-Oligosaccharide/High-Available-Phosphorus Soybean Meal for Tilapia

According to the EPA, concentrated aquatic animal production facilities can release a variety of pollutants into receiving waters, and under certain conditions those pollutants may be harmful to the environment. Recently in Illinois, regulators have cited the aquatic animal production industry as a possible source of impairment to the state's water bodies. The goal of this study was to investigate the impact of low-oligosaccharide/high-available-phosphorus soybean meal on phosphorus bioavailability to tilapia and the potential for reduced phosphorus discharge from aquatic animal production facilities.

In this study, 360 tilapia were fed six nutritionally complete practical diets that contained soybean meal (41%), wheat midds (27.7%), fish meal (3.0%), canola oil (2.2%), corn (24.1 to 25%), and supplementary vitamins and minerals. Three diets contained a normal soybean meal and three diets contained a mutant low-oligosaccharide/high-available-phosphorus soybean meal. The normal soybean contained 0.72% total phosphorus and 0.41% non-phytic-acid phosphorus, whereas the low-oligosaccharide/high-available-phosphorus soybean contained 0.78% total phosphorus and 0.66% non-phytic-acid phosphorus. One normal soybean meal diet and one low-oligosaccharide/high-available-phosphorus soybean meal diet contained zero levels of dicalcium phosphate, and the four remaining diets contained graded levels of dicalcium phosphate at the expense of corn. After a 10-week feeding period, fish were euthanized, and scales and vertebrae were collected and analyzed for ash, macromineral, and micromineral content. Although differences in the phosphorus content of scales and bones were not directly detected by the procedures utilized in this study, data indicated that low-oligosaccharide/high-available-phosphorus soybean meal in practical diets for tilapia could produce significant improvements in scale and bone mineralization as measured by scale and bone ash. With regard to specific minerals, there were increases in scale calcium, scale copper, scale zinc, and bone manganese, which suggested that levels of these minerals in excreta from tilapia-rearing systems could be reduced by substituting low-oligosaccharide/high-available-phosphorus soybean meal for normal soybean meal. Growth, survival, and performance, as measured by the feed efficiency ratio, were not affected by the type of soybean utilized. The results of this study indicated that Illinois' growing aquaculture industry and the citizens of Illinois could benefit from the pollution-reducing effects of low-oligosaccharide/high-available-phosphorus soybean meal.

Kerry W. Tudor, Agriculture

College of Applied Science and Technology

Illinois State University

Alternative, Flexible Pollination Systems for Sustainable Fruit Production

The purpose of this project was to develop and test management strategies and alternative systems to ensure continued pollination of Illinois fruits and vegetables. Specific goals were to (1) develop and test strategies needed to have the optimal percentage of small honeybee colonies surviving and reaching pollination strength in time for pollination of apples; (2) provide economic analysis that determines the economic viability of alternative management strategies; and (3) develop an operation guide and a business plan for dissemination to Illinois beekeepers and other interested parties.

As a result of the project, data were obtained that can be used to increase the capability of Illinois beekeepers to provide pollination services. The data have been incorporated into the publication *Guide to Use of Small Colonies in Pollination*. Information was also collected and case studies prepared on a range of beekeeping operations, from 30 to 8,000 colonies. A *Beekeeping Business Plan Workbook* was developed with a team of small business development specialists at SIU Carbondale, and 300 copies were printed for dissemination to Illinois beekeepers. According to the editors of the two major beekeeping trade journals, there is no other business plan for beekeepers of comparable detail in the country.

A C-FAR External Competitive Grants project

Stewart Jacobson, Institute for Legal, Administrative and Policy Studies

University of Illinois at Springfield

Harnessing the Benefits of an Apple Scab Resistance Gene

The goal of this research was to complete isolating and cloning of the apple scab resistance gene, *Vf*, and transfer it into commercial apple cultivars. These genetically enhanced apples can then be grown with minimal chemical sprays yet retain their commercial adaptability and acceptance. Using a map-based positional cloning strategy, the *Vf* gene for scab resistance was isolated from an apple bacterial artificial chromosome (BAC) library. A total of four *Vf* gene paralogs were present within the *Vf* locus;

these were characterized for their functionality, sequenced, and used for developing various constructs in a plant cloning vector. These various *Vfa* paralogs were then introduced into Gala, M26, and McIntosh apple cultivars. These are currently being analyzed for their resistance to apple scab inoculation.

A C-FAR External Competitive Grants project

Schuyler S. Korban, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Increasing the Genetic Diversity of Illinois Horseradish

The purpose of this research is to revitalize the horseradish germplasm due to a decline in disease resistance and yield over past decades. The first goal was to characterize the Illinois Horseradish Germplasm Collection with the aid of DNA markers. The history and reliability of lineage of this collection is unknown and not well tested. Therefore, it was necessary to identify what amount of genetic diversity is available that can contribute to yield and disease resistance. The second goal was to identify a core collection and develop crossing blocks to capture genetic variation from diverse sources. Lastly, researchers will provide tissue-cultured plants from their initial hybrids for field testing in production fields. The goals of this research are (1) to identify the genetic diversity of the Illinois collection in efforts to use available variation or identify the need for collections from worldwide sources; (2) to create a core crossing block from which new hybrids can be used in horseradish production; and (3) to bring Illinois horseradish production once again to the forefront and dominant producers in the world market.

A C-FAR External Competitive Grants project

Andrew M. Hamblin, Robert M. Skirvin, Mosbah M. Kushad, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Selectable Marker System for Sesquiterpene Biosynthesis and Application for Insect Pest Control in Tomatoes and Sweet Corn

The sesquiterpene carboxylic acids (SCA) α-santalenoic, α-bergamotenoic, and β-bergamotenoic acids synthesized in leaf trichomes of a wild tomato species confer resistance to the corn earworm *(Helicoverpa zea*) and the beet armyworm (*Spodopter exiqua*), major insect pests of sweet corn and tomatoes in Illinois. β-bergamotenoic acid has also been shown to act as an attractant and oviposition stimulant for female *H. zea* moths. The combination of biological activities associated with these compounds provides the rationale for research to investigate potential earworm control strategies in sweet corn and tomato production systems. Specifically, researchers have identified and tagged the genes that regulate SCA biosynthesis from the wild tomato (*Lycopersicon hirsutum*) accession, LA 1777, to facilitate their introgression into cultivated tomato *(L. esculentum)* germplasm. To accomplish this goal, researchers utilized a functional genomics approach coupled with bulk segregant analysis to identify, construct, and test PCR-based primer combinations that generate polymorphic DNA markers associated with SCA biosynthesis in tomatoes. These markers will then be applied to segregating populations derived from crosses between tomato cultivars and LA 1777 to develop commercial-quality germplasm with enhanced insect resistance more rapidly and efficiently. A second goal of this project was to investigate the potential efficacy of SCA as a combined attractant/botanical insecticide for earworm control in sweet corn and tomato field plots. Development of a more selective insecticide that is toxic to a narrower range of target pests is of significant value in these production systems. In addition, there is a great need for an effective and acceptable earworm control practice in organic sweet corn.

