Preface

In September, 2004, the Biological Systems Engineering Department celebrated its 100th anniversary. As the oldest agricultural engineering department in the United States, the department has been a national leader in research, teaching, and extension. We look forward to the next hundred years with anticipation. As this annual summary booklet shows, we are doing exciting things.

To that end, we are pleased to provide you with our 2006 Annual Summary, based on activities underway and completed in 2005. The Biological Systems Engineering Department is affiliated with the College of Agricultural and Life Sciences, the College of Engineering, the UW-Madison Agricultural Research Stations, and the University of Wisconsin Cooperative Extension Service. The mission of the department includes achieving excellence in teaching, research and extension. Our Biological Systems Engineering undergraduate program is accredited through 2006. The graduate program offers both Master of Science and Doctoral degrees. We have approximately 56 undergraduate and 24 graduate students. The department offers a wide range of courses with options in Machinery Systems Engineering, Food and Bioprocess Engineering, Natural Resources and Environmental Engineering, and Structural Systems Engineering.

The goal of our research program is to contribute new and valuable knowledge to the fields of food processing and instrumentation, electrical systems, machinery systems, construction, natural resources and environment, and agricultural safety and health. Research projects also serve to train graduate students and to increase the quality of undergraduate education. Our research program is financially supported by state and federal appropriations and by gifts and grants from industry, government agencies, and individuals. This support is gratefully acknowledged. The gifts and grants continue to increase as a percent of budget.

Extension and outreach programs are an integral part of the department. Many of our Extension personnel are also involved in research and classroom teaching. Extension and outreach activities are directed toward providing continuing education opportunities for the citizens of Wisconsin and the nation. The mission is to extend research knowledge and to assist in assimilating it into the community.

Since this report is a summary without a lot of detail, I encourage you to contact the specific project leader (indicated by a "*" in front of the person's name) or me. Publications listed in this report are available upon request.

I welcome your comments on the Annual Summary and other departmental matters. Please visit our website, <bse.wisc.edu>, to keep informed of our activities. Also, do not hesitate to contact me: e-mail pwwalsh@wisc.edu; telephone 608-262-3310; FAX 608-262-1228; or mail your comments to:

Biological Systems Engineering Department
University of Wisconsin-Madison
460 Henry Mall
Madison WI 53706 USA

Patrick W. Walsh
Professor and Chair

Table of Contents

Faculty

David R. Bohnhoff, Professor, Ph.D.
Teaching / Research: wood structures
Robin K. Connelly, Assistant Professor, Ph.D.
Teaching / Research: food and bioprocess engineering
James C. Converse, Professor, Ph.D.
Teaching / Research / Extension: natural resources
Ferencz S. Denes, Associate Professor, Ph.D.
Teaching / Research: food safety
Sundaram Gunasekaran, Professor, Ph.D.
Teaching / Research: food and bioprocess engineering
Awad D. Hanna, Professor, Ph.D.
Teaching / Research: construction engineering and management
Brian J. Holmes, Professor, Ph.D.
Extension / Research / Teaching: farmstead engineering
David W. Kammel, Professor, Ph.D.
Extension / Research: farm structures
Director, Center for Dairy Profitability
K.G. Karthikeyan, Associate Professor, Ph.D.
Teaching / Research: natural resources and environment
Richard E. Muck, Professor, Ph.D.
USDA Agricultural Research Service: structures and environment
Douglas J. Reinemann, Professor, Ph.D.
Extension / Research / Teaching: milking equipment and facilities, rural energy, stray voltage
Roger M. Rowell, Professor, Ph.D.
USDA Forest Products Laboratory: wood chemistry, composites
Ronald T. Schuler, Professor, Ph.D.
Extension / Research / Teaching: power and machinery
Kevin J. Shinners, Professor, Ph.D.
Teaching / Research: power and machinery
Richard J. Straub, Professor, Ph.D.
Teaching / Research: power and machinery
Director, UW Agricultural Research Stations
Associate Dean, Research Division, College of Agricultural and Life Sciences
Anita M. Thompson, Assistant Professor, Ph.D.
Teaching / Research: natural resources and environment
Patrick W. Walsh, Professor, J.D.
Extension / Research: energy and environment, legal liability
Chair, UW Biological Systems Engineering Dept. and
Co-Chair, Solid and Hazardous Waste Education Center

Faculty with Joint or Adjunct Appointments

(Research activities and publications are not included.)

Mark R. Etzel, Professor, Ph.D. (UW Food Science)
Teaching / Research: food engineering
Robert J. Fick, Adjunct Assistant Professor, Ph.D.
Alliant Energy: rural energy
Richard W. Hartel, Professor, Ph.D. (UW Food Science)
Teaching / Research: food engineering
King-Jau (Sam) Kung, Professor, Ph.D. (UW Soil Science)
Teaching / Research: soil physics
Philip R. O'Leary, Chair and Professor, Ph.D. (UW Engineering Professional Development)
Teaching / Research: environmental quality
Mark A. Purschwitz, Adjunct Assoc. Professor, Ph.D.
Research Scientist, National Farm Medicine Center (Marshfield, WI): agricultural safety and health
Aicardo Roa-Espinosa, Adjunct Asst. Professor, Ph.D.
Dane County Land Conservation Dept.: urban conservation, agricultural engineering
Paul D. Thompson, Adjunct Professor, Ph.D.
Bou-Matic: milking equipment and milk cooling

Emeritus Faculty

Glen D. Barquest
Theodore J. Brevik
Gary D. Bubenzer
Frederick H. Buelow
Calvin O. Cramer
James C. Converse
Marshall F. Finner
Richard G. Koegel
Leonard R. Massie
James O. Peterson

Academic Staff

Acronyms of programs/projects with which several of the academic staff are associated

AAW – AgrAbility of Wisconsin
CASH – UW Ctr. for Agricultural Safety and Health
HFHP – Healthy Farmers/Healthy Profits Project
NAP – National AgrAbility Project

For several others, names of associated faculty follow in parentheses.

LeahNell Adams, Outreach Specialist, M.S.; NAP
Nathan Q. Altfeather, Research Intern, M.S. (R.T. Schuler, P.W. Walsh)
Mary F. Beck, Senior Outreach Specialist, M.S.; NAP
Juliane M. Bowling, Research Intern, M.S. (K.G. Karthikeyan)
Larry J. Chapman, Senior Scientist, Ph.D.; HFHP
Cally A. Ehle, Associate Outreach Specialist; AAW
William E. Enters, Research Specialist; Environmental Quality Lab (J.C. Converse, K.G. Karthikeyan)
Joseph D. Grande, Research Specialist, M.S. (K.G. Karthikeyan)
Kyunghyun Kim, Research Associate, Ph.D. (A.M. Thompson)
Sanghoon Ko, Research Associate, Ph.D. (S. Gunasekaran)
Paul S. Miller, Research Associate, Ph.D. (K.G. Karthikeyan)
Marcia G. Miquelon, Senior Outreach Specialist, M.S.; HFHP
Jeffrey W. Nelson, Research Specialist (departmental IT) and Lecturer (farm equipment and power), M.S.
Astrid C. Newenhouse, Associate Scientist, Ph.D.; HFHP
Mark E. Novak, Outreach Specialist; NAP
John C. Panuska, Associate Faculty Associate (K.G. Karthikeyan)
Kathryn Pereira, Outreach Specialist, M.S.; HFHP & NAP
Daniel C. Rodman, Lecturer (surveying; also Dept. of Civil and Environmental Engineering), M.S. (P.W. Walsh)
Scott A. Sanford, Senior Outreach Specialist; Wisconsin Focus on Energy (D.J. Reinemann)
Cheryl A. Skjolaas, Senior Outreach Specialist; CASH & NAP; Interim Director; CASH

Technical Personnel

Harold M. Bohne, Senior Instrument Maker
Bradley A. Brooks, Instrumentation Specialist

Office Personnel

JacqueLynn M. Cary-Pope, Financial Specialist
Hallie R. Kirschner, University Services Associate
Sherry T. Liantonio, University Services Associate
Candy L. Pharo, Department Administrator
Debra K. Sumwalt, University Services Program Associate

Graduate Students

Names of major advisor follow in parentheses

Graham S. Adsit (K.J. Shinners)
Filiz Altay (S. Gunasekaran)
Nathan Q. Altfeather (D.J. Reinemann, P.W. Walsh)
Robert D. Bade (D.J. Reinemann)
Nicolas Bergh (S. Gunasekaran)
Shanti Bhushan (R.K. Connelly)
Garritt C. Boettcher (K.J. Shinners)
Perry E. Cabot (K.G. Karthikeyan)
Amanda D. Crowe (A.M. Thompson)
Matthew F. Digman (K.J. Shinners)
Baiyan Dong (F.S. Denes)
Philip D. Gaebler (K.G. Karthikeyan)
Cheng Gu (K.G. Karthikeyan)
Kerem Gungor (K.G. Karthikeyan)
Jennifer L. Hermans (D.J. Reinemann)
Wantida Homthawornchoo (S. Gunasekaran)
James B. Jordan (R.K. Connelly)
Andrew J. Kotloski (B.J. Holmes)
Seth B. McClure (K.G. Karthikeyan)
Rebekah L. McIntier (R.K. Connelly)
Gregory D. Mueller (A.M. Thompson)
Jesse T. Munk (K.J. Shinners)
Michael A. Nimmer (A.M. Thompson)
Jane L. O'Dell (R.M. Rowell)
Asli A. Ozkaynak (K.G. Karthikeyan)
John C. Panuska (K.G. Karthikeyan)
Adam C. Paul (A.M. Thompson)
Adam L. Petersen (A.M. Thompson)
Nathan D. Sandwick (D.J. Reinemann)
Ajay P. Singh (S. Gunasekaran)
Eakasit Sritham (S. Gunasekaran)
Adriano Sun (S. Gunasekaran)
Changhui Sun (S. Gunasekaran)
Sai Kit (Terry) Tau (S. Gunasekaran)
Jeffrey B. Topel (R.T. Schuler)
Vladimir Totolin (F.S. Denes)
Anthony J. Vandermuss (A.M. Thompson)
Jinjin Zhou (S. Gunasekaran)

TEACHING

One part of the department's mission is undergraduate and graduate education. The department is responsible for:

- Undergraduate Major – Biological Systems Engineering
- Graduate Program:
  - Master of Science – Biological Systems Engineering
  - Doctor of Philosophy – Biological Systems Engineering
- Technical/Service Courses
- Farm and Industry Short Courses
- College of Agricultural and Life Sciences Student Advising

Biological Systems Engineering

Currently there are about 56 undergraduate majors in Biological Systems Engineering. The major consists of a core of courses taken by all students and four emphasis areas of which students choose one: machinery systems; structural engineering systems; natural resources and environment; food and bioprocess engineering. The following courses are dedicated to the Biological Systems Engineering major.

Engineering Principles for Biological Systems, 3 cr
Surveying Fundamentals, 1 cr
Field Applications in Surveying, 1 cr
Structural Design for Agricultural Facilities, 3 cr
Operating and Management Principles of Agricultural Machines, 3 cr
Engineering Principles of Agricultural Machinery, 3 cr
Measurements and Instrumentation for Biological Systems, 3 cr
Food Engineering Operations, 4 cr
Food and Pharmaceutical Separations, 2-3 cr
Rheology of Foods and Biomaterials, 2 cr
Engineering Properties of Food and Biological Materials, 3 cr
Sediment and Bio-Nutrient Engineering and Management, 3 cr
Irrigation and Drainage Systems Design, 2 cr
Small Watershed Engineering, 3 cr
On-Site Waste Water Treatment and Dispersal, 2 cr
Topics in Natural Resources Engineering, 1-3 cr
Topics in Renewable Energy Systems, 1-4
Biological Systems Engineering Senior Design, 3 cr
Career Management for Engineers, 1 cr

The curriculum consists of 128 credits and is accredited by the Accrediting Board for Engineering and Technology (ABET). In July 2001 our undergraduate program was accredited for another six years, the maximum allowable. Approximately 20 students earn B.S. degrees each year.

Technical/Service Courses

The department provides several service courses for other majors.

Principles of Food Engineering, 3cr
Livestock Housing and Waste Management, 3 cr
Irrigation Systems – Design and Use, 1 cr
Drainage Systems, 1 cr
Surveying Fundamentals, 1 cr
Field Applications in Surveying, 1 cr
Operating and Management Principles of Off-Road Vehicles, 3 cr
Engineering Principles of Off-Road Vehicles, 3cr

Farm and Industry Short Course Program

The department teaches the following courses for the Farm and Industry Short Course (FISC) program offered through the College of Agricultural and Life Sciences.

Agricultural Safety and Health, 1 cr
Agricultural Energy Management, 1 cr
Farm Power, 2 cr
Farm Machinery, 3 cr
Livestock Housing, 3 cr
Milking Systems and Design, 1 cr

Graduate Programs

Each year about 30 graduate students are pursuing a Master of Science or Doctor of Philosophy degree in Biological Systems Engineering. In addition, our faculty advise several graduate-level students in other departments and in the programs of Water Resources Management and Land Resources Management of the Institute for Environmental Studies. The M.S. degree requires a minimum of 18 credits of course work and 6 credits of thesis work. A Ph.D. requires a minimum of 48 credits of course work and 24 credits of thesis work for a minimum of 72 credits beyond a B.S. degree in Biological Systems Engineering. Students who have bachelor's degrees in non-engineering fields may pursue a Master's degree in Biological Systems Engineering but must complete appropriate prerequisites.

AWARDS

Faculty and Staff

LeahNell Adams, Mary F. Beck, Mark E. Nowak, Cheryl A. Skjolaas (Outreach Specialists), and Ronald T. Schuler (Professor), with Doug Carmon, Deborah Danuser and Therese Willkomm). Awarded an ASABE Educational Aids Blue Ribbon – Periodicals/Newsletters for the newsletter *AgrAbility Quarterly*, National AgrAbility Project.

Gary D. Bubenzer (Professor). Honored with the Distinguished Service Award from the College of Agricultural and Life Sciences for meritorious contribution to the College and the people of Wisconsin.

Gary D. Bubenzer (Professor). Presidential Distinguished Service Award from the ASABE developing and implementing a dues review process, thereby ensuring the ASABE dues structure and categories will be regularly and systematically reviewed.

Larry J. Chapman (Senior Scientist). Received the Academic Staff Award for Excellence in Research from the College of Agricultural and Life Sciences.

James C. Converse (Professor). 2005 Outstanding Achievement Award from the Wisconsin On-site Wastewater Recycling Association (WOWRA) in recognition of his contributions to education, research, and extension work in the field of on-site wastewater technology.

Brian J. Holmes (Professor), with Don Jones, Ted Funk, William Koenig, Jack Moore and Letitia Wetterauer. Awarded an ASABE Educational Aids Blue Ribbon – Manuals/Workbooks for the *Farmstead Planning Handbook* published by the MidWest Plan Service in Ames, IA.

Ronald T. Schuler (Professor). Honored with the Extension Career Award for 2005 by the University of Wisconsin Cooperative Extension Service in recognition of his national leadership in educating producers and youth about agricultural technology and safety and adapting technologies for those with disabilities.

Students

Mathew F. Digman. 2005 Graduate Student of the Year Award from the Wisconsin Section of the ASABE. Matt is active in the Lawnmower and Snow-blower Clinic (fund-earning activity of the Pre-professional Club) and works on the Quarter-scale Tractor Team (see below).

Aaron R. Flouro. Elected as President for 2005-2006 of the International Pre-professional Council of the ASABE.

Matthew J. McDonald. Placed Second in the AGCO National Student Design Competition for his Quick-Attach Grapple System.

Pre-professional Student Club. First Place Trophy (also in 2003 and 2004) in the Group B (fewer than 35 members) Competition of the Association of Equipment Manufacturers for its excellence in initiative and professionalism in the conduct of ASABE Student Engineering Branches. The award is based on the quality of club meetings, the club's activities, and individual student's activities.

Quarter-scale Tractor Team. Placed 11th overall in the ASABE-sponsored competition. Competition includes an oral presentation (3rd place), a written report (5th place), tractor design (3rd place), performance/pulling (9th place), and maneuverability. The team was awarded first place for the separate web design competition.

Naomi Uhlenhake. 2005 Undergraduate Student of the Year Award from the Wisconsin Section of the American Society of Agricultural Engineering. She served as President of Wisconsin's Pre-professional Club, worked on the Quarter-Scale Tractor Team (see above) and the Association of Equipment Manufacturers report writing team (see above under Pre-professional Student Club). Naomi was also active with the campus Badger Dairy Club and the Association of Women in Agriculture.

RESEARCH

Biological Engineering

Effects of Silage Inoculants on Dairy Cattle Utilization of Silage

*R.E. Muck, F.E. Contreras-Govea, I. Filya, D.R. Mertens, P.J. Weimer

Funding: USDA Agric. Res. Service
Collaborators: USDA Dairy Forage Res. Ctr.; UW Agronomy

Objective:

Farmers often use bacterial inoculants to supplement the natural lactic acid bacteria on a crop at ensiling, helping to ensure good fermentation in the silo. About half the time, cattle performance (weight gain or milk production) is improved by these additives, typically 3 to 5%. However, the reasons for such improvements are not understood. The objective of this research is to study the digestion of silage in rumen fluid taken from dairy cows to see if there are any differences in how rumen bacteria utilize silage, whether or not it has been inoculated.

Progress:

An *in vitro* method was used to study differences in potential ruminal fermentation among alfalfa silages inoculated with different microbial inoculants. Alfalfa was ensiled in glass jars in two trials [48 and 39% dry matter (DM)] with four treatments [three microbial inoculants (*L. pentosus*, MTD1, 1174) plus uninoculated control]. The alfalfa silages (1-g samples, wet-ground, frozen until analyzed) were incubated with rumen fluid from two dairy cows in sealed 160 mL Wheaton bottles. The bottles were stored at 39°C, and gas pressure was measured at 3, 6, 9, 24, 48, and 96 h. At 9 h, four bottles of each treatment were opened, the pH was measured, and the microbial biomass yield was estimated. On average, gas production increased linearly during the first 9 h of fermentation and was greater in control than in inoculated silage. Although harvests were not statistically compared, greater gas production, *in vitro* true digestibility (IVTD), and microbial biomass yield (MBY) were observed on second cut than on first cut due to the higher quality of the second cut (282 *vs*. 391 g neutral detergent fiber/g DM). Even though treatment differences within harvests were not always significant, the trend among treatments was the same, lower gas production and gas production efficiency (mL/g DM digested) on MTD1 and *L. Pentosus* than control and 1174. In addition, alfalfa inoculated with MTD1 had consistent trends toward higher IVTD and MBY than those of control. Methane production was different among treatments, but trends were not consistent between cuts. The results indicate that the microbial inoculants produced silages that shifted *in vitro* rumen fermentation toward less gas production and more microbial biomass than untreated silages. These results suggest that what happens in a cow's rumen could explain why cows sometimes have better performance when eating inoculated silage.

Current efforts on the project are looking at a wider range of inoculant species and combinations. In addition, we are comparing effectiveness in corn silage as well as alfalfa silage.

Evaluation of a Modified System of Dairy Farm Regulatory Oversight

*P.L. Ruegg, D.J. Reinemann, S.A. Rankin

Funding: UW Coop. Ext. Service
Collaborators: UW Biological Systems Eng.; UW Dairy Sci.; UW Food Sci.

The overall objective of this project is to evaluate the ability of an alternative method of direct regulatory oversight of high-performing Wisconsin dairy farms. Specific objectives are:

- Develop and evaluate objective criteria that can be used to identify producers who qualify as "high-performing producers" based on milk quality;
- Develop criteria for FDA-approved monitoring and reporting systems on milk quality performance;
- Evaluate the performance of producers enrolled in the pilot project relative to specific outcomes important to ensuring the safety and suitability of milk produced on the farms.