The compounds associated with insect resistance (SCA) were introduced into three insect-susceptible tomatoes (cultivars 'Chico III' and E6203 and *L. hirsutum* LA 1033) by hybridization with resistant LA 1777. F2 and backcross progeny were created from the hybrids to generate genetic segregation for SCA biosynthesis and to measure SCA levels in the plants. Randomly generated Amplified Fragment Length Polymorphisms (AFLP) and candidate gene sequences for SCA biosynthesis were used to establish marker associations (chromosomal linkage) with presence and high amounts of SCA in the progeny plants of the populations. Three AFLP markers were consistently associated with high levels of SCA across the populations. These markers segregated independently suggesting linkage to three different genes associated with SCA biosynthesis. The candidate gene strategy found five unique sequence groups (putatively encoding sesquiterpene synthase, sesquiterpene dehydrogenase, germacrene

synthesis, aldehyde dehydrogenase, and a P450) from an LA 1777 trichome expression library, putatively associated with SCA biosynthesis and modification. The AFLP and candidate gene sequences offer utility in selection for breeders, and for gene sequencing and cloning for advance studies into SCA biosynthesis. These markers are currently being evaluated as tools for marker-assisted selection to develop cultivated tomatoes with improved insect resistance.

Greenhouse and field experiments were conducted to determine whether SCA applied to corn and tomato plants could act as botanical insecticides. Field cage studies indicated that two wild tomato accessions (one that synthesized SCA and one that did not) were preferred by female moths as sites for oviposition over a cultivar. Female moth attraction to SCA may account for the observation that greater numbers of larvae and associated fruit damage were observed on sweet corn applied with SCA on silks. Larvae on tomato leaves treated with SCA showed significantly reduced survival.

John A. Juvik, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Wines, Grapes, Tourism, and Rural Economic Development: Lessons Learned from the Shawnee Hills Wine Trail

Business and community leaders in southern Illinois have identified vineyards and wineries as a component of tourism and have recognized that the grape and wine industry contributes to rural economic development. However, no market research studies have been conducted to investigate the characteristics of winery visitors. Additionally, consumer studies researching the winery characteristics that lead to wine purchasing has not been completed. Investigating the characteristics of the wine tourist and reasons for purchasing wines could lead to a more defined marketing and management strategy, resulting in increased consumer direct wine sales and wine production.

Researchers found that 56% (n = 671) of winery visitors were from southern Illinois, approximately 41% (n = 490) were U.S. residents outside of southern Illinois, while 3.2% (n = 38) were international visitors. Approximately 30% (n = 361) were between the ages 21 and 30, 42% (n = 504) between ages 31 and 50, and 25% (n = 295) were over 51. Forty-nine percent (n = 583) were male, while 51% (n = 616) were female. Sixty-eight percent (n = 814) had attained college degrees, and 57% (n = 682) had combined household incomes above $50,000. Approximately 44% (n = 528) of the sample were not residents of southern Illinois, therefore considered visitors from outside the region. Eighty percent (n = 421) of the visitors outside the region were returning visitors, and 57% (n = 302) were visiting for three or more days. Sixty-one percent (n = 324) of the nonresident visitors indicated they intended to spend $30 or more on wine during their visit.

Non-southern Illinois visitors (n = 528) were queried about their demand for tourist facilities, events or attractions. In rank order, the top five facilities, events, or attractions in demand were: restaurants, Shawnee National Forest, state parks/natural attractions/other federal lands, antique/craft shops, and shopping malls. Regression was conducted utilizing length of stay, previous visits, age, travel party size, household income, gender, and education level as predictors of wine spending intentions. Data indicated household income and age predicted how much money visitors intended to spend on wine. Results revealed that restaurants, the national forest, state parks, antique and craft shops, and shopping malls/centers were the top five attractions. Implications from the research depict a targeted marketing approach to more affluent and older consumers. Lastly, the southern Illinois wineries should consider collaborative promotional campaigns with leading attractions cited by winery visitors.

John Salazar, Animal Science, Food and Nutrition

Roger J. Beck, Agribusiness Economics

College of Agricultural Sciences

Southern Illinois University at Carbondale

Rural Community and Agricultural Related Studies

Diversified Farm

This project employs a highly holistic approach to small-farm management, with a focus on the health of crops, people, and land. Attention to the interactions and intersections of crops, people, and land is key to building an understanding of the biotic community that underlies all aspects of the Diversified Farm. The closer the biotic community is to biological balance, the fewer inputs are required. Increased biological balance is important in a holistic approach to farm management, but there are other components as well: (1) The process of farm management and the role that the farm plays in the community should enrich the lives of those who become associated with it; (2) the types of crops that are planted and the manner in which they are planted should have aesthetic value; (3) individual experiences of the farm should be sensory-rich; (4) the farm should be colorful, fragrant, tranquil, and stimulating; and (5) the farm should engage the worker and the visitor, provide a tool for learning and teaching, and be a place to experiment and experience. The Diversified Farm is intended to exemplify this important and inherent interconnectedness of crops, people, and land. Allerton Farm No. 2 was chosen as an appropriate site for the project because it is representative of small farms found in Illinois, as well as throughout much of the Midwest.

In this first phase of the project, a 3-acre plot was fenced as a deer exclosure. The fence was constructed using 12-foot galvanized pipe set ten feet on center. Chicken wire was trenched 2 feet below ground and run 2 feet above ground and attached to the pipe. Above the chicken wire, high-tensile wire was strung every 6 inches and electrified. No mammals were found within the exclosure at any time. Plastic owls were used to deter birds. Raised beds and drip irrigation were put under plastic mulch. An assortment of heirloom vegetables was planted. Also, native wildflower plugs were planted for seed and cut flowers in 2004; harvested gourds will be dried and sold in 2004; and winterberry and pussy willows were planted for craft markets, to begin to be harvested in 2005. The choice of plants was made on the basis of availability, harvest times, aesthetic value, and market value. The goal was to have something to harvest and sell nearly year-round.

The broad diversity of vegetables was important, though heirloom vegetables were not hardy. Particularly marketable were moon and stars watermelon, honey rock cantaloupe, and all varieties of tomatoes. Brittle wax beans sold worst. Pumpkins ripened too early for fall sale; sweet corn was planted too late and didn't produce sellable fruit; and cantaloupe ripened very fast and at the same time, indicating that it should be planted in stages.

A C-FAR External Competitive Grants project

David Schejbal, Office of Continuing Education

University of Illinois at Urbana-Champaign

Examination of Entrepreneurial Curriculum at Illinois Community Colleges

A general reduction of economic development and employment coupled with the low survival rate of small business are among the problems facing today's rural communities. A report from the Corporation for Enterprise Development lowered Illinois' entrepreneurial energy from a grade B in 2000 to a grade C in 2001. New-company formation is one of the principal factors used by the study, and Illinois ranked 45th in new companies created. Illinois' community colleges are a position to provide the necessary educational background to improve the success rate for those students undertaking the challenge of starting their own businesses. This study evaluated the business curriculum at 31 community colleges in an effort to determine the extent of curricular focus on entrepreneurial course offerings.

This study found that Illinois community colleges in general offer a business curriculum that adequately covers such programs as accounting, office careers and technology systems, marketing, and management. However, it was found that Illinois community colleges offer relatively little preparation in entrepreneurship careers. Only four community colleges offer a formal program in entrepreneurial studies, and three of those community colleges were located in urban areas. Nearly all the community colleges surveyed offer courses in managerial, financial, cost, and tax accounting. Nearly all community colleges offered business law, business math, and business communications. However, only nine (29 %) of the colleges surveyed offered a course in entrepreneurship, only eight (25 %) offered a course in marketing for small businesses, and only seven (22 %) offered a course in small-business accounting.