Wisconsin Bio-Refining Development Project

*D.J. Reinemann, P.W. Walsh

Collaborators: The Energy Ctr. of Wis.; Wis. Dept. of Administration; US Dept. of Energy Industries of the Future

The purpose of this project is to expand bio-refining in Wisconsin by investigating commercially-viable bio-refining opportunities that are suited to the bio-feedstocks produced in Wisconsin. The two primary tasks are:

1. Compile a "roadmap" of information on bio-refining that industry needs to understand the opportunities, barriers, and resources for refining multiple products from biomass feedstocks and residuals so industry can start pursuing bio-refining projects;
2. Disseminate this roadmap information and initiate follow-up actions through a video-based workshop approach.

The bio-refining roadmap website, <www.wisbiorefine.org/index.html>, was launched in conjunction with the video workshop.

Plasma *In Vivo*

*F.S. Denes, S.O. Manolache

Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.

A miniature, syringe-type plasma tool has been developed, which permits the initiation and sustaining of the plasma state in individual tiny bubbles that are generated with controlled dimensions and formation frequency. It is suggested that the novel device could allow disinfection of bloodstream or could produce free radicals in tumors to create tumor-shrinking effects. Preliminary tests on bacteria have been initiated at the UW Medical School, and test evaluations will also be performed at the University of Texas at Arlington involving Professors Richard B. Timmons and X. Liping.

Generation of High Density DNA Arrays on Plasma-Functionalized Organic and Inorganic Substrate Surfaces

*F.S. Denes, S.O. Manolache, L.E. Cruz-Barba, J.M. Helgren, M.G. Lagally, B.J. Larson

Funding: UW Biological Systems Eng.; UW Ctr. for Plasma-Aided Manuf.

Conventional surface functionalization procedures of organic and inorganic polymeric substrates usually involve complex wet chemistry approaches and, in most cases, require elaborate environmentally-unfriendly, long-duration, multi-step processes. In addition, technical difficulties associated with total removal of solvents at the end of the functionalization process and with activation of inert surfaces (e.g., polyethylene, quartz, etc.) considerably limit the use of these technologies to prepare surfaces with molecular recognition capabilities.

Recently, it has been demonstrated in the lab of the Center for Plasma-Aided Manufacturing and labs of the Departments of Biological Systems Engineering and Materials Science and Engineering that the low-pressure, cold-plasma approach allows the development of very efficient, dry chemistry surface functionalization mechanisms. Two *Invention Disclosure Reports* have been submitted to the Wisconsin Alumni Research Foundation, and SONOPLAT, a Wisconsin-based company, licensed the plasma-aided technologies. This original method takes advantage of plasma-generated active sites on organic and inorganic material surfaces including $SiCl_x$, $Si(OH)_x$ groups and free radical sites and their interaction with the oxirane ring (e.g., epichlorohydrin, etc.) to mediate further functionalization reactions. Successful surface functionalization reactions of polyethylene, poly(methyl methacrylate), polycarbonate, glass, silicon and quartz substrates were accomplished using argon-, dichlorosilane- and O_2/H_2O-plasma environments followed by *in situ* reaction of active sites with epichlorohydride.

Immobilization of amine-terminated DNA on plasma modified techniques was tested using an original "sono-plot" method (patent application). It was demonstrated that high density DNA arrays can be generated and that the selective attachment of amine-terminated DNA exceeds the performances of the best commercially available arrays. The dry nature of the plasma approach and the simplicity of the entire procedure make the plasma approach very attractive. Further research is concentrated on optimizing the plasma-enhanced reaction mechanisms.

Synthesis of Nanoparticle Systems under Dense Medium Plasma Conditions (Catalytic and Magnetic Nanoparticles)

*F.S. Denes, S.O. Manolache, R.B. Timmons

Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.

Collaborator: U. of Texas at Arlington

The special properties of metallic, semiconductor or dielectric nm-sized structures promise numerous applications in electronic, magnetic, and optical devices and in catalytic applications due to the special physical and physical-chemical interactions developed at atomic and atom-cluster levels. It has been suggested that every property is associated with a critical geometric scale below which the fundamental physics of the property starts to change. Nanotechnologies involve control of matter at the atomic or molecular level where quantum effects play a significant role.

Among other miniature structures, colloidal silver was considered in many investigations as an extremely efficient potential disinfectant due to its high antimicrobial activity and low toxicity to mammalian cells and tissues. It has been suggested that the smaller the silver particles, the more effective the colloid is. Bacteria exposed to colloidal silver do not develop resistance, unlike when antibiotics are used. Tetrasilver tetroxide is suggested to have biocidal properties through an electron release mechanism. The exact antimicrobial action of silver is not completely understood. Several possible mechanisms have been proposed which involve the interaction of silver with biological macromolecules such as enzymes and DNA.

Carbon-based nanoparticles (e.g., fullerenes and carbon nanotubes) and semiconductor nanoparticles have also attracted much attention because of their unique photoelectrochemical properties due to their quantum-level effects. Among the semiconductors, TiO_2 is the most suitable for environmental applications. It is biologically and chemically inert. Its photocatalytic properties are favorable for oxidation of numerous hazardous chemicals, reduction of heavy metals, and photodegradation of bacteria and viruses in water.

Magnetic carbon-based, hybrid TiO_2/Ag nanoparticles and TiO_2/C/N-based nanoparticle systems were synthesized under dense medium plasma (DMP) environments. It has been shown that iron oxide containing carbon-based nanoparticle systems exhibit magnetic properties and that the photocatalytic activity of rutile has been significantly enhanced by dispersing silver nanoparticles and C/N-based structures (derived from acetonitrile-DMP reactions) into the DMP-exposed TiO_2 clusters. Applications of these hybrid nanoparticle systems can be envisaged for localized and controlled drug delivery procedures (e.g., anti-tumor drugs) and in developing efficient photocatalytic technologies to annihilate chemical and biological warfare agents.

Carbon-based nanoparticle systems are currently under evaluation for inflammatory effects at the University of Texas at Arlington.

Structures / Construction

Lateral Load Distribution in a Metal-Clad, Wood-Frame Building

*D.R. Bohnhoff, P.A. Boor, M.H. Gadani

Funding: USDA Hatch; USDA Natl. Research Initiative; UW Biological Systems Eng.; UW Graduate Sch.; Lester Building Systems

This project involved constructing and testing a full-scale, metal-clad, post-frame building with the goal of gaining a better understanding of the complex distribution of load in this popular agricultural building system. The building was erected, instru-

mentation was installed, and initial tests were conducted in 2001. Research in 2002 was dedicated entirely to testing and data analysis. Research in 2003 and 2004 consisted of data analysis and computer modeling.

The test building is 40 × 200 ft with trusses on 10-ft centers. Trusses are pin-connected to posts, which, in turn, are pin-connected to concrete piers. Centered under each interior truss is a hydraulic frame loader (HFL) that is attached by rods to each end of the truss. An HFL can be set to operate in one of four modes: 1) north load, 2) south load, 3) lock, or 4) float. Although there are no HFLs under the endwall trusses, the endwall trusses can be either locked in place or allowed to float during a test.

Using the versatility of the HFLs, 22 different loadings were applied to each of 10 different building configurations. Different building configurations were obtained by adding and removing: the ridge, chord reinforcing hardware, roof-to-sidewall fasteners, roof panel stitch screws, sidewall steel, and eave trim. This experimental design was replicated twice for a total of 440 building tests in 2002. During each test, signals from 225 different transducers were recorded every 4.7 s. With a test time of at least 3 minutes, each loading usually generated at least 10,000 data points, obviously an unwieldy amount of data to analyze without significant data reduction.

During early 2003, research effort was dedicated to data reduction. This was accomplished by first calculating an average horizontal frame force for each 4.7-s scan. The second step was to linearly regress the output from each transducer on the average horizontal frame load values. After these regression analyses, the data file for each load case was reduced to 204 values.

From the latter part of 2003 and throughout 2004, research effort was dedicated to modeling full-scale building behavior. In the end, a model with three displacement degrees of freedom (DOF) per building frame was selected. These included a displacement parallel to the frame and two displacements perpendicular to the frame – one at each sidewall. The 3-DOF/frame model contains four different simple spring elements (a.k.a. truss elements): a frame element, a roof cladding element, a chord element, and a wall cladding element.

The primary task during the modeling phase of the study was to determine axial stiffness properties for each of the four elements or, more specifically, to find element stiffness values that were a function of building configuration and thus could be used to accurately predict full-scale building behavior regardless of building configuration or distribution of applied loads. This turned out to be a formidable task, requiring thousands of computer simulations because of the interdependency of wall cladding, roof cladding, and chord force element properties. Nevertheless, a set of element properties was selected that do a very good job of predicting building displacements as well as the in-plane bending moment and shear forces between building bays. The results of this modeling were presented at the 2004 ASAE/CSAE International Meeting in Ottawa, Ontario.

The 3-DOF/frame model is embodied in computer program DAFI3 (Diaphragm and Frame Interaction 3dof/frame). Once a pre- and post-processor are added to the program, it will be made available to the general public.

Accuracy of Corrugated Metal Panel and Trim Installation

*D.R. Bohnhoff, D.K. Cockrum

Funding: UW Biological Systems Eng.; Natl. Frame Builders Assn.

In January, 1999, the National Frame Builders Association (NFBA) published *Accepted Practices for Post-Frame Building Construction: Framing Tolerances*. In preparing this document, UW-Madison researchers conducted an extensive field investigation to determine just how accurately post-frame building frames are constructed.

In March of 1999, the NFBA Technical and Research Committee proposed that NFBA pursue the development of a second construction tolerances document, covering metal trim and corrugated panel installation. In October of 2002, the committee identified items to include in the document. At this same meeting, it was agreed that UW-Madison researchers would conduct the field research required for document development.

Actual data collection commenced in the summer of 2003 and was completed in early June of 2004. A total of 52 buildings were surveyed. Items investigated included: 1) panel plumbness; 2) roof-to-wall panel rib alignment; 3) corner trim squareness; 4) corner trim connection to wall panel; 5) wainscot panel alignment; 6) roof panel offsets at eaves; 7) variations in roof panel overhang; 8) misalignment of wall panel ends (e.g., saw-tooth effect); 9) fit at openings; 10) dings; 11) scratches and scrapes; 12) crimps/kinks; 13) horizontal fastener alignment; 14) fastener drive depth; 15) fastener driving angle; 16) fasteners missing framing; and 17) irregular fastener patterns.

Data from field investigations were tabulated and then summarized in a technical paper presented at the 2004 ASAE/CSAE International Meeting in Ottawa, Ontario. This information was subsequently used by Professor Bohnhoff to draft the first version of a document entitled *Accepted Practices for Post-Frame Building Construction: Metal Panel and Trim Installation Tolerances*. A subsequent version was presented at the 2005 ASABE International Meeting in Tampa. A final version was drafted in August of 2005 and made available to the general public by NFBA.

Post Installation Tools

*D.R. Bohnhoff

Funding: Wis. Frame Builders Assn.; UW Biological Systems Eng.

Embedded post foundations are largely responsible for the cost-effectiveness of the post-frame building system. However, like other foundation systems, installation of embedded post foundations has its unique challenges. To help overcome some of these difficulties, prototypes of three different tools – a post-hole installation shield, a posthole bottom leveler, and a footing transport and placement cart – were designed by Bohnhoff and tested in 2003. Research in 2004 concentrated on refining the posthole-bottom leveler. Research in 2005 resulted in a new version of the footing transport and placement cart and modifications to the posthole installation shield.

A posthole bottom leveler is a simple, inexpensive device that levels soil at the base of a hole prior to tamping and placement of a precast concrete footing (a.k.a. cookie). The use of such a device becomes increasingly important as footing diameters increase. Without such a device, it is difficult to ensure that the base of a hole is not tilted or uneven. A tilted base results in a tilted footing and, consequently, a significantly reduced area of contact between the footing and post. Uneven terrain (i.e., high and low points) results in more variant footing stresses and increases the likelihood of future foundation settlement. It is recommended that such a tool be present on any job site where precast concrete footings are being placed.

Sloughing of posthole sides is associated with drilling in noncohesive soils (e.g., sands and gravels with low clay content) that are low density, poorly compacted, very wet due to a recent rain, or because they are poorly drained or saturated because they are near or below the water table. Vibrations that arise from hitting rocks and/or tree roots generally increase the likelihood of posthole collapse. As a posthole side sloughs, the top diameter of the posthole enlarges, which makes it more difficult to throw material away from the posthole by spinning the auger after it has been brought to the surface. It also becomes more difficult for workers to prepare the base of the posthole for a footing, to place the footing, and to properly position, brace and backfill the post, even when planking is used to bridge the large opening. A posthole installation shield prevents posthole sides from collapsing during hole drilling and any time prior to footing and post installation. It is recommended that all major post-frame companies stock at least one posthole installation shield to use on job sites where conditions make it difficult to maintain proper posthole geometry.

Round, precast footings (a.k.a. cookies), especially those with diameters less than 17 inches, are frequently dropped into postholes. Unfortunately, the likelihood of a "dropped" footing landing properly in a hole is extremely remote, regardless of its size. If one edge of a footing hits first, the result is a localized soil bearing failure – a failure involving the movement and "loosening up" of a good portion of the surrounding soil. To avoid damage to the footing base, some contractors use special tongs to lower smaller footings. Others wrap steel banding around the footing and remove the banding after the footing is in place. Neither method works very well with larger/heavier footings. Footings too large for one person to lift are typically handled with a rough terrain forklift, skid steer loader, front-end loader tractor, or similar piece of equipment. This equipment is used not just to move footings around a job site, but often is also used to lower larger footings into postholes. In addition to the equipment operator, another worker is typically needed to attach/detach footings to/from the equipment and to guide footings so they do not hit posthole sidewalls as they are lowered. In other words, it takes two workers and a large piece of equipment to properly install large precast footings. Using a footing transport and placement cart, a single person can transport and place precast concrete footings as large as 350 lbm and 34 inches in diameter without the use of self-propelled equipment. Any company that stocks and/or routinely uses footings weighing more than 100 lbm should not be without a footing transport and placement cart.

There are no patents protecting the three post installation tools described above. They are provided for public use and to stimulate development of similar tools. In return, we simply ask that any individual or company that uses the designs, or in any way profits from them, help support through donation the post-frame building research effort at the UW-Madison. University research is a non-profit venture that can only be sustained via continual support from those whom it benefits.

Concrete Pier-to-Wood Post Connector Design

*D.R. Bohnhoff

Funding: UW Biological Systems Eng.

More and more post-frame buildings are being constructed using precast or cast-in-place concrete piers. This increased interest in concrete piers can be attributed to the following seven, largely interrelated reasons.

1. Durability. End users have more confidence in the long-term durability of a concrete foundation than they do in a preservative-treated wood foundation.
2. Reduced availability and/or higher cost of CCA-treated lumber. As of December 31, 2003, no wood treater or manufacturer could treat wood with CCA for most residential uses. While posts for agricultural and commercial buildings can still be CCA-treated, the partial ban on CCA significantly reduces the amount of CCA-treated wood, making it more difficult and expensive to obtain.
3. Corrosiveness of CCA alternatives. Alternative CCA treatments include ACQ (alkaline copper quat) and ACC (acid copper chromate). These alternative treatments have a higher copper concentration, resulting in increased galvanic corrosion when metals less noble than copper (e.g., magnesium, zinc, iron, steel, aluminum) are driven into or brought into direct surface contact with the treated wood. Excessive corrosion of metal fasteners is of primary concern to engineers concerned about structural integrity and hence safety of building occupants.
4. Reduced use of preservative-treated lumber. Where possible, engineers try to eliminate preservative-treated lumber because: a) it costs more than non-treated lumber, b) it generally requires use of more expensive, less-corrosive fasteners, and c) the preservatives are pesticides which can make eventual disposal of preservative-treated wood problematic.
5. Lumber length. Lumber becomes increasingly expensive (on a board foot basis) in longer lengths. Additionally, dimension lumber is not readily available in lengths longer than 20 feet. When concrete piers are used, the overall length of the wood post is generally shortened by four to seven feet. This means engineers are using shorter, less expansive lumber to obtain the same building heights and can also build structures with 20-ft eave heights using unspliced sidewall posts.
6. Ease of building disassembly. Agricultural and commercial buildings have a relatively short functional design life. Therefore, it is beneficial to be able to easily disassemble building components for use in a more functional structure. This is much easier to accomplish when wood posts are attached to concrete piers.

7. Recycling. If history teaches us anything, it is that reuse of lumber treated with a particular preservative is largely dictated by restrictions placed on reusing the lumber after it has been in use for several years. Some researchers have suggested that the development of good organic-based preservative wood treatments may result in restricted use of all heavy-metal based preservatives, thus making products treated with CCA, ACQ and ACC of little value several years from now. If this is the case, anything that can be done to replace preservative-treated wood with untreated wood may increase the future value of a building.

Despite the increased use of concrete piers in post-frame building construction and the number of post-frame buildings that have been erected on concrete frost walls and grade beam foundations, very little attention has been paid to concrete-to-wood post connections. Common steel brackets used by the post-frame industry to attach wood posts to cast-in-place concrete are treated as pin connections in design because of the lack of bending strength and stiffness of: 1) the steel bracket-to-concrete connection, 2) the steel bracket-to-wood post connection, and 3) the steel bracket itself. With concrete-to-post connections that lack bending strength and stiffness, the building designer must rely entirely upon diaphragm action and/or on rigid column-to-truss connections to handle horizontal forces applied to the structure.

In 2005, UW-Madison undergraduates Kyle Bunnow and Aaron Flouro worked on the design of a concrete-to-wood post connection with the goal of developing a connection with significant bending strength and stiffness. This project, which will be completed in 2006, will enable design engineers to either reduce overall post size or rely less on diaphragm action or rigid frame design for building stability. This, in turn, would make concrete piers more attractive to builders and would ultimately decrease dependence on preservative-treated lumber.

High Performance Wood Composite Materials through Activation Bonding

*F.S. Denes, S.O. Manolache, V. Totolin

Funding: McIntire and Stennis Grant

Wood-based composite materials, including particle boards and fiberboards, are produced from disintegrated waste-wood materials. Generation of high-quality composite materials strongly depends on the adhesion between the wood substrate surfaces and the adhesive materials involved.

The main objective of this research is to use plasma-aided technology to modify both wood and lignin-particle surfaces and to generate specific surface functionalities that will enhance adhesion characteristics.

Powdery lignin substrates were exposed separately to oxygen, argon and ammonia plasma environments in a rotating glass plasma reactor and reacted under *in situ* conditions. Thickness swelling of extracted and non-extracted aspen fiberboards decreased in the oxygen-plasma treated samples, while little effect on the thickness swelling was observed in the ammonia-plasma exposed boards.

As expected, the wet strength of all fiberboards was lower than dry strength. Oxygen-plasma treatment of the extracted and non-extracted fiber resulted in the highest dry strength of the fiberboards, whereas oxygen-plasma treatment of the non-extracted fiber resulted in the highest wet strength. Ammonia-plasma treatment of the extracted aspen boards also resulted in a significant increase of the strength values.

Results from these investigations indicate that the cold plasma technique is an efficient approach for surface modification of lignin and wood substrates.

Safety and Health

Midwest Intervention Evaluation Pilot Project

*L.J. Chapman, A.C. Newenhouse, M.G. Miquelon, K.M. Pereira

Funding: US Ctrs. for Disease Control and Prevention; Natl. Inst. for Occupational Safety and Health (NIOSH) via Ohio State University's Great Lakes Ctr. for Agric. Safety and Health

Collaborators: UW Biological Systems Eng.; various Wis. grower organizations; UW Coop. Ext. Service

This project will develop background information and prepare for a full-scale application for funding to intervene in the landscape sector of the agricultural industry in the Great Lakes states. Our intervention strategy will encourage adoption of production practices that are more profitable as well as safer. We plan to accomplish two specific aims.

1. Learn from landscape operation growers and landscape industry resource people about the landscape industry, including work activities, job hazards, candidate safer and more profitable work practices and tools, and sources for a sampling frame of landscape operations in the Great Lakes states.
2. Learn from previously published research and on-going projects about the landscape industry, including work activities, job hazards, candidate safer and more profitable work practices and tools, and sources for a sampling frame of landscape operations in the Great Lakes states.