Rick C. Whitacre, Agriculture

College of Applied Science and Technology

Illinois State University

The Development and Testing of an Apparatus to Assist Rescuers During Extrication of a Victim Who Is Partially Engulfed in Grain

The goal of this research is to design and field-test an engulfment safety ring (ESR) system that is compatible with farm-sized bins and could be used to protect partially engulfed victims during extrication from grain. Preliminary development of the rescue tube dates back to the late 1980s; however, existing designs were not found to be compatible with on-farm engulfment circumstances. Development of a tube targeted for use in farm grains began prior to this project, but significant field-testing had not occurred. From findings resulting from this project, several modifications were made to the existing design of the rescue tube: (1) The coupling system was altered to decrease the gap between the tube section and the coupler; (2) all hardware, connectors, and hinges were changed from brass and aluminum to steel to allow parts to be removed from bins with a magnet; and (3) handles were placed in the tube section in order to increase ease of use.

Although injection molding has been considered as a method for tube manufacturing, it was determined that an investment of more than $100,000 would be necessary to initiate this process. A more economical alternative that was considered included shop-building the devices at Illinois State University. This is feasible because of simplistic design and construction. It is perceived that the production of the rescue tube must be low-cost to be affordable by rural rescuers. With additional non-C-FAR funds, work on the rescue tube was expanded to include safety training workshops, a survey of Ohio corn producers, demonstration events, and the investigation of multi-state applications.

Douglas Kingman, Agriculture

College of Applied Science and Technology

Illinois State University

The Illinois Rural Families Program: Promoting Rural Youth Retention

The continued out-migration of well-educated youth threatens the vitality and viability of rural communities nationwide. Rural communities are thus challenged to find ways to retain young people who will contribute to their future. In light of this challenge, the Illinois Rural Families Program (IRFP) conducted four research projects to identify factors that can help rural communities nurture, retain, and attract competent young people.

Self-report measures of rural high-school students' civic engagement and ties to their home communities indicated that both their community ties and their civic engagement were positively correlated with desires to live in their home communities as adults. One important caveat was that students who rated high on civic engagement and community ties measures but who also had higher academic achievement and education and career aspirations expressed a conflict between their career and educational goals and their desire to live in their home communities as adults. These students often felt that their desire to live in their home communities as adults would hinder their career and educational goals. Qualitative analyses of interviews conducted with leaders of a rural community confirmed and expanded on some of these findings. According to these community leaders, factors contributing to youth out-migration include communitywide encouragement for youth to leave town to seek higher education, poor job prospects within the community, communitywide resistance to changing the status quo and to accepting new economic opportunities, and a lack of awareness on the part of youth as to how they might fulfill meaningful roles in the community as adults. Based on these results, a series of recommendations were provided to the community to help them bolster the retention of talented youth and strengthen youth who are likely to stay in the community. These included creating job and leadership skills training and meaningful employment experiences for high-school students; expanding the options for meaningful summer employment for college students; expanding the options for full-time employment post high-school and college; and finally, accepting change as a necessary means for maximizing youth development, retaining capable youth, and possibly attracting talented, educated youth back to their home communities.

Analyses of the focus-group interviews conducted with 30 university students again confirmed earlier findings in that they suggested that university students were more likely to consider returning to their rural home community after graduation if they saw their community faring well economically, as well as having adequate opportunities for supporting a rich family life (including child care and social/recreational offerings). Analyses of the responses to the 222 questionnaires collected from college students over the course of a two-year time period revealed that social factors and attachment to community were significantly correlated with students' desires to live in their hometowns as adults. Students who

expressed a desire to live in their hometowns as adults were those who visited their hometowns more frequently, who viewed friends and parents as strong influences, who shared their parents' ideas about their own future residence and career choices, who felt loyal to their home community, and who thought there were adequate opportunities to develop rich friendship relationships in their hometowns. Although these students rated economic factors as the most important factor in determining their future and long-term residential plans in general, economic factors were not significantly correlated with students' desires to return to their hometowns to live as adults.

Forty-seven 7- to 12-year-old children and their farming parents responded to questions about the child's involvement in farm work, the father's wishes concerning the child's future in farming, the child's perceptions of their relationship with parents, and the child's perceptions of parents' worry about the farm. Except for the father's wishes concerning the child's future in farming, all of the other factors were associated with the children's plans to farm in the future. The results obtained with these younger children were consistent with the findings obtained with university students in underscoring significant associations between one's relationship with one's family and one's future desires and goals.

Laurie F. Kramer, Joseph H. Pleck,
Human and Community Development

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Natural Resources

Fertilizer Nitrogen Management to Optimize Water Quality

The use of nitrogen fertilizers in Illinois corn production is widespread because nitrogen is required for plant growth, and most soils do not have sufficient capacity to supply enough nitrogen. The importance of proper nitrogen management as it relates to yield is becoming more critical as environmental concerns about excessive nitrogen fertilization intensify. Lake Bloomington is a major source of drinking water for area residents of Bloomington, Illinois, and has a history of nitrate concentrations that exceed 10 ppm. The primary objective of this study is to ascertain the influence of corn fertilizer nitrogen management upon subsequent water quality of Lake Bloomington. The knowledge gained from this study will aid in developing recommendations that deal with fertility and cultural practices that promote the safe stewardship of Illinois farmland, while maintaining high-quality drinking water.

A field nitrogen (N) study evaluated six agricultural fertilizer management techniques for nitrate-N release via tile drainage; 0 lb N/acre fertilizer N (control), 175 lb N/acre fall-applied anhydrous ammonia (AA), 175 lb N/acre fall-applied AA + N-Serve, 125 lb N/acre spring-applied AA+N-Serve, 175 lb N/acre pre-plant spring-applied AA, and 140 lb N/ acre sidedressed AA. Overall, the application of AA in the spring produced similar grain yields to that of the fall-applied treatments. The application of fall-applied AA resulted in tile water that contained more NO_3-N as compared to the same rate of fertilizer N applied in the spring. In addition, spring-applied AA increased plant N accumulation. Thus, one method to reduce NO_3-N of water entering Lake Bloomington is to encourage the application of fertilizer N in the spring. These results need to be verified over a number of years to assess seasonal variability patterns.

Kenneth D. Smiciklas, Aaron S. Moore, Agriculture

College of Applied Science and Technology

Illinois State University

Modeling Nitrogen Dynamics at the Watershed Scale

The purpose of this project was to test the accuracy of relatively simple watershed simulation models that estimate the seasonal variation of nitrate concentrations in streams and rivers based on representative watershed land use, fertilizer sales, and environmental variables such as soil properties, precipitation, and temperature. Such simulation models could be useful as educational and watershed management tools.

After reviewing the literature on several different models, researchers focused attention on the ADAPT model, which has been used to simulate field and watershed processes in Ohio and Minnesota. This model was designed to simulate hydrology, nutrient, sediment, and pesticide loss from agricultural fields with tile drainage. It was found that the model could simulate the annual and monthly hydrology of central Illinois watersheds reasonably well after parameters such as hydraulic conductivity were calibrated so that simulations matched measured stream flow. Riverine nitrate concentrations and mass flows could also be simulated reasonably well when in-field denitrification was used as a calibration parameter and in-stream denitrification was estimated with regression analysis. However, a nitrogen mass balance revealed that the model tends to grossly overestimate biological N fixation in soybeans. This means that in order to simulate the riverine nitrate fluxes accurately, other process, such as in-field denitrification, is probably simulated inaccurately to compensate for the overestimate in biological N fixation. Consequently, researchers do not recommend using the current version of this model for assessing the impacts of alternative nitrogen management practices in central Illinois. The data on weather, soils, crop production, river discharge, and nitrate concentrations that were assembled to test the ADAPT model are currently being used to test other models, such as the SWAT model. Furthermore, the modeling results obtained suggest that the uniformity of the landscape in central Illinois is conducive to simulation approaches that aggregate large spatial areas (approximately 200 square miles). In other words, high-resolution data on soils and management may not be needed for accurate simulation of water and nitrate fluxes in large watersheds in central Illinois, where soils and land-use are highly uniform.

A C-FAR External Competitive Grants project

Gregory F. McIsaac, M. Jean Sogbedji, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Newfound Atrazine Resistance in Waterhemp

Atrazine is an economical and effective herbicide and is used on the majority of cornfields in Illinois. Some weeds, however, have evolved resistance to atrazine, as well as to other herbicides that have the same target site in plants, the D1 protein. For the majority of these resistant plants, resistance is due to a mutation in the gene encoding the D1 protein. A few years ago, several populations of waterhemp were identified in Illinois that apparently had a different

mechanism of atrazine resistance. The mechanism of resistance to a particular herbicide can influence how the resistance is spread within and among weed populations, the magnitude of resistance, and whether resistance to related herbicides will also be expressed. Therefore, characterization of this new atrazine-resistance mechanism was needed to make informed decisions on how to manage atrazine-resistant waterhemp populations effectively.

From a set of crosses involving resistant and sensitive plants, researchers determined that resistance is nuclear-inherited, in contrast to maternal inheritance that is observed for triazine resistance due to an altered D1 protein. An important implication of this finding is that the newfound resistance may spread faster than the altered-target-site resistance, because the newfound resistance is transmitted by both pollen and seed (rather than by just seed). Plants with the new atrazine resistance mechanism are resistant to other triazine herbicides, such as cyanazine and simazine, but not to other classes of herbicides that bind the D1 protein. Thus, metribuzin (a D1 protein-inhibiting herbicide that can be used in corn and soybean) is effective on waterhemp with the newfound triazine resistance mechanism, whereas this herbicide is not effective on waterhemp containing the altered D1 mechanism. When atrazine is applied as a foliar application, plants with the new resistance mechanism can tolerate about 20-fold more atrazine than sensitive plants. In contrast, for soil-applied, preemergence treatments, resistance is less pronounced. Consequently, atrazine can be used as a preemergence treatment to provide at least partial control of waterhemp populations containing the new resistance mechanism. For waterhemp populations containing the altered D1 resistance mechanism, atrazine is not effective as a postemergence or a preemergence treatment. Results of this research indicate that the new resistance is likely to be due to an enhanced ability of the plants to degrade triazine herbicides metabolically. This research revealed several different properties between the new triazine resistance and the typical target-site triazine resistance, including differences in cross resistance (resistance to related herbicides), the magnitude of resistance, and in how the resistance is inherited. Since both types of resistance are present among waterhemp populations, knowledge of the two mechanisms will help to manage this troublesome weed species effectively.

Patrick J. Tranel, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

On-line Hydrologic Model for Watershed Management

The goal of this project was to develop a web-based model to be used by watershed planning groups in managing watersheds. Web-based tools were to be developed that allowed those interested to identify a given area and provide information about various parameters of interest. As a result of this research, a web-based tool was developed that can be used to identify an area and produce a report that list various data-points of interest from National Soil Survey Geographic (SURGO) files. Data that can be identified include soil types, erosion measures, and slopes. The model implements Revised Universal Soil Loss Equation (RUSLE) for the identified area. This new watershed management tool is available on the Resource Management Mapping Service website at **http://space1.itcs.uiuc.edu/website/rmms**. University of Illinois Extension meetings using the tool have been conducted and will be conducted during winter 2004.

A C-FAR External Competitive Grants project

Gary D. Schnitkey, Agricultural and Consumer Economics

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Genotoxic Synergy between OP Insecticides and Environmental Arylamines

Genotoxic (DNA-damaging) synergy is the interaction of two or more agents that causes an increase in DNA damage, greater than the sum of their individual genotoxic effects. Paraoxon is the active metabolite of the organophosphorus ester (OP) insecticide parathion. In the past, researchers discovered that paraoxon and several members of a class of compounds called aromatic amines interact synergistically to generate an enhanced mutagenic response in *Salmonella typhimurium* and enhanced DNA damage in human lymphocytes. The primary goal of this research was to investigate several agriculturally relevant OP insecticides, or their oxon metabolites, with specific environmental or dietary aromatic amines to determine whether the mutagenic synergy is a specific or a general phenomenon.

Researchers discovered that the mutagenicity of three aromatic amines was enhanced in the presence of specific OP insecticides. The agents studied included the OP insecticides ethyl parathion, methyl parathion, malathion, and chlorpyrifos and the insecticide metabolites methyl paraoxon and malaoxon. This mutagenic synergy was expressed in *S. typhimurium* strain YG1024. Mammalian microsomal activation was required for the dietary amines to express mutagenic synergy.

Researchers demonstrated that mutagenic synergy is not a limited phenomenon but is exhibited by several OP insecticides in combination with chemicals that have wide human exposure. A rapid assay was developed to measure chronic cytotoxicity using mammalian cells to evaluate the toxicity of the OP insecticides. All of the agents displayed a significant toxic response. There was significant synergistic cytotoxicity between the active aromatic amine 2-acetoxyacetylamino fluorene (2AAAF) and chlorpyrifos and also between 2AAAF and malathion. The mammalian cell microplate cytotoxicity assay is well suited for the analysis of pesticides and other environmental contaminants. It is relatively rapid, highly sensitive, and especially useful for analyzing test materials where the quantity is limited due to expense or scarcity. The cytotoxicity assay is also useful in determining toxic synergistic effects.

Elizabeth D. Wagner, Michael J. Plewa, Crop Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Influence of Non-transgenic Engineered Plants on Phytoremediation of Crude Oil-Contaminated Soil

As long as crude oil production continues in Illinois, there will be accidental spills. Effective and inexpensive cleanup methods are needed to minimize harmful effects to humans and wildlife and restore soil productivity. The objective of this study was to identify plants capable of growing in crude oil-contaminated soil. Plants may enhance remediation of contaminated soil, reducing the risk of further environmental harm, especially to humans and wildlife. Additionally, these soils may be more quickly returned to agricultural, industrial, or recreational uses.

Six plant species—corn, perennial ryegrass, wheat, alfalfa, hairy vetch, and soybean—were evaluated to determine their suitability to be grown in soil contaminated with up to 10% crude oil. Seeding emergence, plant height, and root and shoot biomass were measured to identify the plant with the greatest potential to survive in crude oil-contaminated soil and one that therefore has potential to enhance remediation of such contaminated soils. Corn and soybean consistently had the highest percent seedling emergence, greatest plant height, and root and shoot biomass and were recommended for further study to determine their potential to enhance remediation of crude oil-contaminated soil. These recommendations are currently being investigated in a separately funded project.