We believe that this study plan will yield useful information for a future NIOSH application about a planned intervention with the landscape industry.

Community Partners for Healthy Farming Nursery Field Crop Growers Intervention Project

*L.J. Chapman, A.C. Newenhouse, M.G. Miquelon, K.J. Josefsson

Funding: US Ctrs. for Disease Control and Prevention; Natl. Inst. for Occupational Safety and Health (NIOSH)

Collaborators: UW Biological Systems Eng.; various Wis. grower organizations; UW Coop. Ext. Service

This project will accomplish three specific aims.

1. Develop or identify existing control technologies for work performed by Midwestern nursery operations engaged in bedding and garden plants and nursery crop production. We will reduce hazards (and thereby injuries) by developing or identifying controls that reduce exposure to physical work hazards for musculoskeletal and traumatic injuries. The types of controls we will consider include work practices, tools, labor aids, and administrative

controls. We will seek out reports from nursery managers, commercial suppliers, university Extension personnel, and others about emerging production practices that could improve both safety and profits. We will also collaborate with university instructors and their students in design and other engineering courses to accomplish this aim.
2. Conduct field research to evaluate the control technologies from #1 above which show the most promise to determine their impact on production and to verify that musculoskeletal risk factors are actually reduced when the practices are adopted. We will undertake small-scale field studies to quantitatively evaluate the hazard-reducing and profit-enhancing aspects of two to four of the best production practices each year. Comparisons will be made in the field or in laboratory situations between accomplishing work by conventional methods and with the improved control technology. Fewer than six subjects in each condition for less than half a day of work are anticipated. Small-scale field studies will also be undertaken on operations that have adopted practices to verify that musculoskeletal risk factors are really reduced.
3. Conduct and evaluate a large, region-wide intervention to promote the best control technologies from #2 above to the 7,888 nursery operations in seven north central states (WI, MN, MI, IA, IL, IN, OH) that produce bedding and garden plants and nursery crops. Disseminate information about the improved work practices through sources that growers already rely on for information about new production methods (e.g., other growers, trade publications, public events, university Extension agents, other private and public sector resource people, the Internet, etc.) Evaluate the interventions with annual mail questionnaires to separate, population-based, rolling probability samples of the study group (n = 650 nursery growers/yr) and the control group (n = 320 New Zealand nursery growers/yr).

Wisconsin Dairy Traumatic Occupational Injury Intervention

*L.J. Chapman, A.C. Newenhouse, M.G. Miquelon, K.M. Pereira
Funding: US Ctrs. for Disease Control and Prevention; Natl. Inst. for Occupational Safety and Health (NIOSH)
Collaborators: UW Biological Systems Eng.; various Wis. dairy organizations; UW Coop. Ext. Service

This project will implement and evaluate the effectiveness of an intervention in the workplace intended to prevent and reduce traumatic agricultural injuries. We plan to build on our ongoing intervention among the 21,000 Wisconsin dairy operations that constitute 20% of the nation's operations and employ more than 73,500 workers. Our intervention strategy will encourage adopting production practices that are more profitable as well as safer. A dairy operation's manager largely determines the work methods and equipment used. The work methods and equipment used largely determine what hazards the workforce is exposed to. Our intervention improves information flow to managers to persuade them to adopt certain production methods that should maintain profitability as well as improve safety, thereby reducing traumatic injuries.

We plan to accomplish three specific aims.
1. Continue, for three additional years, a community-based information dissemination intervention among Wisconsin dairy producers that will reduce traumatic injuries by persuading managers to adopt safer, more efficient work methods. We will reduce hazards (and thereby injuries) by improving information flow to managers to persuade them to adopt production methods that are both safer and more profitable. We will continue this theory-based intervention with a specially-designed information dissemination effort that uses sources dairy producers already rely on for information about new production methods: other farmers, print media, public events, university Extension personnel, other private and public sector resource people, and the Internet.
2. Conduct annual, large-sample, mail questionnaire-based scientific evaluation of the information dissemination intervention that includes both process and outcome measures. We plan to refine and continue, for three additional years, to administer mail questionnaires that tap both process and outcome measures to separate, population-based, rolling probability samples of the study group (n = 800/yr) and a control group (n = 400 Maryland farmers/yr). We intend to determine:
   a) if our materials are reaching the target audience and which intervention aspects are most effective, and
   b) whether producer adoption and awareness of each production method have increased.

We will gather information about injuries, barriers to adopting the production methods, and how to make our intervention effort more persuasive.
3. Add one or two traumatic injury-reducing production methods to the intervention in each of the three additional intervention years. We will seek out reports from farmers and others about emerging production methods that could improve safety and profits. We will evaluate hazard-reducing and profit-enhancing aspects of the best production methods. We plan to add one or more of these new production methods with the clearest labor-saving and injury-reducing advantages to the intervention to promote statewide.

Electric Power and Energy Systems

Food Processing Energy Management

*D. Reindl, D.J. Reinemann, R. Hackner, T. Tucker
Funding: Wis. Focus on Energy
Collaborators: UW Mechanical Eng.; UW Biological Systems Eng.; GDS Associates; Envise

The objectives of this project are to identify and promote energy technologies in food processing plants in Wisconsin with emphasis on dairy plants. Specific activities include:

- Seek and develop methods to promote best practice efficiency opportunities and emerging technologies;
- Develop a strategic plan for the cluster to impact energy efficiency;
- Develop a best practices guide and educational programs on energy efficiency opportunities;
- Coordinate implementation of energy efficiency technologies with key industry associations, trade allies that sell efficient equipment to the industry, economic development agencies, and energy utilities.

Agricultural Energy Management Assessment System

*D.J. Reinemann, S.A. Sanford, E.A.R. Bird
Funding: Wis. Focus on Energy
Collaborators: UW Biological Systems Eng.; UW Soil Sci.

This project will develop and test agricultural energy management assessment support materials. Energy management tools will be developed with various levels of technical detail targeted at specific user groups. A simple self-assessment tool will be developed for producers and will be available as a web-based tool. This interactive agricultural energy management assessment system will be incorporated into the Farm•A•Syst and Wisconsin Environmental Management Assessment programs as well as the Wisconsin Focus on Energy local energy service provider resources website, <www.focusonenergy.com>. More detailed energy audit tools will be developed for energy service providers. The program will be piloted in several counties in which energy auditors and county Extension agents will be trained to use these tools. Programs will be offered at Wisconsin Farm Technology Days and at regional seminars.

Food Engineering and Processing

Development of Atmospheric Pressure Plasma Technologies for Efficient Decontamination and Disinfection (Including Spores) of Surfaces, Air and Water

*F.S. Denes, S.O. Manolache, A.C.L. Wong
Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.; US Office of Naval Research; UW Food Research Inst.; Amer. Meat Inst.; Wis. Energy Ctr.

It was shown that under specified dense medium plasma (DMP) reactor experimental conditions, more than 10^5 bacteria/mL of *Listeria monocytogenes* or a bacterial cocktail of 16 different environmental isolates are inactivated in 10 s at power consumption as low as 200-300 W. It was also shown that aromatic contaminants of 600-1000 ppm concentration are reduced to 2-3 ppb in only 25 s. If nascent colloidal silver particles are present in the contaminated water, disinfection is even more efficient. (Colloidal silver nanoparticles can be generated simultaneously with the plasma process by using silver electrodes.) Experiments are underway to evaluate the efficacy of the DMP system for disinfecting fresh orange juice.

The array electrode reactor (AER) allows efficient disinfection of various static or moving substrate surfaces such as metals, glass, and polymers. Potential applications include disinfecting conveyor belts and cutting blades. The AER can also disinfect incoming or recycled air, which opens up a novel route to develop advanced technologies to eliminate aerosol-based contamination in ready-to-eat food processing locations. Preliminary tests indicate that bacterial mixtures and highly-resistant spores deposited on stainless steel coupon surfaces can be annihilated under both air and oxygen AER plasma environments with treatment times as short as two minutes.

Future research will focus on understanding the discharge-induced reaction mechanisms responsible for killing bacteria and spores and on optimizing plasma parameters and data acquisition to evaluate possible scaling-up of plasma technologies for industrial applications.

Development of Atmospheric Pressure Non-Equilibrium Plasma Technologies for Efficient Disinfection of Milking Machine Teat Cup Liners

*F.S. Denes, S.O. Manolache, J.M. Helgren, D.J. Reinemann
Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.

An original atmospheric pressure non-equilibrium plasma (AP-NEP) reactor was designed and developed in the labs of the Center for Plasma-Aided Manufacturing (C-PAM) and the Biological Systems Engineering Department to disinfect milking machine teat cup liners. (*Invention Disclosure Report* has been submitted to the Wisconsin Alumni Research Foundation.) Preliminary test results indicate that this novel plasma-enhanced technology allows very efficient disinfection of teat cup liners (non-detectable bacteria levels, plasma-exposure times as low as 30 s to 2 min., high voltage power in the range of 10-50 W/liner, easy handling) without using large amounts of liquid-phase conventional disinfecting agents. The simple construction of the plasma tool, based on adapting specially designed electrodes to the liners, and the use of commercially available or custom made (by C-PAM) high voltage power supply permits fast mass production and distribution of the plasma device. The implementation of plasma-enhanced milking systems is expected to considerably reduce mastitis infections.

Plasma-Enhanced Synthesis of Surface Layers that Kill Bacteria on Contact

*F.S. Denes, S.O. Manolache, A.C.L. Wong
Funding: CSREES Natl. Research Initiative, Food Safety

Quaternary ammonium (QA) and phosphonium (QP) functionalities have been successfully implanted onto various substrate surfaces using cold plasma technologies. Preliminary results indicate that the plasma-modified substrate surfaces exhibit significant antibacterial characteristics.

Iodine-containing amylase (starch) layers were also cross-linked using low-pressure non-equilibrium RF-plasma to trap halogen atoms into the polysaccharide structure. It was shown that the plasma-generated thin layers exhibit strong bactericide behavior.

Retention of silver atoms and silver nanoparticles into plasma-modified polysaccharide structures is also under consideration to generate antibacterial surfaces.

The stability of QA-ND QP-bearing surface layers has been evaluated. It was demonstrated that, in addition to the plasma-enhanced generation of allyl chloride and allyl bromide intermediate layers, the presence of a HMDSO-based structure is required to enhance the stability of the QA and QP structures on stainless steel surfaces.

Plasma-Enhanced Deposition of Antifouling Macromolecular Layers on Material Surfaces Usually Involved in Food Processing Technologies

*F.S. Denes, S.O. Manolache, A.C.L. Wong, H. Jiang, B. Dong

Funding: USDA Natl. Integrated Food Safety Initiative Award; Hatch

Collaborator: UW Food Research Inst.

If bacteria attach to surfaces, biofilms may form and create economic and health problems in many settings, including those of food and medical industries. Developing new technologies to prevent or at least attenuate biofilm formation is highly desirable.

In this study, plasma-enhanced deposition of polyethylene glycol (PEG)-type structures are examined as possible antifouling materials, and the resulting antifouling mechanisms are investigated. PEG chains are highly flexible and can cause an intense entropic repulsion of protein molecules due to reduced degrees of confirmation freedom of protein macromolecular chains. PEG is also highly water-soluble and, as a result of hydrogen bonds created between the oxygen atoms of PEG and water molecules, a water molecule-based shield is created around PEG macromolecular chains that may contribute to their antifouling behavior.

Three different approaches were considered for depositing PEG-type layers onto stainless steel and silicon rubber surfaces.

1. Deposit thin layer PEG-type networks from various plasma-generated, charged and neutral, volatile, precursor molecular fragments.
2. Graft PEG molecular chains onto $SiCl_2H_2$-, H_2-, and $SiCl_4$-plasma-functionalized surfaces.
3. Generate antifouling layers by cross-linking predeposited PEG structures under oxygen and argon plasma radio frequency plasma environments.

It was shown that plasma-deposited PEG-type structures exhibit significantly-reduced bacterial attachment and biofilm formation in the presence of a mixed culture of *S. typhimurium*, *S. epidermidis*, and *P. fluorescense*. Biofilms developed on these coated surfaces were less stable and easier to remove than those on uncoated surfaces. Future research will involve optimizing plasma-deposition processes to generate highly effective antifouling layers. Antifouling characteristics will be related to the chemical nature and morphologies of PEG-type structures.

Recently it was demonstrated that PECVD-deposition of diamond-hard carbon thin layers can accommodate biologically active layers. The characteristics of these surface layers are under investigation to evaluate their potential application in the preparation of robust bioactive surfaces.

Atmospheric Pressure Non-Equilibrium Plasma Surface Modification of Low Dimension Capillary Cavities Including Various Catheter Materials

*F.S. Denes, S.O. Manolache, L.E. Cruz-Barba

Funding: Boston Scientific Co.-Minneapolis

Interior surfaces of plastic catheter tubes are plasma-modified using an original, continuous-flow system, atmospheric pressure non-equilibrium plasma technology to generate controlled surface energy catheter wall characteristics.

Design, Development and Testing of Novel Atmospheric Pressure Plasma Installations with Potential Scaling-Up Possibilities for Pilot and Industrial Technologies

*F.S. Denes, S.O. Manolache

Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.; Amer. Meat Inst.

Collaborator: UW Mechanical Eng.

Three original (patents and patent disclosures) atmospheric pressure (AP) plasma reactors were designed and developed at the Center for Plasma-Aided Manufacturing (C-PAM) and the Biological Systems Engineering Department. The reactors are the dense medium plasma (DMP) reactor, the array electrode reactor (AER), the barrier discharge reactor for small dimension cavities (BD-SDC), and the flat-plasma ceramic reactor.

The DMP reactor is based on a digitally controlled, rotating, interchangeable pin array electrode system which generates a volume character of the plasma processes due to the presence of an intense cavitation developed in the reaction media. It can be operated using DC or AC power, and it allows extremely efficient modification of various liquid media (e.g., solutions, suspensions, etc.) in the presence of inert or reactive gases.

The AER installation eliminates the drawbacks of conventional AP gas-phase techniques by using a multi-cylinder/wire electrode array system which allows plasma exposure of various substrates under static or continuous flow system conditions. This electrode configuration assures a uniform flow of plasma gases or gas mixtures through a multitude of cylindrical individual discharges. With the AER, both metal and dielectric materials can be surface-treated uniformly, while the presence of a low dimension gap between the electrode system (usually associated with conventional AP reactors) is not required.

With the BD-SDC tools, electrical discharges can be generated in low dimension dielectric cavities, channels or capillaries by adapting a special electrode/cavity configuration. Embedding the electrodes into dielectric materials and maintaining a certain position of the cavity or capillary or channel volumes relative to these electrodes, AP discharges can be initiated and sustained in capillaries with inner dimensions smaller than 1 mm under batch or continuous system modes.

Use of Plasma Technology to Decontaminate Surfaces and Air in Food Processing Environments

F.S. Denes, S.O. Manolache, A.C.L. Wong

Funding: Dept. of Homeland Security, Natl. Ctr. for Food Protection and Defense

Two original plasma tools (array electrode reactor and flat plasma reactor systems) were tested for disinfecting surfaces that come in contact with food in the processing environment. Preliminary data from plasma-enhanced disinfection of flat surfaces (project developed for the Department of Homeland Security) indicate that under appropriate experimental conditions, the number of 5 log bacteria-count can be reduced 99.99% in treatment times as short as 3-4 minutes.

A Novel Plasma-Enhanced Way to Deposit Diamond-Hard Carbon Thin Layers under Atmospheric Pressure and Room Temperature Environments

*F.S. Denes, S.O. Manolache, L.E. Cruz-Barba, S. Kumar, A. Sumant

Funding: UW Ctr. for Plasma-Aided Manuf.; UW Biological Systems Eng.

Our recent experimental results prove that predeposited high molecular weight C-, H- and O-, and C- and H-based polymer thin layers, and even surface layers of similar solid-state polymeric substrates, are converted under SF_x and protons (generated under SF_6 and H_2 plasma environments) into "diamond-hard" carbon layers at low or atmospheric pressure conditions and room temperature in plasma-conversion times as low as 2 to 4 minutes. These findings open up a very attractive, novel way to synthesize scratch- and wear-resistant large-area surfaces with applications in the fields of advanced biosensors and bioactive materials.

Investigation of UV Treatment of Milk and Milk Products

*R.J. Reinemann, J.R. Bishop, K.B. Houck

Funding: Pure UV
Collaborators: UW Dairy Sci.; UW Ctr. for Dairy Research

A novel UV light treatment system is being evaluated for sanitizing milk and milk products. The objectives of this study are to establish the effect of UV treatment on the total psychrotrophic, themoduric, and spore-forming bacteria load of raw farm milk and the collateral effects of UV treatment on the sensory character of treated milk. The effect of UV treatment on the bacterial load of refrigerated raw farm milk, whey, and brine will also be investigated.

Mixing and Simulation Research

*R.K. Connelly

Funding: UW Foundation

Mixing is a particularly complex operation which is difficult to model due to the complex geometry and motions involved, as well as the fact that the materials being mixed are typically opaque and change continually with time. A tool ideally suited for exploring the effect of material properties and process geometry on flow patterns and mixing effectiveness of mixing processes is Computational Fluid Dynamics (CFD). In CFD, numerical simulation is used along with particle tracking to calculate the velocity, pressure, and stress fields from the fundamental physics that describes the system's behavior, and then uses that information to determine particle trajectories and field parameters that describe the flow conditions and mixing ability. The power of current computer hardware, such as the SGI Octane with dual processors, and the efficiency of current CFD commercial software packages, such as Fluent and Polyflow by Fluent, Inc., have increased to the point that simulation of flow and mixing in realistic mixers and mixing processes in 3-D is entirely possible.

In this work, the Finite Element Method CFD package Polyflow is being used to investigate mixing processes using highly viscous materials that fall into the laminar flow regime. Mixing systems where the flow domain can be fixed in time, such as in the vane mixer rheometer fixture, will be investigated with both generalized Newtonian fluid models and viscoelastic fluid models. Mixing systems with transient flow domains due to moving parts will be modeled using a mesh superposition technique. Research using this simulation approach is underway to model the flow and mixing behavior of model fluids in a Mixograph, a planetary pin mixer commonly used for flour testing. Additional work has been proposed to extend the flow and mixing simulation in the twin sigma blade Farinograph to more complex rheological models. To validate the mixing simulations, experiments are needed using fluids with behavior that is represented by the models used in the simulations. Therefore, an effort is underway to determine the properties of actual fluids that can serve as model fluids, particularly those used as food ingredients that are optically clear so as to allow flow visualization experiments, and then to fit that data to the rheological models available in Polyflow. In addition, experimental techniques are also under development for collecting such data as pressure, torque, energy input, and flow patterns that can validate the simulation results.

Investigation of the Effect of Mixing Intensity on Dough Development and Rheological Property Measurement

*R.K. Connelly

Funding: USDA Hatch

Wheat is one of the most important crops grown in the U.S., with 67.1 million acres planted and a total harvest of 2.34 billion bu in 2003. It is an increasingly important commodity in Wisconsin, with acres planted rising by nearly 60% during the last five years to a total of 212,000 and an excellent harvest of almost 12.3 million bu in 2003. Wheat is mainly used to produce flour for bread, baked goods, and snack foods. The strength of wheat flour is a critical property related to its ability to develop and retain desirable product properties during processing and is a function of the variety and growing conditions. It must be considered by breeders, growers, millers, and processors alike to insure proper flour selection and consistent final product quality for consumers. Mixing is a universal processing operation that must take flour strength into account and can be used to demonstrate it. However, the two most common mixing flour testing instruments, the Farinograph and the Mixograph, do not always give the same information because they use entirely different speeds, geometry, and mixing actions, with resulting differences in the mixing intensity. To better understand and evaluate the results generated by these two mixers, a more thorough understanding is needed of the rate, type, and range of strain experienced by the material as it is tested.