Robert L. Rhykerd, Kenneth D. Smiciklas, Agriculture

College of Applied Science and Technology

Illinois State University

Enhanced Plant Production in Interior Plantscapes with Biological Control Agents

The goal of this research was to assess the compatibility of commonly used reduced-risk insecticides with the citrus mealybug parasitoid, *Leptomastix dactylopii*, under greenhouse conditions by evaluating the effects these materials have on survival (longevity), attack rate, and behavior. This will result in relying less on potentially harmful pesticides and more on biological control to manage mealybugs in interior plantscapes.

This research has shown that certain insecticides are compatible with biological control agents whereas others are not. For example, researchers have clearly demonstrated that the insect growth regulators pyriproxyfen and azadirachtin are compatible with *Leptomastix dactylopii,* whereas kinoprene is not compatible. These results affect greenhouse producers, conservatory curators, and interiorscapers that use insect growth regulators to manage mealybugs. This will lead to a more environmentally friendly method, with less reliance on pesticides, of managing pests such as mealybugs, in turn reducing worker exposure to pesticide residues and minimizing the potential for allergic reactions.

Raymond A. Cloyd, Natural Resources and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Robert N. Wiedenmann, Illinois Natural History Survey

C-FAR-Funded Projects Receiving Extensions

Researchers for the following projects were granted no-cost extensions to complete the proposed research. No-cost extension requests are granted when unforeseen circumstances arise. While the due dates for these projects have been extended, no additional funds were allocated for research. These projects will be reported on after their new maturity dates in 2004.

Advanced but Affordable Composites from Agricultural By-Products

FY02 External Competitive Grants Program
Vivak M. Malhotra, Physics
Southern Illinois University at Carbondale

Agricultural Pests and Pesticides: Backgrounds for Decision Making

FY00 UIUC Internal Program
Richard A. Weinzierl, Crop Sciences
University of Illinois at Urbana-Champaign

An Evaluation of the Safety of a Genetically Modified Corn: A Porcine Model

FY02 External Competitive Grants Program
Gary A. Apgar, Animal Science, Food and Nutrition
Southern Illinois University at Carbondale

An Integrated Approach to Reduce Pathogen and Nutrients in Runoff from Animal Production Systems

FY01 UIUC Internal Program
Prasanta K. Kalita, Agricultural and Biological Engineering
University of Illinois at Champaign-Urbana

Assessing the Role of Health Benefits in the Consumption of Soy-Based Foods

FY02 External Competitive Grants Program
Wanki Moon, Agribusiness Economics
Southern Illinois University at Carbondale

Biomarkers to Study Synergy Among Phytochemicals in Prevention of Cancer by AFB

FY02 External Competitive Grants Program
Matthew A. Wallig, Veterinary Pathobiology
University of Illinois at Urbana-Champaign

Continuous Production of Butanol from Corn and Recovery by Gas Stripping

FY01 UIUC Internal Program
Nasib Qureshi, National Center for Agricultural Utilization Research
United States Department of Agriculture

Determining the CLA Production Capacity of Ruminant Diets

FY02 External Competitive Grants Program
Kenneth E. Griswold, Animal Science, Food and Nutrition
Southern Illinois University at Carbondale

Dietary Genistein and NMU-Induced Tumor Growth in a Postmenopausal Animal Model

FY01 UIUC Internal Program
William G. Helferich, Food Science and Human Nutrition
University of Illinois at Urbana-Champaign

Economics of Grazing Stocker Cattle as a Sustainable Alternative to Row Crops

FY02 External Competitive Grants Program
Kenneth O. Nimrick, Agriculture
Western Illinois University

Effects of Extruded Fiber on Digestibility and Gastrointestinal Characteristics
FY01 UIUC Internal Program
Neal R. Merchen, Animal Sciences
University of Illinois at Urbana-Champaign

Effects of Soy Protein Feeding on Diabetic Nephropathy
FY00 UIUC Internal Program
John W. Erdman, Food Science and Human Nutrition
University of Illinois at Urbana-Champaign

Enhancing Value of Corn by Fermentation to Butanol and Removal by Extraction
FY02 External Competitive Grants Program
Nasib Qureshi, National Center for Agricultural Utilization Research
United States Department of Agriculture

Ethanol Policy in the Presence of Other Economic Distortions: Is a Win-Win Policy Change Possible?
FY02 UIUC Internal Program
David S. Bullock, Agricultural and Consumer Economics
University of Illinois at Urbana-Champaign

Evaluation of BT Toxin Persistence in Soils
FY02 External Competitive Grants Program
Michelle M. Wander, Natural Resources and Environmental Sciences
University of Illinois at Urbana-Champaign

Hydrologic and Water Quality Consequences of Alternative Crop Management
FY02 External Competitive Grants Program
Gregory F. McIsaac, Natural Resources and Environmental Sciences
University of Illinois at Urbana-Champaign

Increase Capability to Measure and Modify Soybean Seed Composition and Functionality in Foods
FY02 UIUC Internal Program
Marvin R. Paulsen, Agricultural and Biological Engineering
University of Illinois at Urbana-Champaign

Increasing Wool Value through Producer Cooperatives and Niche Markets
FY02 External Competitive Grants Program
Dean R. Oswald, University of Illinois Extension, Macomb Center

Isolation and Characterization of Agronomic Antimutagens and Human Cancer Cell Growth Suppressors
FY01 UIUC Internal Program
Michael J. Plewa, Crop Sciences
University of Illinois at Urbana-Champaign

Mass Media Frames and Public Understanding of Agricultural Biotechnology
FY02 UIUC Internal Program
Napoleon K. Juanillo, Jr., Human and Community Development
University of Illinois at Urbana-Champaign

Measurement of 3-Dimensional Airborne Particulate Spatial Distribution in Indoor Environments
FY01 UIUC Internal Program
Yuanhui H. Zhang, Agricultural and Biological Engineering
University of Illinois at Urbana-Champaign

Meeting Community Standards to Improve Siting of Livestock Facilities
FY03 External Competitive Grants Program
Peter D. Goldsmith, Agricultural and Consumer Economics
University of Illinois at Urbana-Champaign

Molecular Pathogen Detection for Herd Health and Food Safety
FY02 UIUC Internal Program
Gail Scherba, Veterinary Pathobiology
University of Illinois at Urbana-Champaign

Probiotics as an Alternative to Antibiotics in the Diet of Weaning Pigs
FY02 External Competitive Grants Program
Roderick I. Mackie, Animal Sciences
University of Illinois at Urbana-Champaign

Fiscal Year 2004:

Internal Competitive Grants Programs

The FY04 internal competitive grant programs at the University of Illinois at Urbana-Champaign (UIUC), Southern Illinois University at Carbondale (SIUC), Illinois State University (ISU), and Western Illinois University (WIU) focused primarily on supporting ongoing research initiatives. At UIUC, this included Sentinel Program projects. SIUC funded the continuation of a selection of its multiple-year initiatives. ISU and WIU funded the following projects in FY04.

FY04 Projects	Principal Investigator
Research Focus: Expanding Agricultural Markets	
Consumer Perception of Irradiated Ground Beef Products	Aslihan D. Spaulding, ISU
Survey Characterization of the Illinois Lamb Industry in an Effort to Improve Marketing Opportunities	Bryon R. Wiegand, ISU
Research Focus: Rural Economic Development	
Alternative Crops Breeding and Production Program for Western Illinois	Winthrop B. Phippen, WIU
E-Commerce and Internet Use by Rural and Urban Small Businesses in Illinois	Rick C. Whitacre, ISU
Implementation of ProStar: A Web-enabled Agribusiness Management Simulator of Farm Supply Dealerships	Patrick D. O'Rourke, ISU
Measurement of the Wind Resource at the ISU Farm at Lexington	Douglas Kingman, ISU
Using Worms for Processing Agricultural Biosolids into High Value Enviro-socially Acceptable Potting Soil Amendments (Year Two)	Gary Bachman, ISU
Research Focus: Agricultural Production Systems	
Efficacy of Vacuum Bag Ensiling of Wet Distillers Grain for Beef Cows	Paul M. Walker, ISU
The Role of Cover Crops in Supplying Nitrogen and Controlling Weeds in Organic Crop Production	Gerald T. Vigue, WIU
Research Focus: Natural Resources	
Degradation of Phytate and Lectins in Soybean Meal by Processing	Kerry W. Tudor, ISU
Remediation of Biodiesel Contaminated Soil	Robert L. Rhykerd, ISU
Utilizing Compost or Processed Manure as a Soil Amendment for Corn and Soybean Production	Ken D. Smiciklas, ISU

Fiscal Year 2004:
External Competitive Grants Program

In accordance with the Food and Agriculture Research Act, the C-FAR appropriation's enabling legislation, a minimum of 15% of the total C-FAR appropriation (minus fees) is dedicated to an external competitive grants program. This program enabled support to the following projects in FY04.

FY04 Projects	Principal Investigator
Research Focus: Expanding Agricultural Markets	
Effect of Milling Parameters on Fiber and Its Removal from the DDGS	Vijay Singh, UIUC
Research Focus: Rural Economic Development	
Development of High-Lauric-Acid Cuphea Varieties	Winthrop B. Phippen, WIU
Research Focus: Agricultural Production Systems	
Strategies for Management of Vegetable Diseases in Organic and Traditional Farms	Mohammad Babadoost, UIUC
Research Focus: Human Nutrition & Food Safety	
Evaluating the Beneficial Health Effects of Conjugated Linoleic Acids	William J. Banz, SIUC
High Quality Protein Enhances Diet Control of Type 2 Diabetes	Donald K. Layman, UIUC
Research Focus: Natural Resources	
Identification of the Sources of Nitrate in the Upper Illinois River	Samuel V. Panno, Illinois State Geological Survey

Fiscal Year 2004:

Strategic Research Initiatives

The C-FAR Strategic Research Initiatives provide a targeted, multidisciplinary, and multi-institutional approach to addressing major issues and concerns of the Illinois food and agriculture industry and consumers. The SRI research portfolio includes the following initiatives in FY04.

FY04 Projects	Principal Investigator
Biomass Energy Crops for Power and Heat Generation in Illinois: Diversifying Cropping, Improving Energy Security, and Benefiting the Environment	
Agronomic Trials	Stephen P. Long, UIUC
Water Resource Implications	Mark B. David, UIUC
Miscanthus Breeding and Improvement	Andrew M. Hamblin, UIUC
Economic Analyses	Madhu Khanna, UIUC
Social Acceptability	Anne Heinz Silvis, UIUC
Harvesting Technology	Lei Tian, UIUC
Propagating and Eradicating Miscanthus x giganteus	Thomas B. Voigt, UIUC
Carbon Sequestration and Greenhouse Gas Accounting	Michelle M. Wander, UIUC
Genetic Engineering	Jack M. Widholm, UIUC
Bioconversion	Yuanhui Zhang, UIUC
Illinois First Livestock Focus Initiative	
Technology Development	Michael F. Hutjens, UIUC
Livestock Facility Siting in Illinois	Peter D. Goldsmith, UIUC
Using Illinois By-Product Feeds in Livestock Feeding Program	Larry L. Berger, UIUC
Animal Identification for Enhanced Food Quality and Monitoring Livestock Health	Geoffrey L. Dahl, UIUC
Pasture Based Forage Systems to Sustain Illinois Livestock Producers	Edward N. Ballard, UIUC
Water Quality with a Focus on Total Maximum Daily Loads	
SRI Leader Support and Coordination	George F. Czapar, University of Illinois Extension
Seasonal Dynamics of Nutrients, Algae and Dissolved Oxygen in Agriculturally Dominated Headwater Streams	William L. Perry, ISU
Effects of Phosphorus Mediated through Algal Biomass in Illinois Streams	Walter Hill, Illinois Natural History Survey
Spatial and Temporal Relationships between Biotic Integrity of Illinois Streams, Dissolved Oxygen, and Nutrients (Including Controls on Dissolved Reactive and Particulate Phosphorus)	Mark B. David, UIUC
The Impact of Sediments on the Potential Bioavailability of Phosphorus in Illinois Streams	Michael L. Machesky, Illinois State Water Survey

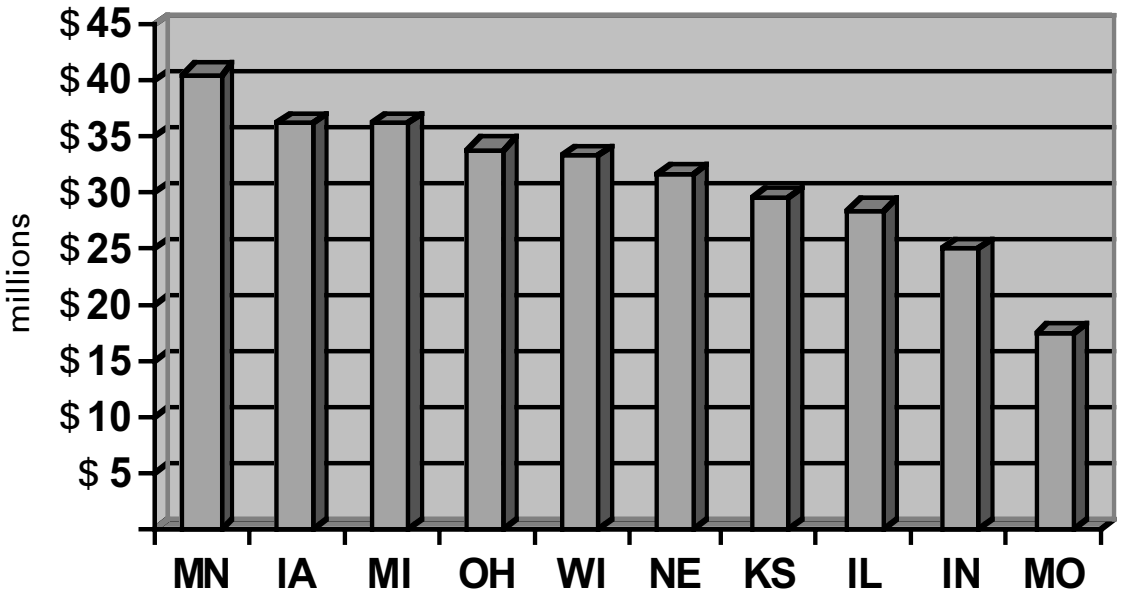
Importance of the C-FAR Investment

The C-FAR appropriation, provided by the State of Illinois, is the core base of funding for conducting publicly funded food and agricultural research in Illinois. Additional funds are appropriated to universities by way of the Illinois Board of Higher Education, but the vast majority of these funds are utilized for faculty salaries, not to actually carry out research. Researchers seek funds from various agencies of the U.S. government; however, such funds are made available to support work that is of importance to the national research agenda. The practical needs of Illinois agriculture are not always reflected there. C-FAR, with the State of Illinois, has altered that paradigm, making it possible for Illinois to recruit and retain a broad cohort of faculty with skills and interests that are aligned with the needs of Illinois. Through C-FAR, these scientists work closely with industry representatives to strengthen our state's food and agricultural industry.