The main focus of this work is to explore the links of rate and type of strain to dough development for hard and soft winter wheat flour in a planetary pin mixer (Reomixer) and a twin-bladed sigma mixer (Farinograph). Initial results confirmed the dependence of dough development of flour/water dough on mixing

speed at low speeds in the Farinograph seen in the literature, while dough development at high speeds was attributable solely to energy input with hard and all-purpose strength flours in both mixers. Soft flours broke down too quickly to be conclusive. There was also visually apparent evidence of a lack of dough development at very low speeds in the Farinograph with hard flour. Since the Reomixer did not provide a direct measurement of torque that was needed to calculate energy input, modifications have been designed to allow both a lower speed range where dough mixing is expected to be speed-dependent, as well as to directly measure energy input. Work is currently underway looking at the differences due to mixing detectable in full formulation dough that includes baking tests, rheological testing, and NIR spectroscopy. Future work has been proposed in collaboration with R. Dempster at the American Institute of Baking and J.L. Kokini at Rutgers University that will further explore the ability of NIR spectroscopy to follow changes taking place in dough during mixing in batch and continuous mixers. In addition, extension of this research is planned to understand the effect of whole grain flours on dough mixing and development.

Effect of Drying Temperature, Water Content, and Heating Rate on Gelatinization of Corn Starches

*S. Gunasekaran, F. Altay

Funding: Hatch Funds

Gelatinization properties of starch extracted from corn and waxy corn dried at different temperatures were determined at various water contents and heating rates by differential scanning calorimetry. All gelatinization transition temperatures increased with drying temperature and heating rate. Onset and peak temperatures remained relatively constant, while end temperatures decreased in the presence of excess water. The gelatinization enthalpy (ΔH_g) of corn starch decreased with drying temperature at 50% water. It remained constant for waxy corn starch. The effects of water content and heating rate on ΔH_g depended on each other. Minimum water content required for gelatinization of starch extracted from corn dried at 20°C and 100°C are 21% and 29%, respectively. Activation energy (E_a) was calculated using an Arrhenius-type equation and two first-order models. The degree of conversion (α) was predicted using a new model we proposed which produced good results for both E_a and α.

In Situ Food Microstructure Evaluation

*S. Gunasekaran, S. Ko

Funding: Hatch Funds.

Image processing methods were developed for correcting confocal microscopy images for errors introduced while acquiring images and subsequent three-dimensional (3-D) image reconstruction. These include corrections for aberrations due to refractive index mismatch, light attenuation with sample depth, uneven intensity across image layers, and image misalignment. These procedures were validated using a simulated image with different illumination conditions. As example applications, dynamic changes in microstructure of process cheese during heating and gelation of β-lactoglobulin (whey protein) were studied *in situ*. The error-corrected image layers were used to reconstruct a 3-D composite image of fat globules in cheese. The techniques presented will allow objective evaluation of *in situ* changes in 3-D microstructural features in different foods.

Preparation of Sub-100 nm β-lactoglobulin Nanoparticles

*S. Gunasekaran, S. Ko

Funding: Gift Funds

We prepared sub-100 nm nanoparticles from β-lactoglobulin (BLG) with a narrow size distribution by a dissolving method using glutaraldehyde for cross-linking. By preheating the BLG solution to 60°C and subsequent pH re-adjustment to 9.0, the average particle size obtained was 59±5 nm. Preheating also improved particle size uniformity. Bovine serum albumin (BSA) nanoparticles, prepared under similar conditions for comparison purposes, were larger and less uniform. The half-width of 80% particle distribution was used to compare uniformity of particle size distribution. The stability of the nanoparticles was investigated by degradation experiments at neutral and acidic pHs with and without the proteolytic enzymes trypsin and pepsin. The degradation time, determined by a graphical approach, was used to compare the relative stabilities of BLG and BSA nanoparticles. BLG particles were more stable than those of BSA in acidic and neutral media with and without added enzymes.

Gelation of Alfalfa Soluble Leaf Proteins

*S. Gunasekaran, R.G. Koegel, B.P. Lamsal

Funding: USDA

Various alfalfa soluble leaf protein concentrates were prepared by freeze-drying acid-precipitated proteins (pH 3.5), resolubilized proteins (pH 7), and membrane-concentrated clarified alfalfa juice. Dilute leaf protein solutions were prepared by dissolving these concentrates in water. Storage modulus (G') of soluble leaf protein (SLP) solutions as they gel was monitored with a cone-and-plate probe during temperature sweep from 25 to 90°C and back to 25°C. G' values during the heating phase ranged from 5 to 120 Pa for 1.6 to 4% protein solutions. They increased to 3 kPa for 4% protein solution while cooling back to 25°C. Although the resulting gels were weaker, they exhibited distinct gelation temperatures of 77, 68, 66, and 60°C for 1.6, 2.7, 3.6, and 3.9% acid-precipitated SLP solutions, respectively. Apparent viscosities of solutions were also studied as a function of temperature and shear rate. Similar tests were conducted for soluble leaf protein and whey protein isolate biopolymer systems at different ratios. At a 1:3 ratio, leaf proteins interacted with whey proteins to increase G' during heating and cooling. The compressive failure force of standing gels produced from soluble leaf proteins and whey protein mixtures correlated well with their G' values from solution rheology. Results indicated that stable soluble leaf protein gels could be made in combination with whey protein isolates, presenting the possibility of incorporating them in food and non-food systems.

Microencapsulation and Oxidation Stability of Freeze-Dried Menhaden Oil Powder

*S. Gunasekaran, M.P. Richards, C. Sun
Funding: Gift Funds

Emulsions of menhaden oil and β-cyclodextrin (BCD) incorporating whey protein isolate (WPI) were freeze-dried to produce microencapsulated menhaden oil powder. WPI concentration, core-to-wall ratio, and storage temperatures were varied to evaluate their effects on microencapsulation efficiency (ME) and oxidative stability (OS) of menhaden oil powders. Peroxide value (PV) and anisidine value (AV) were measured to assess OS. Emulsion viscosity was measured before freeze-drying as a complementary tool to evaluate effects of composition and process parameters. ME of the microencapsulated oil powder was significantly affected by the composition parameters. The emulsion with 15% WPI exhibited an antioxidant activity based on the 30% BCD microencapsulation system. The PV increased with storage temperature due to high oxygen diffusion into the microencapsulated oil droplet. The 30% BCD + 15% WPI emulsion system with a core-to-wall ratio of 1:6 developed relatively higher ME of 74.2% and better OS compared to the same systems at core-to-wall ratios of 1:2 and 1:4. The results based on rheological measurements were consistent with those based on ME and OS. The statistical analyses indicated that the core-to-wall ratio might be the most important factor affecting ME and OS of menhaden oil powders.

Broadband Viscoelastic Spectroscopy of Foods

*S. Gunasekaran, R.S. Lakes, A.P. Singh
Funding: USDA Natl. Research Initiative

Three disparate food systems (gummy candy, Mozzarella cheese, and cooked ham) were characterized for their viscoelastic behavior under isothermal conditions over an extended frequency range of 10^{-3} to 10^{4} Hz using broadband viscoelastic spectroscopy (BVS). The materials were tested for any stress-induced fluid flow. However, no evidence of fluid flow was found under the tested frequency range. Validity of time-temperature superposition for the selected materials was also tested and compared with data from BVS.

Machinery and Harvesting

Manure Application Equipment Compaction Study

*J.L. Posner, G. Sanford, R.T. Schuler
Funding: UW Agronomy; UW Biological Systems Eng.
Collaborators: UW Agronomy; UW Biological Systems Eng.

Compaction caused by manure application equipment was evaluated in privately owned production fields and at the UW Agricultural Research Station in Arlington, WI. The equipment wheel traffic created compacted soil based on increased cone penetration resistance and reduced corn yield in the trafficked area. The yield for the total fields was not significantly reduced due to wheel traffic.

Krusenbaum Dairy Farm Study

*J.L. Posner, R.T. Schuler
Funding: UW Agronomy; UW Biological Systems Eng.
Collaborators: UW Agronomy; UW Biological Systems Eng.

Since 1990 scientists have followed changes and decision-making during the transition on the Krusenbaum Dairy Farm near East Troy, WI, from a confinement dairy to a rotational grazing dairy and to organic milk production. The time associated with machinery operation has been substantially reduced due to increased grazing. Machinery cost has not been significantly reduced because initially tractors and tillage machinery were purchased as used. Later, forage equipment was purchased as new, creating higher fixed costs.

Natural Resources and Environment

Densifying Agricultural Plastic Films into Packages Making Them More Convenient to Recycle

*B.J. Holmes, K.J. Shinners
Funding: UW Solid Waste Research Ctr.; UW Biological Systems Eng.

Objectives:

1. Improve Wisconsin's environment by developing a system for safely and conveniently delivering used agricultural plastic films to recycling centers or landfills.
2. Develop and test the effectiveness of a system for removing contaminants (water, soil and forage) from used agricultural plastic film.
3. Develop and test a system for densifying plastic film for convenient and economical transport to recycling centers.
4. Communicate results of the debris removal and densification system to representatives of the plastics recycling industry to determine if they can find a market for low density polyethylene (LDPE).

Use of agricultural plastic films has increased dramatically in recent years as low-cost forage storages and greenhouses for plants and animals have become more widely used. Plastic is seen throughout the countryside as: bunker silo and silage pile covers; silo bags; bale wraps or bags; bale tubes; and hoop structures with transparent covers. These films have a relatively short useful life from several months to several years before they become a waste product. Current disposal of waste plastic film is handled by on-farm dumping or burning, municipal landfill, and recycling. Recycling and municipal landfilling are usually acceptable environmental disposal methods, while on-farm dumping and burning raise environmental concerns and are illegal.

On-farm dumping and burning are convenient and low-cost. However, regulatory agencies throughout the country have raised concerns about the dioxin released during open burning of waste materials in general. Increased use and burning of agricultural plastic films pose health concerns for farmers, their families, their neighbors, and the customers who consume farm products. The Air Quality Division of the Wisconsin Department of Natural Resources (DNR), has conducted listening sessions to determine how open burning can be reduced. Recommendation 6 of the *Open Burning and Backyard Dumping Stakeholder* report to the DNR Board in December of 2003 states:

> Agricultural Wastes. We recommend an effort at the state level to develop workable efficient systems for the collection and recycling or disposal of agricultural plastic films and bags such as silage bags. These widely used agricultural plastic products can be very bulky, making them difficult and inconvenient to properly dispose. Farmers need convenient low cost alternatives in addition to information about regulations.

Recycling is limited because the films become soiled, and they are bulky and difficult to handle and relatively expensive to transport to landfills or recycling centers. Until recently, recyclers required extremely clean plastic, a requirement most used agricultural plastic could not meet. Also there is no convenient method for removing feed particles and soil to make them more acceptable to recyclers. Recently developed products made from recycled plastic have lower requirements for cleanliness, which has opened new markets for recycled agricultural plastic.

A machine to clean and densify plastic films has been developed and tested. The machine's cleaning portion uses rotating rubber rolls to pull the film through the machine. The rolls are powered by the hydraulics of a farm tractor through hydraulic pumps. As the plastic is drawn through the machine, rotating brushes scour dirt and debris from all surfaces. The plastic accumulates in a cage behind the cleaning portion of the machine. A hydraulic cylinder forces a plate against the accumulated plastic to compact it into a bale. Once sufficient film has accumulated, the compacted bale is tied and ejected from the cage so it can be picked up and put into storage prior to transport to a recycling center.

Mixing and Loading Facility Design Specifications

*D.W. Kammel

Funding: Wis. Dept. of Agric., Trade, and Consumer Protection

The Department of Agriculture, Trade, and Consumer Protection is updating rules for the bulk storage, mixing and loading of fertilizers and pecticides at commercial operations. Current recommendations on function system design and construction must be updated as well. This project involves editing and updating appropriate sections of the publication *Designing Facilities for Pesticide and Fertilizer Containment* (MWPS-37, copyright 1991) for use as the appendix that will accompany the written rules. This material will assist facility managers and designers with the design process and construction details for building properly designed facilities.

New Polymer Technologies for Controlling Soil and Phosphorus Loss from Farm Fields

*A.M. Thompson, J.M. Norman, C. Baxter, T.C. Hunt

Funding: UW Consortium for Ext. and Research in Agric. and Natural Resources (CERANR)

Collaborators: UW Biological Systems Eng.; UW Soil Sci.; UW-Platteville; Soil Net LLC

Management practices to reduce soil loss from agricultural fields are vital to sustain crop productivity and prevent nutrients that are adsorbed to soil particles from reaching waterways. Producers need cost-effective management practices for reducing soil and phosphorus (P) exports from their fields to meet strict environmental standards and still be able to earn a living. The goal of this study is to determine the ability of new polymer technologies to reduce soil and P loss from conservation tilled fields. New technologies have the potential of overcoming the two major impediments to polymer success/acceptance in rainfed regions: 1) the high application rates required and corresponding high cost, and 2) the labor and water required to dissolve polymers and maintain a low viscosity solution for spraying. Specifically, the polymer formulations show promise for effectiveness at low application rates and are highly soluble in water. Combined, these aspects will reduce the labor, water and cost required for effective soil and P control.

In the summer of 2005, laboratory rainfall simulations were conducted to screen several PAM formulations. Tests were performed on silt loam soil from the UW Arlington Agricultural Research Station. Soil was air-dried, crushed, passed through a 4-mm sieve, and packed in soil boxes (20×45 cm) on top of a coarse aggregate layer. Soil boxes were placed at a 10% slope. PAM was applied to the surface, and the boxes were exposed to simulated rain for 60 min. Total sediment loss from PAM-treated plots was compared to sediment loss from controls (no treatment). Three formulations that showed promise of reducing sediment loss at low application rates were selected for field testing.

In fall 2005, rainfall simulation experiments were conducted at the Arlington Research Station. Experimental plots 1.0×1.5 m were prepared by raking and removing surface residue. The soil was silt loam on a 8% slope. The PAM formulations included: 1) a liquid micro-emulsion of PAM, inorganic salts, water, oil and surfactant; 2) a dry granular formulation of high molecular weight PAMs and inorganic salts; 3) a dry granular formulation of different molecular weight PAMs, inorganic salts and carbohydrates. The liquid form was sprayed on the soil surface and the granular forms were applied by hand at 5.0 kg/ha. Rainfall was simulated at approximately 80 mm/hr for 30 minutes. All treatments were replicated three times. Repeat experiments were conducted about 10 days after the first ones to evaluate the longevity of the PAM treatments. The liquid emulsion was most successful at reducing total sediment loss. After 30 minutes of simulated rainfall, the liquid formulation reduced sediment loss by 89% on the first experiment and 58% on the repeat experiment. After the same duration, the liquid formulation reduced runoff by 32% on the first experiment and 6% on the repeat experiment. Total P was reduced an average of 29% compared to controls.

Characterizing Thermal Pollution in Urban Landscapes

*A.M. Thompson, K. Kim, J.M. Norman

Funding: USDA Hatch

Collaborators: UW Biological Systems Eng.; UW Soil Sci.

Impervious surfaces in urban areas are a source of thermal pollution in cold climates and threaten the health of cold-water ecosystems. Impervious surfaces absorb energy from the sun. During a rainfall/runoff event, runoff is warmed as it absorbs some of that heat energy. Higher runoff temperatures can raise the temperature of receiving waters. Stream temperature is a major limiting factor for cold-water fisheries. Increases in water temperature can result in biological impairment to aquatic habitat.

A field study has been conducted at the UW West Madison Agricultural Research Station (WMARS): 1) to study increases in pavement temperature and the subsequent transfer of heat to stormwater runoff, and 2) to compare the hydrologic and thermal response of similarly sized areas of asphalt and sod. Asphalt and sod plots (9×15 m) have been instrumented to measure rainfall intensity and spatial depth, rainfall temperature, solar radiation, wind speed, air temperature, pavement temperature at various depths and locations, sod temperature at various depths and locations, soil moisture, runoff temperature, and flow rate. The system is designed to capture both natural and simulated rainfall/runoff events. Two seasons of simulated field experiments have been conducted. Natural rainfall/runoff events will be monitored during the summer of 2006.

A LaGrangian-stochastic model was developed to simulate thermal runoff from impermeable surfaces. The model employs an approach based on the framework of the mass response functions (MRFs) originally developed for non-point source pollutant transport in watersheds. The model is the first attempt to apply MRFs to thermal runoff modeling. The model has been applied to the data collected from the field study conducted at WMARS. The model successfully reproduced the temperature of impermeable surface and runoff. An urban watershed in Madison, WI, has been selected for the watershed-scale application of the developed model. Preliminary geographic information system (GIS) data of the site have been established. Thermocouples and a flow meter have been installed at the watershed outlet to measure runoff temperature and flow rate in 2006.

Rock cribs are a current mitigation strategy to reduce runoff temperature prior to runoff entering thermally sensitive waters. A laboratory study has been conducted to quantify the effectiveness of rock cribs on reducing runoff temperature. Their effectiveness depends on the influent temperature, the initial crib temperature, the amount of water in the crib prior to stormwater entering the crib, and the size of the crib. Results from the laboratory experiments have been used to validate and modify a numerical routine that predicts heat transfer between the stone and the water and, ultimately, the effluent water temperature. The model will be used to develop design standards for using rock cribs as temperature reduction devices.

Effectiveness of Urban Lawns to Hydrologically Disconnect Impervious Areas

*A.M. Thompson, R. Bannerman, K.W. Potter

Funding: Wis. Dept. of Natural Resources

Collaborators: UW Biological Systems Eng.; Wis. Dept. of Natural Resources; US Geological Survey; UW Civil & Env. Eng.

Accurate stormwater runoff prediction depends on the amount of impervious surface area within a watershed and the level of connectedness of that impervious area. Although the degree of imperviousness is relatively simple to quantify, the level of connectedness is not. The issue is further complicated by the lack of understanding of the hydrologic response of urban semi-pervious areas. The goal of this project is to quantify the rainfall-runoff response of urban residential lawns and determine their ability to hydrologically disconnect impervious surfaces. Two seasons of field experiments on residential lawns in Dane County, WI, have been conducted.

During the first season, lawn run-on from rooftop downspouts was simulated on six residential lawns in Madison, WI. Runoff was measured at two distances from the downspouts, and inundated area was delineated as a function of distance from the downspout. During the second field season, experiments were conducted to further quantify the relationship between inundated area and distance from a downspout. Experiments were conducted on six young lawns (less than 10 yrs old) in Cross Plains, WI, and on six well-established lawns (more than 50 yrs old) in Madison, WI, at two run-on rates. Inundated areas were periodically delineated until steady-state conditions were achieved.

Regression models were fit to the combined distance-area data sets, and a power function produced the highest R^2 (area = $1.20 \times \text{distance}^{1.26}$). A mass balance was used to predict lawn runoff coefficients as a function of the ratio of roof/lawn area and lawn saturated hydraulic conductivity.

Development of Polymer Application Method for Water Clarification

*A.M. Thompson, R. Shrestha, A. Roa-Espinosa

Funding: UW Industrial and Economic Development Research Fund; gifts

Collaborators: UW Biological Systems Eng.; CFM, Inc.; Soil Net LLC

A common management practice for controlling sediment is the use of stormwater detention facilities. These facilities remove sediment from stormwater runoff by reducing discharge rates, thus allowing time for sediment to settle out of suspension. Due to practical size limitations, these devices are usually only able to retain stormwater discharges for a period of minutes or hours. Since silt and clay particles may require days to settle out, traditional stormwater detention facilities are not very effective at removing such particles from stormwater. Sediment-flocculating polymers can accumulate and remove suspended sediment from stormwater, thereby enhancing water clarification.

The use of polymers for sediment removal in detention ponds is complicated by the temporal variability in sediment loads to the basin and the need for mixing to ensure adequate distribution of the polymer. Laboratory experiments were conducted to determine the effect of different types, forms and concentrations of polymers, and of mixing speeds on removal of suspended sediment. In addition, calcium, aluminum and citric acid were evaluated to determine their ability to increase the efficacy of polymers to remove suspended sediment. Four polymers (Magnafloc LT27, SoilNet 926, SoilNet 934, SoilNet 945) were studied with a silt loam soil. Solution forms of polymers were highly effective immediately after application with more than 95% suspended sediment reduction regardless of mixing speed. However, granular forms of polymers were effective in reducing suspended sediment by 95% or more only at mixing speeds greater than 130 rpm. The effectiveness of the polymers to reduce suspended sediment was related to sediment load and polymer concentration. At sediment concentrations more than 10,000 ppm, polymer concentration of 1 ppm reduced suspended sediment more than 90% after two minutes of settling and more than 95% after five minutes of settling. At low sediment concentrations (2,000 ppm), greater polymer concentrations (5, 10 ppm) decreased the efficiency of the polymers significantly. At the same low sediment concentration, polymer:citric acid:$AlCl(0H)_5$ and polymer:Ca:$AlCl(OH)_5$ at ratios of 1:1:1 increased the polymer efficiency from 62% to 85% while maintaining the solution pH above 8 and close to the initial pH.

Infiltration and Pollutant Removal Capacity of Engineered Soils for Use in Urban Bioretention Basins

*A.M. Thompson

Funding: UW Graduate Sch.; Wis. Dept. of Natural Resources
Collaborators: UW Biological Systems Eng.; Wis. Dept. of Natural Resources

Bioretention is a relatively new management practice to treat urban stormwater. A bioretention basin is a gravity flow system which combines plants, mulch, engineered soil, and piping at the base to allow drainage. Engineered soil is a mixture of sand, soil, and compost. Stormwater runoff is directed into and temporarily stored in the basin, allowing contaminated water to infiltrate through the engineered media. As the water filters through the media, physical, chemical, and biological processes treat this water. After passing through the media, the water either infiltrates into the surrounding native soil where it can enhance groundwater recharge, or excess water is discharged to a stable outlet. The goals of this study are to determine infiltration rates and pollutant removal capabilities of engineered soils.

Laboratory experiments using flow-through columns were conducted on engineered soils with percentages of sand, soil, and compost ranging from 30-60%, 20-50%, and 20-50%, respectively, Columns were 15.2 cm in diameter, contained 30.5 cm of engineered soil, and were maintained at a constant water head of 30.5 cm. Infiltrative capacity, saturated hydraulic conductivity, porosity, bulk density, and moisture-holding capacity were measured. All soil mixtures provided rapid infiltration rates and high saturated hydraulic conductivity. Porosity, bulk density, and moisture-holding capacity were primarily influenced by the percentage of compost in each mixture.

Flow-through studies using synthetic stormwater were conducted to determine pollutant removal rates from the same engineered soil mixtures. Columns were 5.1 cm in diameter and contained 10.2 cm of engineered soil. Synthetic stormwater was prepared by dissolving cadmium, copper and zinc at concentrations of 0.5, 0.5 and 6.25 ppm, respectively (representative of typical urban stormwater). It was then passed through the soil columns at a rate approximately equal to the saturated hydraulic conductivity for 8 h, and the removal efficiencies of each dissolved metal species were monitored over time. Each engineered soil mixture provided more than 90% removal of all three metals. Concentrations were increased by more than an order of magnitude to determine breakthrough curves of each metal. The ability of the engineered soils to remove dissolved contaminants over longer periods of time is related to the composite cation exchange capacity of the mixture. Soils with higher exchange capacities removed the metals more efficiently for longer periods.

Surface Water Quality Impacts of Management Intensive Rotational Grazing

*A.M. Thompson, F.W. Madison

Funding: USDA Natural Resources and Conservation Service; UW Ctr. for Integrated Agric. Systems; Wis. Dept. of Agric., Trade, and Consumer Protection
Collaborators: UW Biological Systems Eng.; UW Soil Sci.; UW Agronomy

Management Intensive Rotational Grazing (MIRG) is a farming system that has grown in acceptance in Wisconsin. Herd sizes are increasing, and animals are being overwintered in a variety of settings, some of which may create environmental problems. The objective of this project is to further understanding of the environmental impacts of MIRG through: 1) quantification of sediment and nutrient loads (nitrogen, N; phosphorus, P) from overwintering areas and 2) quantification of spatial and temporal variations in soil and vegetation characteristics in overwintering areas. Two research sites representing different soil and physiographic regions in Wisconsin have been selected: 1) the Breneman Farm located in Columbia County and 2) the Klessig Farm located in Manitowoc County. Both farms are part of the Discovery Farm program. Soils on the Breneman and Klessig farms are coarse-textured and red clay, respectively.

An H-flume and automatic water sampler (ISCO) were installed at the outlet of the overwintering area on the Breneman farm. A culvert, area-velocity meter and automatic water sampler (ISCO) were installed at the outlet of the overwintering area on the Klessig farm (for which USGS weather station data are available). On both sites, intensive topography surveys have been conducted to build digital elevation models of the watersheds. Initial soil surveys were conducted on each farm. Approximately 100 surface soil samples (0-10 cm) were taken on each overwintering area and analyzed for P.

Snowmelt and runoff samples collected at the Breneman

site during 2005 were analyzed for total suspended solids, chloride, P (total, total dissolved, dissolved reactive P) and N (total, nitrate/nitrite, ammonium-N) species. Intensive soil and vegetation sampling was conducted in October of 2005 on both farms. Twenty samples were taken in each paddock (7 paddocks on the Breneman farm, 6 paddocks on the Klessig farm) within the overwintering drainage areas. Sampling locations were recorded by GPS coordinates and were determined by applying a stratified random unaligned sampling scheme to each of the roughly equal area partitions in individual grazing paddocks. At each sampling site, leaf area index (Li-Cor LAI-2000), forage yield (rising plate meter), stem density, thatch cover, and thatch thickness were measured. Surface soil samples (top 5 cm) were taken at each sampling location and analyzed for total N, nitrate-N, ammonium-N, organic matter, total P, and available P. A statistical analysis is being conducted to determine relationships among sampling parameters, among paddocks on the same farm, and between the Breneman and Klessig overwintering areas. Data have been incorporated into a geographic information system using ArcView 3.3 to allow for temporal and spatial comparisons.

Heat tape and insulation pipes were installed, along with running electricity directly to the runoff collection sites, to improve runoff monitoring during freezing and thawing periods. Sampling of vegetation and soil will continue throughout 2006 with the addition of surface roughness and soil compaction measurements.

Groundwater Mounding and Contaminant Transport Beneath Stormwater Infiltration Basins

*A.M. Thompson

Funding: Wis. Dept. of Natural Resources
Collaborators: UW Biological Systems Eng.; Wis. Dept. of Natural Resources

Landscape changes that accompany urbanization cause increases in runoff rates and volumes and decreases in groundwater recharge. Infiltration basins are a stormwater management practice often used to enhance groundwater recharge, thereby offsetting the impacts of urbanization. Infiltration basins are contructed as depressions in the landscape's surface and function by holding large volumes of stormwater long enough to allow the water to infiltrate into the soil. Groundwater mounding may be caused by localized recharge to the saturated zone in an unconfined aquifer in the immediate vicinity of the infiltration basin. Estimating the shape and height of the groundwater mound is important to provide an estimate of the ability of the soil beneath an infiltration basin to absorb stormwater. Since urban stormwater commonly contains pollutants (pesticides, nutrients, heavy metals, dissolved minerals, volatile organic compounds), stormwater movement into and through the soil beneath the infiltration basin can deliver these pollutants to the groundwater.

In an urban setting, the depression-focused recharge that occurs beneath infiltration basins represents an important connection between surface water and groundwater. The complex interactions between surface and groundwater in depression-focused recharge zones are poorly understood, yet critical for the accurate design, implementation, and management of infiltration basins and assessment of groundwater contamination through infiltration of stormwater. The objectives of this project are:

1. Monitor groundwater levels and changes in soil moisture content in the unsaturated zone in response to infiltrating stormwater from an infiltration basin.
2. Apply a conservative and non-conservative tracer to the infiltration basin and to monitor the migration of the tracer from the basin into the unsaturated zone and into the groundwater.
3. Calibrate and validate a groundwater flow and contaminant transport model using data obtained under objectives 1 and 2.
4. Use the model to extrapolate field data to other hydrogeologic settings.

Work conducted to date includes site selection, research of groundwater models to be used, and monitoring well and equipment installation. Site selection involved reviewing many potential sites in both Dane and Waukesha Counties. Site selection criteria included recent documentation of infiltration (or high likelihood of infiltration in the case of new basins), shallow depth to groundwater, permeable soils, large watershed to basin area ratio, site access, and permission of basin owner.

An infiltration basin installed during 2001 serving a 23-acre subdivision on the east side of Oconomowoc, WI, was selected. Infiltration was required to mitigate the thermal impacts of runoff to Rosenow Creek, a cold-water fishery approximately 500 feet northeast of the basin. The basin covers roughly 0.25 acre with a 0.27-acre sediment basin/wetland area for pretreatment.

Three monitoring wells were installed inside the basin, and soil moisture probes were installed at two depths in the unsaturated zone at the center of the basin. The monitoring wells have been developed, and slug tests were performed to determine horizontal hydraulic conductivity. A groundwater penetration radar survey of the site has been completed, which shows subsurface changes in stratigraphy. A datalogger, weather station, and pressure transducers have been installed at the site. The datalogger will collect data on groundwater level, soil moisture, ponded water level, precipitation, solar radiation, wind speed, relative humidity, and air temperature. Water level and soil moisture readings will be collected at an increased frequency during and shortly after precipitation events.

Use of Cold Plasma to Functionalize Fibers for Filtration Research

*F.S. Denes, R.M. Rowell, C.G. Hunt

Funding: USDA Forest Service, Forest Products Lab; UW-Madison

Use of low-pressure, non-equilibrium, plasma-crosslinked surfaces of cellulose fibers previously embedded into poly(acrylic acid) to improve their ability to absorb contaminants from water is the main objective of these investigations. A rotating and a stationary parallel plate plasma-reactor is considered for the functionalization of cellulose and low-cost wood fibers.

The plasma-modified fibers will be used to remove both cations and anions, as well as other toxic organics, from contaminated water. These research investigations are performed in collaboration with PPL-Madison and industrial partners for the evaluation of scaling-up possibilities of the plasma technology.

Biomaterials as Sorbents for Environmental Contaminants

*K.G. Karthikeyan, E.W. Shin, M.A. Tshabalala

Funding: USDA Forest Service, Forest Products Lab

Collaborators: UW Biological Systems Eng.; USDA Forest Service

This study compared the capacity of sorbents prepared from juniper wood (JW) and bark (JB) to adsorb cadmium (Cd) from aqueous solutions at different pH values. Adsorption behavior was characterized through adsorption kinetics, adsorption isotherms, and adsorption edge experiments. Results from kinetic and isotherm experiments showed that JB (76.3-91.6 μmol Cd/g substrate) had 3 to 4 times higher adsorption capacity for Cd than JW (24.8-28.3 μmol Cd/g). In addition to higher capacity, JB exhibited a higher strength of adsorption (45.3 *vs*. 9.1 L/mmol) and faster uptake kinetics (0.0119 *vs*. 0.0083 g/μmol/min) compared to JW. For both adsorbents, increasing Cd adsorption with increasing solution pH in the range of 2 to 6 suggests that surface carboxyl groups (RCOOH) might be involved in interaction with Cd. Diffuse reflectance infrared Fourier transform spectra showed that the surface concentration of carboxyl groups was higher on JB compared to JW. The ratio of Ca released to Cd adsorbed was 1.04 and 0.78 for JB and JW, respectively, indicating that Ca-Cd ion exchange was the primary mechanism involved. The higher Ca content in JB (15 times more) and the surface RCOOH concentration (2.5 times more) can be attributed to the observed differences in Cd adsorption behavior between the two lignocellulosic adsorbents.

A Spatially Distributed Phosphorus Module of the Precision Agricultural-Landscape Model: Description, Calibration and Verification

*K.G. Karthikeyan, P.S. Miller, J.M. Norman, C.C. Molling

Funding: USDA Natl. Integrated Water Quality Program, Integrated Research, Educ. and Ext. Applications

Collaborators: UW Biological Systems Eng.; UW Soil Sci.; Wis. Discovery Farms Program; UW Agric. Research Stations

` The goal of this research is to use a process-level model to quantify phosphorus (P) losses from farm fields under different management options and then to extend the use of this model to recommend practices that should minimize water quality degradation. The objective is to add sediment loss and P-chemistry components to an existing Precision Agricultural-Landscape Modeling System (PALMS), to evaluate key runoff parameters with measurements on several field plots, and to test the model over the entire sub-watershed using USGS stream monitoring data. The selected watershed is known to be subject to large P losses from USGS stream monitoring (0.5 mg P/L) and is a Wisconsin Discovery Farm, one of 30 such farms chosen from a pool of volunteer farmers to represent standard farming practices and to serve as a focus for research that will maintain profitability while improving environmental health. Therefore, this study will benefit directly from the Discovery Farm infrastructure, and results will be directly transferable to other Discovery Farms.

4D-P is a spatially and temporally distributed agricultural P-cycling model being built as part of PALMS. PALMS is a complex environmental simulation model integrating diffusive wave runoff routing with ponding capabilities and a biosphere simulator. The General Erosion Modeling Subroutine (GEMS), a new module which integrates the algorithms from WEPP for spatially distributed applications, has also been included. 4D-P is being built into this system to model P cycling within an agricultural field and is an extension of the P modeling systems developed and incorporated in EPIC and SWAT. Five sub-modules comprise 4D-P: INITP, a 3-dimensional P soil initializing sub-module; PSSL, a P-cycling single soil layer sub-module; PMOVE, a chemical transport sub-module; PTILL, a tillage and fertilizer sub-module; and PSUM, a chemical transport aggregator that tracks and accounts for P redistribution across the landscape. Each module will track P cycling at various time steps from seconds for PMOVE to singular event occurrences such as tillage operations in PTILL. Results will be contrasted with field data including total dissolved P and total P from three fields established under different crop harvesting and manure management systems at the UW Agricultural Research Station in Arlington, WI.

Storage of Sediments and Particulate-Bound Phosphorus in an Agricultural Landscape

*K.G. Karthikeyan, P.E. Cabot, P. Novak, R.C. Lathrop

Funding: US Env. Protection Agency (STAR Program) – Nutrient Sci. for Improved Watershed Mgmt. Program

Collaborators: UW Biological Systems Eng.; UW Civil and Env. Eng.; UW Forest Ecology and Mgmt.; UW Rural Sociology; UW-Platteville; Wis. Dept. of Natural Resources

This study fosters more effective landscape targeting of non-point problems by analyzing sediment and phosphorus (P) accumulation in landscape "depressions". These depressions are of particular interest to the study of P delivery from farm fields because they may be acting to reduce the overall watershed area that contributes to non-point source pollution. Thus, the study elucidates the disproportionate influence of specific landscape features by abetting or mitigating non-point source pollution. The potential for colluvial storage zones and unchanneled landscape depressions to alter the temporal pattern of constituent delivery and interrupt sediment and P transfer continuums was assessed. A more complete understanding of these continuums is needed in watersheds dominated by colluvial landscape features in order to accurately manage for P delivery from upland agricultural areas to downstream receiving waters.

The study of colluvial storage zones focused on three primary objectives. First, radiometric techniques for sampling soils using fallout Cs-137 were used to quantify erosion and deposition rates. Although various methods are used to predict watershed degradation and aggradation rates from areal Cs-137 inventories, these methods are rarely extended to examine sediment-bound constituent movement.

Secondly, erosion and deposition patterns estimated from Cs-137 activities were then examined in relation to P sorption

characteristics of sediments delivered to and deposited within erosional and depositional landscape locations. The purpose of this objective was to determine the immobility of P at particular positions within the watershed and ultimately to understand the degree to which depressional zones act as sinks or sources of P in spillage or subsurface drainage pathways.

Finally, the potential for P movement in different forms from depressional zones was explored. Erosion is often regarded as the primary factor influencing P transport since P is less readily desorbed from soil particles once it has been adsorbed. So P movement is typically associated with particulate P forms. At scales where the sediment and P transfer continuums are interrupted by colluvial sinks and depressional zones, however, exceptions to this condition may exist.

Evaluation of Temporal and Spatial Sediment Dynamics in Agricultural Fields using Lanthanide Tracers

*K.G. Karthikeyan, P.S. Miller, P.D. Gaebler, S.M. McClure, J.D. Grande, P.E. Cabot, P.J. Whiting

Funding: USDA Natl. Research Initiative

Collaborators: UW Biological Systems Eng.; UW Agric. Research Stations; Case Western Reserve U.; USDA Agric. Research Service

A fully integrated hill-slope scale hydrologic monitoring project has been initiated to evaluate sediment transport mechanisms by combining a network of surface runoff sensors monitoring the temporal and spatial occurrence of runoff with lanthanide (rare earth element [REE] oxides) tracer analysis and radiometric (Be-7, Pb-210, Cs-137) fingerprinting. These methods have been combined on a hill slope with a Plano silt loam soil at Arlington, WI, under two tillage orientations. Data were collected from a series of three rainfall-runoff events. The objectives are: 1) to determine spatial patterns of runoff and sediment movement for different agricultural management systems, and 2) to link sediment source areas to phosphorus export dynamics. The runoff sensors contain an IC chip design comprising a voltage regulator and a hex Schmitt trigger. The sensor operates in a current loop calibrated to be 4 mA when no water is present and 20 mA when water bridges a section of the circuit mounted on precision laser-cut steel mounts located in critical areas in the field. Areas of soil erosion are being characterized by monitoring the migration of REE oxide-tagged soils. An optimal hill-slope length (36 ft from edge-of-field) has been divided into three segments within which different types of soil-REE (Gd, ND, Pr) oxide mixtures were placed. The redistribution of REE-tagged soils and the REE concentration in suspended sediments are being used to delineate source regions and to determine characteristic transport distances. Preliminary data indicate a good correspondence between the sedigraph peaks and contributions from the downslope REE segment during the initial runoff event. Contributions from the upslope REE segments become more pronounced during the second and third runoff events in the storm series. Our results suggest the suitability of using REE-tagging technique to acquire information on spatial and temporal patterns of sediment movement in agricultural fields.

Evaluation of Temporal and Spatial Sediment Dynamics in Agricultural Fields using Naturally-Occurring and Fallout Radionuclides

*K.G. Karthikeyan, P.E. Cabot, A. Stubblefield, P.J. Whiting, G. Matisoff, P.D. Gaebler, S.M. McClure, J.D. Grande

Funding: USDA Natl. Research Initiative

Collaborators: UW Biological Systems Eng.; UW Agric. Research Stations; Case Western Reserve U.; USDA Agric. Research Service

Sediment yield from specific erosional mechanisms is difficult to quantify in agricultural settings. However, management and understanding of erosional processes can benefit from improved process description. We report on using use of novel techniques for tracing and fingerprinting soil movement in response to thunderstorm activity. Two erosion plots (one with contour tillage, one with up-down tillage) were installed on a hill slope planted to corn on a Plano silt loam soil at Arlington, WI. Within the framework of an erosion plot study, soil depth distributions and runoff concentrations of the radionuclides Cs-137, Pb-210, and Be-7 were determined, lanthanide-tagged soil applied, and a surface runoff sensor network installed. The objectives were: 1) to quantify rill and sheetwash erosional mechanisms for different agricultural management techniques, and 2) to investigate the implications of our findings for phosphorus export. Radionuclides have characteristic depth distributions in surface soils as a result of the time and mechanism of delivery and land use practices. Thus, the radionuclide concentrations of runoff sediment can be used to estimate from what depth sediment eroded. Preliminary data show strong temporal variation in sediment Be-7 activity in relation to storm intensity and sediment yield. Be-7 activity varies inversely with sediment yield. We interpret this to indicate periods of peak runoff resulting in rill incision and the access of low Be-7 sediment deeper in the profile. Radionuclide data will be modeled using the Simultaneous Rill-Sheet Erosion Model (SiRSEM). The program uses the depth distributions in a mass balance approach to determine the depth and area of rill and sheet erosion on the plot that best matches the sediment and radionuclide yield for each event.