The C-FAR investment is leveraged to attract additional dollars into Illinois' state economy. C-FAR dollars are leveraged by researchers to obtain roughly four times their project funding amount in additional funding. Often, the C-FAR appropriation serves as the "seed money" to begin a particular research initiative, which can lead to substantial federal and other funding.

The Food and Agriculture Research Act, the C-FAR appropriation's enabling legislation, which became effective July 1, 1995, states that "the purpose of this Act is to put a solid foundation of stable and long-term state support under the important public activity of food and agricultural research while improving accountability and gathering public input concerning that research." It also asserts that "Illinois should be among the top 10 agricultural states in state funding" since it consistently ranks in the top five states in gross agricultural production and is a national leader in food processing.

Comparison of U.S. Midwestern Agricultural States' Annual Research Expenditures (FY02)



Source of this data is Inventory of Agricultural Research, USDA/CREES (land grant institutions), which reflects FY02 expenditures (not appropriations) of state funds for food and agricultural research by land grant institutions. The Illinois figure includes both C-FAR-appropriated funds and other general revenue funds as appropriated by the State of Illinois.

Summary of FY03 Expenditures and Obligated Funds

External Competitive Grants Program	**$2,707,850**
Research Expenditures	$1,598,151
Research Obligations	$1,104,349
Scientific Reviewers	$5,350
University Internal Programs and Other Programs/Accounts	**$7,988,927**
Research Expenditures	$5,641,540
Research Obligations	$2,336,779
Administrative Office Obligations	$10,608
Strategic Research Initiatives Program	**$5,478,225**
Research Expenditures	$3,449,861
Research Obligations	$2,023,764
Scientific Reviewers	$4,600
Illinois Department of Agriculture Fee	**$34,840**
Member Expense Account	**$49,871**
Total FY03 Expenditures and Obligated Funds	**$16,259,713**
Research Expenditures	$10,689,552
Research Obligations	$5,464,892
Scientific Reviewers	$9,950
IDOA Fee & Member Expense	$84,711
Programs/Accounts Obligations	$10,608

Note: The FY03 research expenditures are higher than the FY03 appropriation as a portion of funds from the previous fiscal year are typically obligated for investment in the subsequent year.

Summary of FY04 Allocations

External Competitive Grants Program (15% of the total appropriation, after IDOA Fee and Member Expense)	**$743,784**
University Internal Programs and Other Programs/Accounts	**$3,302,525**
Strategic Research Initiatives Programs	**$800,000**
Illinois Department of Agriculture Fee ($50,000, or ½ of 1% of the total appropriation, whichever is less)	**$24,500**
Member Expense Account (1% of the total appropriation)	**$49,000**
Total FY04 Allocations	**$4,919,809**

Note: An additional $19,809 was allocated to the FY04 External Program due to redirecting unexpended funds from the FY03 1% Member Expense Account.

C-FAR FY03 Expenditure Summary: University Internal Programs and Other Programs/Accounts

(July 1, 2002 - June 30, 2003)

Actual Fiscal Year Expenditures							
C-FAR Research Focus Areas and Programs	**Expenditure Areas**	**UIUC**	**SIUC**	**ISU**	**WIU**	**Per Legislation**	**TOTALS**
Expanding Agricultural Markets	Equipment	73,661	0	0	0		**73,661**
	Materials/Supplies	9,914	0	0	0		**9,914**
	Personnel	181,317	0	4,780	0		**186,097**
	Services/Contracts	20,848	0	0	0		**20,848**
	Transportation	12,219	0	0	0		**12,219**
Rural Economic Development	Equipment	3,544	0	249	10,657		**14,450**
	Materials/Supplies	6,156	0	3,025	5,605		**14,786**
	Personnel	245,257	390	17,564	81,815		**345,026**
	Services/Contracts	25,695	618	2,734	6,833		**35,880**
	Transportation	16,232	0	338	2,863		**19,433**
Agricultural Production Systems	Equipment	212,635	33,919	409	0		**246,963**
	Materials/Supplies	313,053	43,490	574	53		**357,170**
	Personnel	1,656,591	115,457	3,909	93		**1,776,050**
	Services/Contracts	304,212	11,017	0	780		**316,009**
	Transportation	45,675	2,876	61	0		**48,612**
Human Nutrition and Food Safety	Equipment	156,151	18,280	2,021	0		**176,452**
	Materials/Supplies	122,070	16,016	82	0		**138,168**
	Personnel	619,280	48,600	12,217	0		**680,097**
	Services/Contracts	96,195	22,351	1,294	0		**119,840**
	Transportation	12,853	0	331	0		**13,184**
Natural Resources	Equipment	3,817	0	3,157	0		**6,974**
	Materials/Supplies	53,282	0	2,660	677		**56,619**
	Personnel	420,090	18,930	12,933	14,830		**466,783**
	Services/Contracts	15,710	3,000	3,394	1,097		**23,201**
	Transportation	7,307	0	3,869	216		**11,392**
Subtotals		4,633,764	334,944	75,601	125,519		**5,169,828**
Indirect Cost		0	0	3,780	6,902		**10,682**
Research Support		95,838	66,400	11,650	0		**173,888**
C-FAR Administrative Office		235,456	31,586	11,486	8,614		**287,142**
Achievement Award		0	0	0	0		**0**
1% Member Expense		N/A	N/A	N/A	N/A	49,871	**49,871**
IDOA Fee		N/A	N/A	N/A	N/A	34,840	**34,840**
Awards/Obligated Funds for FY04 Research		2,259,061	4,310	59,900	13,508		**2,336,779**
Total FY03 Expenditures and Obligated Funds		**7,224,119**	**437,240**	**162,417**	**154,543**	**84,711**	**8,063,030**

C-FAR FY03 Expenditure Summary: External Competitive Grants Program

(July 1, 2002 - June 30, 2003)

Actual Fiscal Year Expenditures							
C-FAR Research Focus Areas	**Expenditure Areas**	**UIUC**	**SIUC**	**ISU**	**WIU**	**Other Entities***	**TOTALS**
Expanding Agricultural Markets	Equipment	4,276	28,983	0	0	0	**33,259**
	Materials/Supplies	8,043	3,502	0	0	0	**11,545**
	Personnel	112,880	92,277	0	0	0	**205,157**
	Services/Contracts	4,360	8,970	0	0	17,060	**30,390**
	Transportation	5,971	4,216	0	0	0	**10,187**
Rural Economic Development	Equipment	5,770	2,203	0	1,247	33,415	**42,635**
	Materials/Supplies	16,348	86	0	6,920	2,377	**25,731**
	Personnel	96,759	45,373	0	15,209	33,423	**190,764**
	Services/Contracts	30,682	3,266	0	5,971	8,925	**48,844**
	Transportation	18,719	1,362	0	0	788	**20,869**
Agricultural Production Systems	Equipment	5,916	7,742	0	0	0	**13,658**
	Materials/Supplies	20,096	14,371	0	0	0	**34,467**
	Personnel	252,802	56,796	0	0	0	**309,598**
	Services/Contracts	49,201	14,935	0	0	0	**64,136**
	Transportation	14,524	7,878	0	0	0	**22,402**
Human Nutrition and Food Safety	Equipment	11,232	0	0	0	4,409	**15,641**
	Materials/Supplies	8,392	5,341	0	0	19,986	**33,719**
	Personnel	100,427	26,715	30,273	0	34,482	**191,897**
	Services/Contracts	12,018	59	19,459	0	2,629	**34,165**
	Transportation	5,080	937	851	0	264	**7,132**
Natural Resources	Equipment	4,424	7,750	0	0	0	**12,174**
	Materials/Supplies	6,514	3,480	0	0	0	**9,994**
	Personnel	115,250	25,084	0	0	0	**140,334**
	Services/Contracts	22,617	7,135	0	0	0	**29,752**
	Transportation	9,633	1,217	0	0	0	**10,850**
Subtotals		941,934	369,678	50,583	29,347	157,758	**1,549,300**
Indirect Cost		0	29,130	2,529	2,935	14,257	**48,851**
Scientific Reviewers		N/A	N/A	N/A	N/A	N/A	**5,350**
Awards Obligated Funds for FY04 Research		802,864	271,502	1,127	0	28,856	**1,104,349**
Total FY03 Expenditures and Obligated Funds		**1,744,798**	**670,310**	**54,239**	**32,282**	**200,871**	**2,707,850**