Characterizing Phosphorus Forms in Snowmelt Runoff from Three Corn Management Systems

*K.G. Karthikeyan, J.C. Panuska, P.S. Miller, R.C. Lathrop

Funding: US Env. Protection Agency (STAR Program) – Nutrient Sci. for Improved Watershed Mgmt. Program

Collaborators: Wis. Dept. of Natural Resources

Information on phosphorus (P) transport in agricultural landscapes has been mainly generated for rainfall runoff events from both plot and field-scale studies. Data on P losses and the forms of P from snowmelt and rain-on-snow runoff events are limited. The processes governing detachment and transport of sediment differ significantly between the snowmelt and growing season time periods. In this study a systems approach was used

on three hydrologically isolated hill-slope tracts (3.7 × 36.6 m) where natural snowmelt and rain-on-snow runoff were collected using bulk overland flow samplers. All fields were planted in corn (with conservation tillage-fall chisel plow) but had extremes in residue cover created by different harvesting schemes. The schemes considered in this study were: grain (high residue), silage (low residue), and silage with fall manure application (intermediate). Runoff samples were analyzed for total solids, volatile solids, and different forms of P (dissolved *vs*. particulate bound). The median total P, total dissolved P, and dissolved reactive P concentrations during melt events were higher from the silage-manure site compared to the other two treatments, attributable to manure (i.e., P) inputs during the previous fall season. Time-dependent changes in sediment concentration and P forms were also observed during the snowmelt process.

Measuring and Modeling the Source, Transport and Bio-Availability of Phosphorus in Agricultural Watersheds

*K.G. Karthikeyan, P.E. Cabot, J.C. Panuska, P. Novak, R.C. Lathrop

Funding: US Env. Protection Agency (STAR Program) – Nutrient Sci. for Improved Watershed Mgmt. Program

Collaborators: UW Biological Systems Eng.; UW Civil and Env. Eng.; UW Forest Ecology and Mgmt.; UW Rural Sociology; UW-Platteville; Wis. Dept. of Natural Resources; UW Agric. Research Stations

The focus of this project is on scale-dependent processes that link agricultural phosphorus (P) sources to watershed export of bio-available P (BAP). Specific objectives are to quantify the effects of manure management on runoff BAP and to determine the relation of BAP losses to the scale of animal operations. Firstly, this research addresses the need to validate plot-scale research at coarser scales. This issue is of growing importance in understanding the effect that the watershed flow system has on P delivery from agricultural fields. Secondly, it illustrates how field-scale studies can be conducted without greatly compromising the detail provided by research at finer scales. A research design is being used involving sheet-flow samplers that are capable of capturing runoff from fields comparable in size to fields farmers actually manage. Finally, we will use manure management as a research variable at the scale that farmers manage animal manures.

A systems approach was used on three hydrologically isolated hill-slope tracts (3.7 × 36.6 m) and natural runoff from both rainfall and snowmelt events collected using bulk overland flow samplers. The objectives were: 1) to determine the size distribution of primary particles and aggregates in runoff, 2) to determine total P mass distribution across particle-size fractions in runoff, 3) to investigate the physical stability of aggregates and the factors affecting their stability in runoff, and 4) to evaluate the transport potential of particulate P. All fields were planted in corn (with conservation tillage-fall chisel plow) but had extremes in residue cover created by different harvesting schemes, namely grain (high residue) and silage (low residue). Runoff samples were analyzed for total solids, volatile solids, particle size distribution (five discrete size classes by gravity sedimentation – <2, 2-10, 10-50, 50-500, and >500 μm; continuous size distribution using laser diffraction), different forms of P, and P mass distribution in different size classes. Results indicated that more than 90% of P was transported in a particulate-bound form with a significant fraction (60%) on particles less than 50 μm. Higher P loads were observed in rainfall-runoff compared to snowmelt events. A P mass-particle-size regression equation was developed to quantify P-mass distribution in different sediment-size classes. Among the three different corn management systems, sediments from the corn-grain field had the highest degree of aggregation and the most stable aggregates. Unique time series data was generated on solids and P losses for three events in a series that occurred during a one-week period.

Solution and Nitrogen Dynamics in Soils Receiving Chemically Treated Manure

*K.G. Karthikeyan, M. Kalbasi, P.S. Miller

Funding: Wis. Fertilizer Research Council

This study attempts to bridge the gap between our knowledge of chemical treatment systems for dairy manure and the ultimate fate of nutrients (N and P) when the treated manure is land applied. Our results, in conjunction with those from chemical treatment studies, will help select optimum formulations of chemicals (coagulants and flocculants) that can maximize concentration of solids/nutrients in dairy manure as well as provide the greatest protection against adverse water quality impacts. Our findings are critical for designing any chemical treatment and land application system, which will provide increased options to manage dairy manure.

An incubation study was conducted to determine the effect of chemically treated manure addition (three treatments: alum-Al; $FeCl_3$-Fe; CaO-Ca) on short- and long-term N dynamics in soils. Two manure application rates were used in addition to a control (no manure). Sub-samples were analyzed for pH, electrical conductivity (EC), water-extractable NO_3^- ($WENO_3$), NO_2^-, and K^+-extractable NH_4^+ after 1 d, 1 and 2 wks, 1, 3 and 6 mos, and 1 and 2 yr. Soil pH increased significantly only for the application of Ca-treated manure after all incubation periods and was sensitive to the application rate. Soil pH decreased sharply, however, between 1 d and 1-2 wks or remained unchanged (compared to control) for the other treatments. Nitrate release was controlled by the treatment type (untreated > chemically treated manure > control) and increased sharply between 1 d and 1 wk and then slowly at longer incubation periods. Based on the percent of applied inorganic N released as $WENO_3$ (P_{WENO3}), differences between chemical treatment types mostly followed this order: untreated > Al-treated > Ca-treated > Fe-treated. Doubling the manure application rate had no effect on P_{WENO3}. The trend in EC followed that of $WENO_3$, resulting in an excellent correlation ($r^2 = 0.96$) between the two variables. In contrast to NO_3^-, K^+-exchangeable NH_4^+ decreased sharply between 1 d and 1 wk and then remained relatively constant for up to 2 years. Untreated manure had the highest ratio of exchangeable NH_4^+ to applied inorganic N after 1 wk, and the differences between

chemical treatment types were insignificant. Application of chemically treated (especially Fe- and Ca-treated) manure appears capable of decreasing the extent of initial (up to 1 wk) rapid nitrification. Besides short-term effects, adding $FeCl_3$ is effective in lowering $WENO_3$ even after 2 years of incubation.

Soluble Phosphorus Extraction and Recovery from Anaerobically Digested Dairy Manure

*K.G. Karthikeyan, K. Gungor

Funding: Wis. Fertilizer Research Council

The major goal of this study was to investigate the feasibility of developing a phosphorus (P) recovery system for anaerobically digested dairy manure. Effluent samples were collected from six on-farm anaerobic digesters in five dairy operations in Wisconsin: Double S, Gordondale, Stencil, Tinedale, and Wholesome. Wholesome dairy has two digesters (Wholesome-East and Wholesome-West), while the other operations have only one. All effluent samples, except for Double S, were obtained directly downstream of the digesters. Since the Double S digester has no direct access to the effluent, the sample was collected downstream of the solids separator. Average water-extractable P (WEP) of these digester effluents was comparable: 2.9, 2.9, 2.8, 2.8, 2.4, and 2.5 g/kg for Double S, Gordondale, Stencil, Tinedale, Wholesome-East, and Wholesome-West, respectively. However, differences were observed in the ratio of WEP to total P (TP). WEP/TP ratios were 36.9, 26.5, 43.1, 35.6, and 38.2% for the corresponding samples. Samples from Gordondale with the lowest and from Stencil with the highest WEP/TP ratio are being used in the P recovery program. P fractionation of Gordondale effluent was performed using a Retsch automated sieve shaker. Six sieves with opening sizes of 1000, 500, 250, 106, 53, and 25 μm were used. Percentage of TP retained by each sieve was 34.8, 21.6, 11.0, 5.4, 5.2, and 22.0%, respectively. Preliminary results indicate that P in anaerobically-digested effluent can be partitioned into two major size fractions: 67.4 and 22% of P in size ranges of >250 and 25-53 μm, respectively.

Phosphorus Forms and Extractability in Dairy Manure: A Case Study for Wisconsin On-Farm Anaerobic Digesters

*K.G. Karthikeyan, K. Gungor

Funding: USDA CSREES

The effect of anaerobic digestion on phosphorus (P) forms and water P extractability was investigated using dairy manure samples from six full-scale on-farm anaerobic digesters in Wisconsin. Total dissolved P constituted 12±4 and 7±2% of total P (TP) in samples influent to and effluent from anaerobic digesters, respectively. Dissolved unreactive P (DUP), comprising polyphosphates and organic P, dominated the dissolved P component in both influent and effluent. In most cases, it appeared that the fraction of DUP mineralized during anaerobic digestion became subsequently associated with particulate-bound solids. Geochemical equilibrium modeling with Mineql+ indicated that dicalcium phosphate dihydrate, dicalcium phosphate anhydrous, octacalcium phosphate, newberryite, and struvite were the probable solid phases in both digester influent and effluent samples. Water-extractable P fraction in undigested manure ranged from 45 to 70% of TP, which reduced substantially after anaerobic digestion to 25 to 45% of TP. Anaerobic digestion of dairy manure appears capable of reducing the fraction of P that is immediately available by increasing the stability of the solid phases controlling P solubility.

Complexation of the Antibiotic Tetracycline with Humic Acid

*K.G. Karthikeyan, C. Gu, J.A. Pedersen

Funding: Wis. Groundwater Coordinating Council; UW Water Resources Inst.; Wis. Dept. of Natural Resources; Wis. Dept. of Agric., Trade, and Consumer Protection
Collaborators: UW Biological Systems Eng.; UW Soil Sci.

Antibiotics are used extensively in human therapy, veterinary medicine, and as animal husbandry growth promoters. Detection of antibiotics as emerging contaminants in surface and ground water raises concerns about their presence. Our recent statewide survey detected eight compounds in five classes in the following order of frequency of detection: tetracyclines and trimethoprim > sulfonamides > macrolides > fluoroquinolones. Our ability to predict the fate and mobility of antibiotics is hampered by a lack of information on fundamental processes governing their environmental reactivity. The sorption process is particularly important as it influences the mobility and transport of antibiotics in surface and sub-surface environments and affects their propensity to undergo transformation reactions.

Effects of solution chemistry and sorbate-to-sorbent ratio on the interaction of the antibiotic tetracycline with Elliott soil humic acid (ESHA) was investigated using equilibrium dialysis and FITEQL modeling. Tetracycline speciation strongly influenced its sorption to ESHA over the entire pH range studied. Sorption was strongly pH-dependent with a maximum around pH 4.3, and competition with H^+ and electrolyte cation (Na^+) was evident. The pH-dependent trend is consistent with complexation between the cationic/zwitterionic species of tetracycline and deprotonated sites in ESHA (mainly carboxylic function groups) as the primary underlying sorption mechanism. Modifying ESHA by $Ca2^+$ addition increased tetracycline sorption, suggesting that ternary complex formation (ESHA-metal-tetracycline) may be important at higher multivalent metal concentrations. The macroscopic data (pH-envelope and sorption isotherms) were successfully modeled using a discrete log K function with the FITEQL 4.0 chemical equilibrium program, indicating that ESHA-tetracycline interaction could be reasonably represented as complex formation of a monoacid with discrete sites in humic acid. Sorption-desorption hysteresis was observed; both sorption and desorption isotherms were well described by the Freundlich equation. Aggregation of ESHA in the presence of tetracycline, as indicated by flow field-flow fractionation, may have resulted in different microscopic pathways during sorption and desorption processes, causing the observed hysteretic behavior. Our findings will increase understanding of the environmental occurrence, fate and transport characteristics of antibiotics, which are considered as emerging organic contaminants.

Reducing Phosphorus Concentration in Lactating Dairy Diets Based on By-Products of the Corn Distilling Industry

*K.G. Karthikeyan, L.E. Armantano, A. Ozkaynak

Funding: USDA CSREES

Collaborators: UW Biological Systems Eng.; UW Dairy Sci.

Ethanol production from corn is a new and growing industry in Wisconsin. Recent Wisconsin research shows that a diet with 15% corn distillers' grains and solubles (DGS), a by-product of ethanol production, provides food production at reduced ration cost. However, phosphorus (P) levels in these diets can exceed a cow's requirement by 17 to 25%. Excess dietary P is incompatible with many P-based nutrient management plans used by dairy producers. Failure to feed DGS will harm corn processors and corn growers, as well as dairy producers. This project plans to investigate ways to feed DGS without exceeding the cows' P requirements. The best method would be to reduce the P content of DGS while retaining as much mass and nutritive value in the feed. Because P is concentrated in the solubles in DGS, we will focus on removing or reducing P in this stream. The distribution of P within the solubles is being examined to determine likely successful methods of removing P. Experiments will be performed with different physico-chemical methods commonly used in wastewater treatment to reduce P. These include physical separation by gravity sedimentation and chemical treatment with coagulants and flocculants. The intent is to concentrate P stream to facilitate shipment to areas of lower livestock density where it could be used as a fertilizer or perhaps as a P supplement in non-rumenant diets.

EXTENSION

Dairy Production

Research and Extension Grants

*D.W. Kammel

As a chair of the modernization work group of the UW Cooperative Extension's Dairy Team, I was asked to help coordinate and develop proposals for the Dairy Industry Revitalization Grants as part of a USDA request. I am the primary contact for the following projects.

- Dairy Industry Revitalization Grants, USDA:
  Dairy Modernization Website, $17,000;
  Dairy Modernization Construction Cost Database, $14,200;
  Dairy Producer Modernization Survey, $15,000.
- Wisconsin Department of Agriculture, Trade, and Consumer Protection Mixing Loading Pad Design Specifications, $8,000.
- Developing Dairy Modernization Planning Teams, USDA, $60,800.
- Dairy Modernization Team Training, USDA, $12,025.
- Regional Dairy Modernization Workshops, USDA, $6,250.
- Odor Control Workshops, USDA, $9,775.
- A Comparison of Traditional and Composted Bedded Barn Housing Systems for Dairy Cattle, WIS0M218. UW Consortium Project: P. Clark, L.E. Bauman, P.T. Kivlin, D.W. Kammel, $22,091.

Dairy Production and Profitability

*B.J. Holmes, D.R. Reinemann, D.W. Kammel, S.A. Sanford

Funding: UW Coop. Ext. Service

Collaborators: UW Biological Systems Eng.; UW Dairy Sci.; UW Ctr. for Dairy Profitability; U. of Minn.; U. of Ill.; Iowa State U.; MidWest Plan Service; Four-States Dairy Programming Group

Increasing profitability on dairy farms requires proper selection of facilities for housing, feeding, and milking. The following strategies have been proposed.

- Enhance milk production efficiency by improving cattle environment, including long day lighting which has the benefit of improving the safety of workers as they work in the barn.
- Reduce electric hazards and expenses by improving the efficiency of electrical energy use.
- Increase milk harvesting profitability by properly selecting milking equipment and facilities.
- Improve efficiency of feed storage and handling through better methods of providing balanced diets and ample feeding space.
- Enhance dairy industry modernization by encouraging selection of profitable facilities.

- Protect water quality with improved methods of handling and storing manure, silage leachate, and milking center wastewater.

In collaboration with companies, other universities and other UW departments, faculty planned and participated in conferences on a variety of dairy-related topics. We have developed publications and software to inform farmers and their advisors on farmstead planning, feed storage, feeding, animal housing, milking, energy efficiency, and manure handling systems.

Faculty have aligned themselves with self-directed teams such as the UW Cooperative Extension's Dairy Team and the Four-State Dairy Programming effort. Faculty have assumed leadership roles within the Dairy Team. Extension educational programs related to dairy will be coordinated within a team.

The Dairy Modernization workgroup of the UW Cooperative Extension Service Dairy Team developed and is marketing a collection of materials on a CD (*Milking Parlor Start-up*, *Low Cost Parlor and Dairy Housing and Manure Management Alternatives*) for use by agents, instructors at vocational/technical schools, and farmers to help with decision-making when transitioning from stall barn milking to milking in a remodeled parlor and housing cows in freestall barns. A full size model, low-cost parlor stall has been built and displayed at many farm shows throughout the state. This exhibit has attracted much attention to the Dairy Modernization program.

Funding through a USDA-supported project is helping to develop:

- Low Cost Milking Parlor Display;
- Dairy Modernization Website;
- Dairy Modernization Cost of Construction Database;
- Design and Management Options for Low-Cost, Retrofitted Milking Parlors.

Maintaining Forage Quality from Harvest through Storage and Feeding

*B.J. Holmes, R.T. Schuler, K.J. Shinners, R.E. Muck

Funding: UW Coop. Ext. Service; UW Biological Systems Eng.; USDA Dairy Forage Research Ctr.

Collaborators: UW Coop. Ext. Team Forage; UW Agronomy

Forage is an extremely valuable component of the feed for dairy and beef animals. The quality of forage as delivered has a significant impact on the production efficiency of these animals. However, losses in feed quantity and quality through harvest, storage, and feeding are very high on many dairy and livestock farms. The following practices contribute to these losses.

- Hay exposed to precipitation.
- Hay harvested too moist.
- Hay stored without adequate protection from precipitation.
- Hay and corn silage harvested too dry or too wet.
- Haylage and corn silage inadequately packed and/or covered in bunker silos, piles, and silo bags.
- Haylage and corn silage improperly removed from bunker silos, piles, and silo bags.
- Corn silage improperly processed.
- Improper use of inoculants and additives that are intended to enhance forage fermentation and preservation.

Presentations were made at Midwest Forage Association meetings, Forage Field Days, and county extension meetings to encourage producers to improve management in these areas. Articles on these subjects have appeared in conference proceedings, the *Crop Manager* newsletter and on UW Extension's Team Forage website, <www.uwex.edu/ces/crops/uwforage.htm>. Computer spreadsheets were developed as decision aids and are also at this website.

A major effort was made to plan and prepare papers for the NRAES "Silage for Dairy Farms" conference being held in 2006.

Forage production members of Team Forage have encouraged producers to select appropriate varieties, to properly adjust equipment, and to harvest at the correct stage of maturity to enhance yield and quality. Our group has been working to preserve and feed as much of that yield and quality as possible. As recommended practices are adopted, the efficiency of forage production and livestock feeding will improve. The Harvest and Storage Work Group of Team Forage has established a website, <www.uwex.edu/ces/crops/uwforage/storage.htm>, for access to publications and software related to these topics.

Development of an International Web-Based Educational Program for Machine Milking

*D.J. Reinemann, R. Greenall, G.A. Mein, I. Gunn, I. Ohnstad

Funding: Babcock Inst. for Int. Dairy Research and Development

Collaborators: UW Biological Systems Eng.; U. of Melbourne; Australian Milking Machine Trade Assn.; New Zealand Milking and Pumping Trade Assn.; ADAS; United Kingdom Milking Machine Manufacturer's Assn.

Our goal is to combine the efforts of international experts to develop a web-based educational program for milking and milk quality advisors. We assembled an international group of experts to develop a comprehensive curriculum covering the principles of machine milking, milking machine design standards, and milking machine testing, and began creating digital instructional media from the milking machine curriculum already developed by my Milking Instruction and Research Lab. We are coordinating this effort with milking manufacturers and milk plants in the U.S., Australia, New Zealand, and the U.K.

Milking Parlor Management User Group

*D.J. Reinemann, K. Bolton

Funding: UW Coop. Ext. Service

Collaborators: UW Biological Systems Eng.; UW Coop. Ext. Service

The objective of this project is to develop a self-sustaining user group focused on milking parlor management. The modern milking parlor is a data collection center for the dairy farm. Twice daily visual inspection of cows occurs in parlors that are not automated. In automated parlors, milk yield and other animal health

and behavior data are collected during milking using a variety of sensors. These data have the potential to substantially improve the profitability of a dairy farm as well as improve detection of animal health issues and thereby improve animal welfare. These potentials are seldom used to their fullest capacity, however. National and international competitiveness in dairy production will increasingly rely on better information management to improve profitability, food safety, and animal welfare.

Electric Power and Energy Systems

Farm Energy and Stray Voltage Program

*D.J. Reinemann, M.A. Cook, R. Reines, R. Kasper, J. Roberts, D. Hansen

Collaborators: UW Biological Systems Eng.; Wis. Public Service Commission; Wis. Dept. of Agric., Trade, and Consumer Protection; Midwest Rural Energy Council

The objective of this program is to promote safe, efficient use of electrical energy in rural areas. Issues addressed include energy conservation and load management technologies for farms and food processing plants, electrical safety and power quality on farms, detection and mitigation of stray voltage, renewable energy sources, and distributed generation prospects for farms. Educational activities include the following:

- Presentations at Wisconsin Farm Technology Days and other agricultural events;
- Presentations at county, state, and national seminars;
- Support of Midwest Rural Energy Council educational efforts;
- Stray Voltage Investigators Training courses;
- Support of other state agencies with rural energy activities.

Energy Conservation and Renewable Energy Education

*P.W. Walsh, S.G. Gruder

Funding: Wis. Energy Conservation Corp.

Collaborators: UW Coop. Ext. Service; Wis. Focus on Energy; UW Coop. Ext. Solid and Hazardous Waste Educ. Ctr.; Wis. Renewable Energy Network

The Wisconsin Focus on Energy program promotes adoption of energy conservation and renewable energy technology by Wisconsin's citizens, businesses, and governments. In collaboration with public and private sector partners, this program works through UW-Extension offices to deliver energy education to Extension's statewide clientele regarding adoption of improved energy management techniques, technologies to save and generate energy, and incentives available through Wisconsin Focus on Energy, <www.focusonenergy.com.>, to stimulate adoption of energy conservation and renewable energy technology.

Machinery and Harvesting

Agricultural Field Machinery

*R.T. Schuler, K.J. Shinners, J.W. Nelson

Funding: UW Coop. Ext. Service; Wis. Farm Technol. Days, Inc.

Collaborators: UW Biological Systems Eng.; UW Soil Sci.; UW Agronomy; UW Dairy Sci.; various county Extension agents

Proper operation, maintenance and selection of agricultural field machinery are the primary focus of the agricultural machinery program. Specific machines and systems receiving the most attention in 2005 were mower-conditioners, rakes and mergers, forage harvesters, balers, grain combines, grain drills, and conservation tillage equipment. Energy-saving methods were highlighted in much of the material presented on these topics.

Forage harvesting remains the primary interest of Wisconsin forage producers. New cutting and conditioning technology (specifically, intensive conditioners and impeller conditioners) continues to generate questions on its merits. Large square bale usage increased because of very high productivity. However, these bales must be baled at lower moisture for proper storage due to their greater density compared to small rectangular bales. Producers have raised many questions on ways to reduce storage losses in large square bales. With higher energy costs, producers are looking for energy conserving steps when operating this equipment.

Wisconsin's annual Farm Technology Days (FTD) provide an opportunity to work with the farm machinery industry to demonstrate field machinery and to reach thousands of farmers. Field demonstrations at FTD allow comparison of machines harvesting forage as chopped alfalfa silage and baled hay. In 2005, demonstrations included mower-conditioners, forage harvesters, balers, silage baggers, rakes, mergers, and TMR mixers.

Environmental Quality

Improving Water Quality

*B.J. Holmes, D.W. Kammel, J.O. Peterson, D.J. Reinemann

Funding: UW Coop. Ext. Service

Collaborators: UW Biological Systems Eng.; UW Soil Sci.; UW Environmental Resource Ctr.; UW Nutrient and Pest Mgmt.; UW Ctr. for Dairy Profitability; USDA Natural Resource Conservation Service; Wis. Dept. of Agric., Trade, and Consumer Protection

The collaborators developed a series of educational materials and seminars and participated in events to educate communities and agencies about water quality. The following topics are included.

- Proper storage and handling of fertilizers, pesticides, and fuel to minimize losses to water resources.
- Regulations and standards to store and handle manure which are aimed at reducing the amount of manure and nutrients entering surface and ground water.
- Equipment demonstrations and management practices of conservation tillage techniques which have proven effective in reducing soil erosion.

- Work with committees to establish standards for proper management of milking center wastewater and silage leachate/runoff from feed storage areas.
- A survey of grazier outwintering practices which could affect surface runoff of nutrients.
- Investigation of environmentally friendly cleaning and sanitizing agents.
- Reduction of wastewater volume from milking parlors.
- Home water quality testing and interpretation for students in the Farm and Industry Short Course livestock housing class.
- Demonstration of ground water flow and contaminant transport using sand tank models.

Safety and Health

AgrAbility of Wisconsin

*R.T. Schuler, C.A. Ehle

Funding: USDA CSREES; UW Coop. Ext. Service

Collaborators: UW Biological Systems Eng.; Easter Seals Wis.; Wis. Div. of Vocational Rehabilitation; Wis. Dept. of Agric., Trade and Consumer Protection

AgrAbility of Wisconsin staff has provided direct assistance to about 1200 disabled farmers and disabled members of their families since 1991. Disabilities addressed include arthritis, lower back pain, spinal cord injuries, respiratory and cardiac problems, amputations, cancer, and visual and hearing impairments.

This partnership of the UW Cooperative Extension Service and the FARM Center of Easter Seals Wisconsin (ESW) provides education and assistance to farmers with disabilities and to disabled members of their families. Extension staff provides education and awareness of AgrAbility through extension/outreach activities. ESW's role is to provide on-farm help via worksite assessments and development of individual plans.

The Wisconsin Division of Vocational Rehabilitation (DVR) provides on-site support to farmers to implement their assistive technology plans and to refer them to the AgrAbility program. Examples of assistance provided are computer software, air-suspension tractor seats, added tractor steps, powered feed carts, milking pipelines, personal transport machines, and tractor lifts. During the past year, the value of the assistive technology provided by DVR to Wisconsin farmers exceeded $2 million. DVR counselors receive training from AgrAbility staff regarding accommodations most effective for farmers with disabilities.

The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) staff provides financial analysis of the farmers when requested by DVR staff. In addition, DATCP staff refers farmers to AgrAbility through their Farm Center.

AgrAbility is promoted through staffed displays at machinery shows and demonstrations and presentations at county, area, and statewide events. The quarterly newsletter *Plowing Ahead* is prepared, posted at website <www.bse.wisc.edu/agrability>, and sent to county Extension offices, DVR offices, rural hospitals, and current and former clients. Staff members provide an in-depth awareness program through radio programs, newspaper articles, and visits to key community people and events. An advisory committee meets annually and provides excellent support and increased awareness.

National AgrAbility Project

*R.T. Schuler, C.A. Skjolaas, M.E. Novak, M.F. Beck, L.N. Adams

Funding: USDA CSREES; UW Coop. Ext. Service; contributions from agri-businesses

Collaborators: UW Biological Systems Eng.; Natl. Easter Seals

The National AgrAbility Project staff provides training and educational support for 21 state/regional AgrAbility projects. The projects provide education and assistance for farmers with disabilities as described above for AgrAbility of Wisconsin. The national project requires a joint effort between state Cooperative Extension staff and staff from a non-profit disability organization, which is National Easter Seals. Technical news appears in the *AgrAbility Quarterly* newsletter, and training and education are offered through a national workshop, monthly staff newsletters (distributed electronically only), and e-mail. Information for state project staff and the general public is provided by the website <www.agrabilityproject.org>. The website maintains a database listing more than 1000 agriculture-related assistive technology. In 2005 the National Workshop to train state staff and others serving farmers with disabilities was held in Burlington, NH.

Evaluation of all aspects of the project is a major component. A needs assessment for the state projects was developed and implemented. Plans have begun to determine how well the state projects are meeting the needs and expectations of the farmers whom they serve. An impact survey was developed to determine how well AgrAbiity meets the needs of farmers with disabilities. These activities have improved the productivity and profitability of those who have been served.

Youth Agricultural Safety and Health

*C.A. Skjolaas, R.T. Schuler

Funding: UW Coop. Ext. Service

Collaborator: UW Biological Systems Eng.

Youth are at risk of serious and fatal farm injuries. Each year several Wisconsin children and youth, from preschool through high school age, are seriously hurt and even die from farm work or worksite-related injuries. Youth must learn proper, safe behaviors in a farm environment, both to avoid hazards as bystanders and to work safely. Youth must also learn fundamental injury and illness prevention techniques, such as hazard control, and must be motivated to apply such techniques throughout during their lifetimes.

This program includes presentations to youth at a variety of meetings, both in and out of a school setting. Presentations and planning assistance are provided to youth safety day camps throughout the state. Safety materials were developed for Extension agents and, within 4-H and vocational agricultural programs, for children and youth. Close contact is maintained with agricultural education instructors and county Extension staff who work with youth. The tractor and machinery certification program described under the section "Youth Education" (below) is part of this overall youth safety and health programming.

Farm Machinery Systems Safety

*R.T. Schuler, C.A. Skjolaas
Funding: UW Coop. Ext. Service
Collaborator: UW Biological Systems Eng.

Tractors and other machines are involved in the majority of incidents resulting in temporary or permanent injury and even death on farms. The most effective method of prevention, of course, involves hazard control (removing or guarding hazards). Safe operation is still necessary but cannot be depended upon to completely prevent machine-related injuries. Numerous presentations, media interviews and information requests on machinery safety are handled. The website <www.wiscash.uwex.edu> contains safety information available from the UW Center for Agricultural Safety and Health, including annual summaries of state farm-related fatalities since 1993 which highlight machinery-related fatalities. In-depth instruction on machine hazards and hazard control is a major component of the UW's Farm and Industry Short Course, "Agricultural Safety and Health," taught each year by the Biological Systems Engineering Department

Youth Education

Mechanical Sciences (Youth Development)

*R.T. Schuler, J.W. Nelson, M. Miller
Funding: UW Coop. Ext. Service; Wis. Rural Insurance
Collaborators: 4-H Youth Development; Natl. Eng., Sci. and Leadership Mgmt. Team; Lincoln Welding; Deere and Co.

In 2005, 35 4-H youth participated in the state mechanical events, which included tractor, small engine, and aerospace. Many county youth development volunteers and 15 county agricultural and youth development Extension agents supported these events. Winners at the state level advance to the National 4-H Engineering, Science, and Leadership Event held each year in West Lafayette, IN. Wisconsin staff is responsible for the small engine activity at the national event and is part of the management team that plans and conducts this event.

Two half-day workshops were conducted at a state 4-H conference in Madison. Small engines and aerospace had a maximum enrollment in 2005.

Approximately 12,000 youth participate in these Mechanical Science projects at the county level. About 1000 volunteers within the various counties direct them. Biological Systems Engineering Department staff provides technical support for the 4-H mechanical science projects including woodworking, tractor, small engine, electricity, bicycle, and aerospace.

Future Farmers of America Agricultural Mechanics Events

*R.T. Schuler, J.W. Nelson, C.A. Skjolaas
Funding: UW Coop. Ext. Service
Collaborators: UW Biological Systems Eng.; Wis. Future Farmers of America

Twenty teams took part in the Wisconsin Future Farmers of America Agricultural Mechanics event in 2005. Each year the top teams from four area Agricultural Mechanics contests take part in a statewide event organized by this department. Guidelines are developed for the four area events. The state event also gets input from faculty at UW-River Falls, UW-Platteville, and the Fox Valley Technical College who direct area events. Biological Systems Engineering Department staff provided training for agricultural educators in Wisconsin.

Tractor and Machinery Operation Certification Program

*C.A. Skjolaas, C.C. Wilke, R.T. Schuler
Funding: UW Coop. Ext. Service
Collaborator: UW Biological Systems Eng.

Federal child labor laws require specific training relating to tractor and machinery operation for youth ages 14 to 15 working on farms other than those of their parents. In addition, Wisconsin law requires such training for youth 12 to 16 years old who operate tractors or other farm machines on public roads. Training programs are conducted by county Extension agents working with youth and by agricultural education instructors with help from many volunteers. Greater standardization was brought into the program statewide and help was offered to counties that had not previously offered programs. Supplemental materials, such as an instructor training manual, were developed, and instructor training was offered statewide. These efforts have resulted in more than a thousand youth successfully completing certification programs annually.

Publications

Peer Reviewed Publications

Altan, A, M Turhan, S Gunasekaran. 2005. Comparison of covered and uncovered Schreiber tests for cheese meltability evaluation. *J Dairy Sci* 88(3):857-861.

Alvarez, S, A Garcia, SO Manolache, FS Denes, FA Riera, R Alvarez. 2005. Plasma-enhanced modification of the pore size of ceramic membranes. *Desalination* 184(1-3):99-104.

Dong, B, SO Manolache, EB Somers, ACL Wong, FS Denes. 2005. Generation of antifouling layers on stainless steel surfaces by plasma-enhanced crosslinking of polyethylene glycol. *J Appl Polymer Sci* 97(2):485-497.

Grande, JD, KG Karthikeyan, PS Miller, JM Powell. 2005. Corn residue level and manure application timing effects on phosphorus losses in runoff. *J Env Qual* 34:1620-1631.

Grande, JD, KG Karthikeyan, PS Miller, JM Powell. 2005. Residue level and manure application timing effects on runoff and sediment losses. *J Env Qual* 34:1337-1346.

Gu, C, KG Karthikeyan. 2005. Sorption of the antimicrobial ciprofloxacin to aluminum and iron hydrous oxides. *Env Sci Technol* 39:9166-9173.

Gu, C, KG Karthikeyan. 2005. Interaction of tetracycline with aluminum and iron hydrous oxides. *Env Sci Technol* 39: 2660-2667.

Gungor, K, KG Karthikeyan. 2005. Influence of anaerobic digestion on dairy manure phosphorus extractability. *Trans ASAE* 48:1497-1507.

Gungor, K, KG Karthikeyan. 2005. Probable phosphorus solid phases and their stability in anaerobically digested dairy manure. *Trans ASAE* 48:1508-1520.

Jampala, SN, SO Manolache, S Gunasekaran, FS Denes. 2005. Plasma-enhanced modification of Xanthan gum and its effect on rheological properties. *J Agric and Food Chemistry* 53:3618-3625.

Karthikeyan, KG, M Kalbasi, PS Miller. 2005. Nitrogen and solution dynamics in soils receiving chemically treated dairy manure. *Trans ASAE* 48:601-610.

Lamsal, BP, RG Koegel, S Gunasekaran. 2005. Gelation of alfalfa soluble leaf proteins. *Trans ASAE* 48(6):2229-2235.

Larson, BJ, JM Helgren, SO Manolache, AY Lau, MG Lagally, FS Denes. 2005. Cold-plasma modification of oxide surfaces for covalent biomolecule attachment. *Biosensors and Bioelectronics* 21:796-801.

Leonardi, C, KJ Shinners, LE Armentano. 2005. Effect of different dietary geometric mean particle length and particle size distribution of oat silage on feeding behavior and productive performance of dairy cattle. *J Dairy Sci* 88:698-710.

Reinemann, DJ, LE Stetson, NK Laughlin. 2005. Water, feed and milk production response of dairy cattle exposed to transient currents. *Trans ASAE* 48(1):385-392.

Reinemann, DJ, GA Mein, MD Rasmussen, PL Ruegg. 2005. Evaluating milking performance. *Bull Int Dairy Fed* 396/2005 (29 p), Brussels, Belgium.

Schuler, RT, M Sage Mach, R Buchele. 2005. *Start Your Engines Series (Crank It Up!, Warm It Up!, Tune It Up!, Leader's Guide)*. Natl 4-H Cooperative Curriculum Service.

Shin, EW, KG Karthikeyan, MA Tshabalala. 2005. Orthophosphate sorption onto lanthanum impregnated lignocellulosic adsorbents. *Env Sci Technol* 39:6273-6279.

Stevenson, DM, RE Muck, KJ Shinners, PJ Weimer. 2005. Use of real time PCR to determine population profiles of individual species of lactic acid bacteria in alfalfa silage and stored corn stover. *Appl Microbiol and Biotechnol*, <www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s00253-005-0170-z>.

Sudduth, KA, NR Kitchen, WJ Wiebold, WD Batchelor, GA Bollero, DG Bullock, DE Clay, HL Palm, FJ Pierce, RT Schuler, KD Thelen. 2005. Relating apparent electrical conductivity to soil properties across the north-central USA. *Computers and Electronics in Agric* 46:263-283.

Webendorfer, B, JW Pingry, J Derricks, RT Schuler, RP Wolkowski. 2005. *A Guide to Managing Crop Residues in Corn and Soybeans*. USDA-NRCS GWQ029.

Yu, C, S Gunasekaran. 2005. Performance evaluation of different model mixers by numerical simulation. *J Food Eng* 71(3):295-303.

Yu, C, S Gunasekaran. 2005. Modeling of melt conveying and heat transfer in a twin-screw cheese stretcher. *J Food Eng* 70(2):245-252.

Yu, C, S Gunasekaran. 2005. A systems analysis of pasta filata process during Mozzarella cheese making. *J Food Eng* 69(4):399-408.

Books and Chapters

Denes. FS, LE Cruz-Barba, SO Manolache. 2005. Plasma treatment of wood. In: RM Rowell (ed.), *Handbook of Wood Chemistry and Wood Composites*, Ch. 16, pp. 447-473. Boca Raton, FL: CRC Press.

Kammel, DW. 2005. Wisconsin Minimum Design and Construction Standards for Concrete Mixing and Loading Pads and Secondary Containment Structures. Madison, WI: Dept of Agric, Trade, and Consumer Protection, Feb.

Patents

Denes, FS, SO Manolache, LE Cruz-Barba, MG Lagally. Disclosed 4/11/05. RF-plasma-enhanced deposition of fluorinated macromolecular olefin thin layers for low fluorescence background biosensor and catheter application, WARF P05359US.

Denes, FS, SO Manolache, LE Cruz-Barba, AJ Martinez-Gomez. Disclosed 5/16/05 Plasma-enhanced generation of quaternary ammonium and phosphonium surfaces, WARF P05376US.

Denes, FS, SO Manolache. Disclosed 5/16/05. Generation of AP non-equilibrium plasma solely located on interior surface walls of dielectric tubular cavities, WARF P05377US.

Conference Proceedings and technical Papers and reports

Bohnhoff, DR. 2005. Post installation tools, ASAE Paper No. 054117. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Bohnhoff, DR. 2005. Metal panel and trim installation tolerances, ASAE Paper No. 054117. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Bohnhoff, DR. 2005. NFBA's newest post-frame construction tolerances document. Presented at *Annl Mtg Wis Frame Builders Assn*, Eau Claire, WI, Jan 12.

Bohnhoff, DR. 2005. Accepted practices for post-frame building construction: Metal panel and trim installation tolerances. Presented at *Natl Frame Building Expo*, Columbus, OH, Feb 24.

Bohnhoff, DR. 2005. WI and LBS full-scale metal-clad wood-frame diaphragm study. Presented at *Natl Frame Building Expo*, Columbus, OH, Feb 24.

Bohnhoff, DR. 2005. Agricultural building design. Presented at *2005 NAMIC Agric Risk Inspection Sch*., West Des Moines, IA, Aug 2-4.

Cabot, PE, KG Karthikeyan, PS Miller, P Nowak. 2005. Storage of sediment and particulate-bound phosphorus in an agricultural landscape. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Cabot, PE, KG Karthikeyan, PS Miller, P Nowak. 2005. Phosphorus delivery from manured alfalfa fields during successive natural rainfall events. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Cabot, PE, KG Karthikeyan. 2005. Source/sink dynamics of depressional zones regulating phosphorus migration through a Wisconsin agricultural watershed. Presented at *2005 Annual Int Mtg Soil Sci Soc of Amer*, Salt Lake City, UT, Nov 6-10.