* Other entities are Eastern Illinois University, Illinois Crop Improvement Association, Illinois Institute of Technology, Southern Illinois University School of Medicine, University of Illinois at Springfield, and U.S. Grains Council.

C-FAR FY03 Expenditure Summary: Strategic Research Initiatives (SRIs)

(July 1, 2002 - June 30, 2003)

Actual Fiscal Year Expenditures							
Strategic Research Initiative	**Expenditure Areas**	**UIUC**	**SIUC**	**ISU**	**WIU**	**Other Entities***	**TOTALS**
Information Systems and Technology	Equipment	40,082	0	0	0	0	**40,082**
	Materials/Supplies	19,425	117	181	0	44	**19,767**
	Personnel	432,783	23,129	33,596	0	14,646	**504,154**
	Services/Contracts	40,518	380	107	0	0	**41,005**
	Transportation	12,126	0	0	0	547	**12,673**
	Coordination	50,752	N/A	N/A	N/A	N/A	**50,752**
Rural Community Development	Equipment	0	1,286	0	0	0	**1,286**
	Materials/Supplies	5,230	770	0	5,872	0	**11,872**
	Personnel	107,382	177,262	0	52,205	0	**336,849**
	Services/Contracts	32,815	6,053	0	17,226	0	**56,094**
	Transportation	3,086	3,492	0	3,155	0	**9,733**
	Coordination	N/A	49,828	N/A	N/A	N/A	**49,828**
Swine Odor and Waste Management	Equipment	67,508	1,950	22,511	0	0	**91,969**
	Materials/Supplies	48,663	4,420	6,793	0	122	**59,998**
	Personnel	514,368	32,149	23,750	0	486	**570,753**
	Services/Contracts	65,609	2,478	9,054	0	0	**77,141**
	Transportation	12,519	1,280	0	0	0	**13,799**
	Coordination	101,253	N/A	N/A	N/A	N/A	**101,253**
Food Safety	Equipment	2,129	2,398	0	918	4,595	**10,040**
	Materials/Supplies	9,729	14,833	0	834	2,247	**27,643**
	Personnel	77,386	142,355	0	4,710	64,209	**288,660**
	Services/Contracts	9,853	67,550	0	3,680	17,000	**98,083**
	Transportation	2,048	11,516	0	1,587	5,976	**21,127**
	Coordination	N/A	84,987	N/A	N/A	N/A	**84,987**
Water Quality	Equipment	7,396	0	0	0	0	**7,396**
	Materials/Supplies	47,311	3,074	0	0	0	**50,385**
	Personnel	450,199	68,984	0	0	0	**519,183**
	Services/Contracts	123,322	5,839	0	0	0	**129,161**
	Transportation	20,422	21,686	0	0	0	**42,108**
	Coordination	45,753	N/A	N/A	N/A	N/A	**45,753**
Subtotals		2,349,667	727,816	95,992	90,187	109,873	**3,373,534**
Indirect Cost		0	56,971	4,800	11,171	3,385	**76,327**
Scientific Reviewers		N/A	N/A	N/A	N/A	N/A	**4,600**
Awards/Obligated Funds for FY04 Research		1,755,451	185,473	1,127	6,290	75,423	**2,023,764**
Total FY03 Expenditures and Obligated Funds		**4,105,118**	**970,260**	**101,919**	**107,648**	**188,681**	**5,478,225**

* Other entities are American Farmland Trust, Iowa State University, Illinois Institute of Technology, Springfield (IL) Department of Public Health, and Southern Illinois University School of Medicine.

FY04 C-FAR Allocations Summary Report

(July 1, 2003 - June 30, 2004)

Actual Fiscal Year Expenditures									
C-FAR Research Focus Areas (RFAs) and Programs	Internal Grants Program					External Competitive Grants Program	Strategic Research Initiatives	Per Legislation	TOTALS
	UIUC (82%)	SIUC (11%)	ISU (4%)	WIU (3%)	Total Internal University Allocations				
Expanding Agricultural Markets	364,457	0	13,595	0	378,052	102,952	N/A	N/A	**481,004**
Rural Economic Development	0	5,094	36,420	73,393	114,907	141,388	213,387	N/A	**469,682**
Agricultural Production Systems	1,098,672	115,924	11,535	10,596	1,236,727	200,181	96,871	N/A	**1,533,779**
Human Nutrition and Food Safety	559,986	16,000	0	0	575,986	211,665	N/A	N/A	**787,651**
Natural Resources	245,128	0	33,688	0	278,816	80,000	487,414	N/A	**846,230**
Scientific Reviewers	N/A	N/A	N/A	N/A	N/A	7,598	2,328	N/A	**9,926**
Research Support	85,000	55,782	500	0	141,282	N/A	N/A	N/A	**141,282**
Research Discretionary	77,530	133,280	17,190	600	228,600	N/A	N/A	N/A	**228,600**
Indirect Cost	N/A	N/A	5,646	4,342	9,988	N/A	N/A	N/A	**9,988**
C-FAR Administrative Office [2]	256,797	34,448	12,527	9,395	313,167	N/A	N/A	N/A	**313,167**
Achievement Award	20,500	2,750	1,000	750	25,000	N/A	N/A	N/A	**25,000**
1% Member Expense	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49,000	**49,000**
IDOA Fee	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24,500	**24,500**
Totals	**2,708,070**	**363,278**	**132,101**	**99,076**	**3,302,525**	**743,784** [1]	**800,000**	**73,500**	**4,919,809** [1]

(1) An additional $19,809 of unexpended funds from the FY03 1% Member Expense Account was allocated to the FY04 External Competitive Grants Program.
(2) The C-FAR administrative office budget for FY04 is $323,775. This budget is met with $313,167 from the FY04 appropriation and $10,608 of unexpended FY03 funds from this account.

Published by the Illinois Council on Food and Agricultural Research

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Photographer: Ron Ackerman, Daniels/Ackerman Photography

For Publication Services, Inc.:
Project Manager: Susie Yates
Production Manager: Ted Young, Jr.
Editor: Jerome Colburn
Graphic Designer: Anni Poppen
Production Assistant: James Torbit

Printed March 2004 by Crouse Printing

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