Cabot, PE, F Pierce, P Nowak, KG Karthikeyan. 2005. Monitoring manure application at sub-field scales with precision conservation technology Presented at *2005 Annual Int Mtg Soil Sci Soc of Amer*, Salt Lake City, UT, Nov 6-10.

Chien, H, DS Mackay, PE Cabot, KG Karthikeyan. 2005. Parameterization of natural depressions in distributed hydrologic models: Implications for scaling up predictions of sediment and nutrient yields in ungauged agricultural watersheds. Presented at *2005 Fall Mtg Amer Geophysical Union*, San Francisco, CA, Dec 5-9.

Cho, J, FS Denes, R TImmons. 2005. Plasma surface modifications to improve the photocatalytic activity of titanium dioxide. Presented at *Materials Chemistry and Nanotechnology Symp, PACIFICHEM 2005*, Honolulu, HI, Dec 15-20.

Contreras-Govea, FE, RE Muck, I Filya, DR Mertens, PJ Weimer. 2005. *In vitro* gas production and bacterial bio-mass estimation for lucerne silage inoculated with one of three lactic acid bacterial inoculants. In: RS Park and MD Stronge (eds), *Silage Production and Utilisation*, p. 207. Belfast, Northern Ireland, July 3-6, Wageningen, The Netherlands: Wageningen Academic Publishers.

Denes, FS, AJ Martinez-Gomez, LE Cruz-Barba, SO Manolache. 2005. Plasma-enhanced generation of quaternary ammonium and phosphonium functionalities on polymer surfaces. Presented at *Pacific Polymer Conf IX*, Maui Westin, HI, Dec 11-14.

Dong, B, SO Manolache, EB Somers, ACL Wong, FS Denes. 2005. Generation of anti-fouling thin layers by plasma-enhanced crosslinking of polyethylene glycol. Presented at *Annl Mtg Food Res Inst*, Sept 28.

Gu, C, KG Karthikeyan. 2005. Interaction of tetracycline with dissolved humic substances. Presented at *2005 Annl Int Mtg Soil Sci Soc Amer*, Salt Lake City, UT, Nov 6-10.

Gungor, K, A Jurgensen, KG Karthikeyan. 2005. Investigation of probable phosphorus solid phases in dairy manure using X-ray absorption near edge structure analysis. Presented at *2005 Annl Int Mtg Soil Sci Soc Amer*, Salt Lake City, UT, Nov 6-10.

Hatfield, RD, ML Sullivan, RE Muck. 2005. Using the red clover polyphenol oxidase gene to inhibit proteolytic activity in lucerne. In: RS Park and MD Stronge (eds), *Silage Production and Utilisation*, p. 212. Belfast, Northern Ireland, July 3-6, Wageningen, The Netherlands: Wageningen Academic Publishers.

Holmes, BJ. 2005. Tunnel ventilation freestall barns – What is needed and what are the limitations?. *Proc Arlington Dairy Day Program*. Madison, WI: UW Dairy Sci.

Hymes-Fecht, UC, GA Broderick, RE Muck. 2005. Effects of feeding legume silage with differing tannin levels on lactating dairy cattle. In: RS Park and MD Stronge (eds), *Silage Production and Utilisation*, p. 163. Belfast, Northern Ireland, July 3-6, Wageningen, The Netherlands: Wageningen Academic Publishers.

Jampala, SN, SO Manolache, M Sarmadi, FS Denes. 2005. Plasma-enhanced deposition of reactive functionalities for antibacterial surfaces. Presented at *Annl Mtg Food Res Inst*, Sept 28.

Jiang, H, SO Manolache, ACL Wong, FS Denes. 2005. Plasma-enhanced deposition of antifouling layers on silicon rubber surfaces. Presented at *Annl Mtg Food Res Inst*, Sept 28.

Kammel, DW. 2005. Heifer housing considerations: Designing facilities to enhance heifer performance. In: *Proc Dairy Calves and Heifers, "Integrating Biology and Mgmt"*, pp. 182-197, Syracuse, NY, Jan 25-27. Ithaca, NY: Natural Resource, Agric and Eng Service.

Kammel, DW. 2005. Remodeling dairy barns for dairy beef housing. In: *Proc Managing and Marketing Quality Holstein Steers*, pp. 285-298, Rochester, MN, Nov 2-3.

Karthikeyan, KG, PS Miller, JD Grande, PD Gaebler, SB McClure, PJ Whiting, A Stubblefield, G Matisoff. 2005. Evaluation of sediment transport mechanics using lanthanide tracers and radiometric fingerprinting. Presented at *2005 Annl Int Mtg Soil Sci Soc Amer*, Salt Lake City, UT, Nov 6-10.

Kotloski, AJ, BJ Holmes, KJ Shinners. 2005. Cleaning agricultural plastic film for recycling. Report to UW Solid and Hazardous Waste Education Ctr.

Manolache, SO, LE Cruz-Barba, K Sridharan, AV Sumant, FS Denes. 2005. The synthesis of hard carbon nanostructures using SF_6 plasma environments. Presented at *Pacific Polymer Conf IX*, Maui Westin, HI, Dec 11-14.

Miller, PS, KG Karthikeyan, CA Bonilla, C Molling, JM Norman. 2005. 4D-P – A spatially distributed phosphorus module of the Precision Agricultural Landscape Model: Model description, calibration, and verification. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Muck, RE, BJ Holmes. 2005. Factors affecting bag silo densities and losses. In: FP O'Mara, RJ Wilkins, L 't Mannetje, PAM Rogers (eds), TM Boland, *XX Int Grassland Congress: Offered Papers*, p. 480. Dublin, Ireland, June 26-July 1, Wageningen, The Netherlands: Wageningen Academic Publishers.

Muck, RE, I Filya, FE Contreras-Govea. 2005. Inoculant effects on ensiling and *in vitro* gas production in lucerne silage. In: RS Park and MD Stronge (eds), *Silage Production and Utilisation*, p. 204. Belfast, Northern Ireland, July 3-6, Wageningen, The Netherlands: Wageningen Academic Publishers.

Muck, RE, BJ Holmes. 2005. Factors affecting bag silo densities and losses. In: RS Park and MD Stronge (eds), *Silage Production and Utilisation*, 245. Belfast, Northern Ireland, July 3-6, Wageningen, The Netherlands: Wageningen Academic Publishers.

Mueller, GD, AM Thompson, KW Potter. 2005. The runoff response of urban residential lawns. Presented at *2005 Annl Int Mtg ASABE*, Tampa, FL, July 17-20.

Palmer, RW, BJ Holmes. 2005. Cow comfort issues in freestall barns. *Proc Gaining the Competitive Edge Dairy Seminar Series*. Madison, WI: UW Ctr for Dairy Profitability.

Panuska, JC, KG Karthikayan, PS Miller. 2005. Characterizing edge-of-field particulate phosphorus losses under three corn management systems. Presented at *2005 Annl Int Mtg Soil Sci Soc Amer*, Salt Lake City, UT, Nov 6-10.

Panuska, JC, KG Karthikayan, PS Miller. 2005. Characterizing edge-of-field particulate phosphorus losses under three corn management systems. Presented at *2005 Annl Mtg North Amer Lake Mgmt Soc*, Madison, WI, Nov 9-11.

Paul, AC, AM Thompson. 2005 The hydraulic and pollutant removal capacity of engineered soils. Presented at *25th Annl Symp North Amer Lake Mgmt Soc, "Lake Effects: Exploring the Relationship between People and Water"*, Madison, WI, Nov 9-11.

Reinemann, DJ. 2005. The history of vacuum regulation technology. In: *Proc 44th Annl Mtg Natl Mastitis Council*.

Reinemann, DJ. 2005. What's new in milking technology? Presented at *Int Dairy Summit*, Vancouver, BC, Sept. Sponsored by Int Dairy Fed.

Reinemann, DJ, K Houck, JR Bishop, T Cilliers. 2005. Bacterial and sensory assessment of ultraviolet treated raw milk. Presented at *Int Dairy Summit*, Vancouver, BC, Sept. Sponsored by Int Dairy Fed.

Reinemann, DJ. 2005. Planning to upgrade your milking facilities? Here are some tips for doing it right. *Dairy Update No. 703*, Madison, WI: UW Babcock Inst for Int Dairy Research and Development.

Sanford, SA. 2005. Irrigation scheduling and uniformity for improved water management. In: *Proc Fertilizer, Aglime, and Pest Mgmt Conf*, Jan 19.

Sanford, SA. 2005. Uniformity testing of center pivots: 2004 field results. In: *Proc Annl Mtg Wis Potato Growers Assn*, Feb 15.

Sarmadi, M, SN Jampala, SO Manolache, FS Denes. 2005. Deposition of reactive functionalities by plasma polymerization of nitrogen-containing compounds. Presented at *Twelfth Annl Int Conf on Composites/Nano Eng*, Tenerife, Canary Islands, Spain, Aug 1-6.

Schuler, RT, RH Meyer, LN Adams. 2005. AgrAbility of Wisconsin impact evaluation. *2005 Annl Conf Natl Inst for Farm Safety*, Wintergreen, VA, June 26-30.

Schuler, RT, RH Meyer, LN Adams. 2005. Natlonal AgrAbility Project demographic analysis: Serving farmers and ranchers with disabilities, ASAE Paper No. 055014. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Schuring, N, DJ Reinemann. 2005. Procedures for evaluating vacuum levels and air flow in milking systems: 2005 Update. In: *Proc 44th Annl Mtg Natl Mastitis Council*.

Shinners, KJ, GS Adsit, BN Binversie, MF Digman. 2005. Characteristic performance and yields using a single-pass, split-stream maize grain and stover harvester, ASAE Paper No. 056051. Presented at *2005 Annl Int Mtg ASAE*, Tampa, FL, July 17-20.

Shinners, KJ. 2005. High-capacity mowing equipment of the future. Presented at *2005 Vita-Plus Customer Focus Mtg*, Minneapolis, MN, March 18.

Shinners, KJ. 2005. Getting the most from your cutting equipment. Presented at *Outagamie County Forage Council Mtg*, New London, WI, June 29.

Shinners, KJ. 2005. Future direction of hay and forage equipment design. Presented at *Fond du Lac County Forage Council Mtg*, New London, WI, Dec 7.

Somers, EB, SO Manolache, FS Denes, ACL Wong. 2005. Use of plasma technology to decontaminate surfaces in food processing environments. Presented at *Annl Mtg NCFDP*, Atlanta, GA, Nov 1-2.

Steinke, K, JC Stier, AM Thompson, KW Kussow. 2005. Prairie and turf buffer strips for controlling urban runoff. In: *Proc Amer Chem Soc Conf, "The Fate of Nutrients and Plant Protection Chemicals in the Urban Environment"*, Arlington, VA, Oct 12-13.

Steinke, K, JC Stier, WR Kussow, AM Thompson. 2005. The role of turfgrass and prairie buffer strips in mitigating urban stormwater pollution. Presented at *Annl Mtg ASA-CSSA-SSSA*, Nov.

Vandermuss, AJ, AM Thompson. 2005. Thermal enhancement of stormwater runoff from impervious surfaces. Presented at *2005 Annl Int Mtg ASABE Mtg*, Tampa, FL, July 17-20.

Abstracts, Posters and Oral Presentations

Altay, F, S Gunasekaran. 2005. Effect of drying temperature on gelation of corn starch (Abstract 71D-29). *Annl Mtg Inst Food Technologists, Technical Program Abstracts*, New Orleans, LA, July 16-20.

Altay, F, S Gunasekaran, S Kasapis. 2005. Viscoelasticity of gelation gels in mixture with high levels of sugar (Abstract 36D-33). *Annl Mtg Inst Food Technologists, Technical Program Abstracts*, New Orleans, LA, July 16-20.

Chapman, LJ, KM Pereira, AC Newenhouse. 2005. A theory-driven, evidence-based intervention: Seven years, four thousand businesses, three safer ways to work (abstract and oral presentation). Presented at session "Using Theory to Guide Development of Occupational Safety and Health Interventions," *Annl Mtg Amer Public Health Assn*, Philadelphia, PA, Dec 14.

Chapman, LJ, C Brunette, KM Pereira, KG Josefsson . 2005. Safer practices with better profits: A seven-year intervention to Wisconsin dairy farmers (abstract and poster). Presented at *2005 Annl Conf Natl Inst for Farm Safety*, Wintergreen Resort, VA, June 26-30.

Gungor, K, KG Karthikeyan. 2005. Investigation of phosphorus forms in full-scale anaerobic digesters for dairy manure (poster). Presented at *2005 Annl Int Mtg ASABE*, Tampa, FL, July 17-20.

Karthikeyan, KG, JC Panuska, PS Miller, JD Grande. 2005. Characterizing edge-of-field particulate phosphorus losses under three corn management systems (poster). Presented at *2005 Annl Int Mtg ASABE*, Tampa, FL, July 17-20.

Ko, S, S Gunasekaran. 2005. Preparation of β-lactoglobulin and bovine serum albumin nanoparticles (Abstract 71C-13). *Annl Mtg Inst Food Technologists, Technical Program Abstracts*, New Orleans, LA, July 16-20.

McIntier, R, RK Connelly. 2005. Comparison of dough development between two mixers with different geometries (poster). Presented at *Inst. Annl Mtg Food Technologists*, New Orleans, LA, July 16-20.

Miller, PS, KG Karthikeyan, CA Bonilla, JM Norman. 2005. Comparing trends of snowmelt and storm runoff sediment and phosphorus losses from agricultural fields in Wisconsin (poster). Presented at *2005 Annl Int Mtg ASABE*, Tampa, FL, July 17-20.

Sun, C, S Gunasekaran, MP Richards. 2005. Beta-cyclodextrin microencapsulation and oxidation stability of freeze-dried fish oil powder (Abstract 71C-21). *Annl Mtg Inst Food Technologists, Technical Program Abstracts*, New Orleans, LA, July 16-20.

Non-refereed publications and Newsletters

Beck, MF. 2005. Wrote for/edited *AgrAbility Quarterly* newsletter, <www.agrabilityproject.org/newsletter>.

Bohnhoff, DR. 2005. NFBA's newest post-frame construction tolerances document. *Frame Bldg News*, Nov., pp. 32-39.

Ehle, CA. 2005. Wrote for/edited *Plowing Ahead*, quarterly newsletter of AgrAbility of Wis. Project, <bse.wisc.edu/agrability>.

Karthikeyan, KG. 2005. Press release and article in *Milwaukee Journal Sentinel* newspaper. Interviewed on Aug 30.

Karthikeyan, KG. 2005. Sediment Journey. Press release and article in UW College of Agric and Life Sciences *Quarterly* 23(3).

Schuler, RT. 2005. Anhydrous ammonia applicator calibration. *Wis Crop Manager* 12(2).

Schuler, RT. 2005. Getting your planter ready. *Wis Crop Manager* 12(3).

Schuler, RT. 2005. Broadcast fertilizer spreader calibration. *Wis Crop Manager* 12(3).

Schuler, RT. 2005. Field operation fuel savings tips. *Wis Crop Manager* 12(4).

Schuler, RT. 2005. Spraying tips for Asian soybean rust. *Wis Crop Manager* 12(4).

Schuler, RT. 2005. Impact of increased energy prices on machinery costs. *Wis Crop Manager* 12(5).

Schuler, RT. 2005. Mower-conditioner adjustments for rapid forage drying in the field. *Wis Crop Manager* 12(12).

Schuler, RT. 2005. Combine harvesting adjustments in drought conditions. *Wis Crop Manager* 12(24).

Schuler, RT. 2005. Crop processor adjustment in corn silage harvest. *Wis Crop Manager* 12(24).

Schuler, RT. 2005. Fuel saving tips for corn silage harvesting. *Wis Crop Manager* 12(25).

Schuler, RT. 2005. Fuel saving tips for tractors and self-propelled equipment. *Wis Crop Manager* 12(26).

Schuler, RT. 2005. Yield costs/losses resulting from delayed harvest. *Wis Crop Manager* 12(27).

Schuler, RT. 2005. Some fall tillage fuel saving tips. *Wis Crop Manager* 12(28).

Schuler, RT. 2005. Nebraska tractor tests provide useful management information. *Wis Crop Manager* 12(30).

Shaver, RD, KJ Shinners, BJ Holmes, L Kung. 2005. Here's the latest on making corn silage. *Hoard's Dairyman*, p. 512.

Shinners, KJ. 2005. Wide swath speed drying. *The Forage Leader* 10(1).

Shinners, KJ. 2005. Net wrap bales to improve storage. *The Forage Leader* 10(2).

Shinners, KJ. 2005. Got ash? Set your mower-conditioner correctly. *The Forage Leader* 10(3).

Webendorfer, B, JW Pingry, J Derricks, RT Schuler, RP Wolkowski. 2005. *A Guide to Managing Crop Residues in Corn and Soybeans*, USDA-NRCS GWQ029.

Departmental Bulletins

Chapman, LJ, AC Newenhouse, MG Miquelon. 2005. Electronic pruners: faster and safer. Work Efficiency Tip Sheet, UW Biological Systems Eng, <bse.wisc.edu/hfhp>, 2nd ed, Nov.

Newenhouse, AC, MG Miquelon, LJ Chapman. 2005. Pot-filling machine saves time: Work Efficiency Tip Sheet, UW Biological Systems Eng, <bse.wisc.edu/hfhp>, 2nd ed, Nov.

Newenhouse, AC, MG Miquelon, LJ Chapman. 2005. Container stabilization systems. Work Efficiency Tip Sheet, UW Biological Systems Eng, <bse.wisc.edu/hfhp>, Nov.

Newenhouse, AC, MG Miquelon, LJ Chapman. 2005. Try a tree guard zipper. Work Efficiency Tip Sheet, UW Biological Systems Eng, <bse.wisc.edu/hfhp>, 2nd ed, Nov.

Newenhouse, AC, MG Miquelon, LJ Chapman. 2005. No-climb truck tarping systems. Work Efficiency Tip Sheet, UW Biological Systems Eng, <bse.wisc.edu/hfhp>, Nov.

CD Technology / Software / Internet / Radio and Television Shows

Barnett, KH, BJ Holmes. 2005. Silage pile dimension calculator (updated). UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Holmes, BJ. 2005. Sources of supply – face cutters for bunker and pile silos (focus on forage series). UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Holmes, BJ. 2005. Using a custom harvester – factors to consider (PowerPoint presentation). UW-Ext Team Forage Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Holmes, BJ. 2004. Floor length to achieve bunker/pile filling layer thickness calculator with documentation. UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Holmes, BJ. 2005. Stored density calculator with documentation. UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Holmes, BJ. 2005. Silage pile capacity and capital cost calculator (updated). UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/ storage>.

Holmes, BJ, RE Muck. 2005. Bunker silo density calculator (updated). UW-Ext Team Forage, Harvest and Storage website, <www.uwex.edu/ces/crops/uwforage/storage>.

Jones, DA, BJ Holmes. 2005. Farmstead Planning Handbook (FPLAN-CD). Ames, IA: MidWest Plan Service.

Newenhouse, AC, MG Miquelon, LJ Chapman. 2005. Healthy Farmers/Healthy Profits website, <bse.wisc.edu/hfhp/>, contains approximately 20 titles of downloadable tipsheets plus slide shows, press releases, and articles.

Newenhouse, AC. 2005. Guest on Larry Meiller's hour-long "Garden Talk" radio show, WPR 970 AM, Dec. 2.

Reinemann, DJ. Use of my web sites has increased again this year, with <www.uwex.edu/uwmril> for the UW Milking Research and Instruction Lab logging more than 30,000 unique visits and 200,000 pages downloaded. This site has become one of the leading international resources for machine milking technology. The Midwest Rural Energy Council site, <www.mrec.org>, logged more than 20,000 unique visits and 70,000 pages downloaded.

Sanford, SA. 2005. Updated Dairy Ctr. audit tool, Excel spreadsheet. UW Energy Efficiency and Renewable Energy website, <www.uwex.edu/energy>.

Schuler, RT, ST Liantonio. 2005. Website – Small Engines, 4-H Coop Curriculum Service, <www.4hccsprojects2.com/smallengines/>.