USDA United States Department of Agriculture

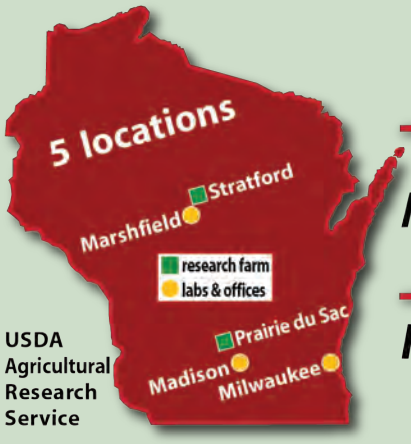
The Year in Review

U.S. Dairy Forage Research Center

Agricultural Research Service

Fiscal Year 2013

October 2012 through September 2013



One Center	**U.S. Dairy Forage Research Center**
Three Management Units	**Dairy Forage & Aquaculture Research Unit** **Cell Wall Biology & Utilization Research Unit** **Environmentally Integrated Dairy Management**
Five Locations	Madison • Prairie du Sac • Milwaukee Marshfield • Stratford

U.S. Dairy Forage Research Center

Unique in Our Field

The U.S. Dairy Forage Research Center is one of about 90 units in the Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA). We're the only USDA-ARS unit with the mission of improving forage use by dairy cattle.

Our Mission

To develop knowledge and tools to enhance sustainable and competitive dairy forage systems that protect the environment, promote animal health, and ensure a safe, healthy food supply.

Web Site

www.ars.usda.gov/mwa/madison/dfrc

Five Locations

The U.S. Dairy Forage Research Center conducts research at five locations in Wisconsin but is managed as one Center. The five locations are:

USDFRC at Madison, WI

Laboratories, greenhouses, engineering lab, and the administrative offices on the west side of the University of Wisconsin-Madison campus.

1925 Linden Dr. West
Madison, WI 53706
Phone: (608) 890-0050

Madison

USDFRC at Prairie du Sac, WI

The research farm consists of 2,006 acres and about 350 cows in milk.

S8822 Sunset Dr. (off of Hwy. 78)
Prairie du Sac, WI 53578
Phone: (608) 643-2438

Prairie du Sac

USDFRC at Marshfield, WI

The Environmentally Integrated Dairy Management Research Unit (EIDMRU) is researching manure and nutrient management options.

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Marshfield, WI 54449
Phone: (715) 387-4609

Marshfield

USDFRC at Stratford, WI

Research farm for the EIDMRU. Same contact info as above.

USDFRC at Milwaukee, WI

Great Lakes Aquaculture Lab located at the University of Wisconsin-Milwaukee School of Fresh Water Sciences.

600 East Greenfield Ave.
Milwaukee, WI 53204
Phone: (414)382-1767

Stratford

Dairy Forage Research Scientists

Research at the U.S. Dairy Forage Research Center is directed by 18 scientists who manage the personnel and activities in their respective laboratories in Madison, Marshfield and Milwaukee, and also the research conducted at the farms in Prairie du Sac and Stratford. Three of these scientists are also Research Leaders for their respective management units.

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Vacant
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Vacant
Center Director

National Dairy Forage Road Map

One major project for the Center Director and Research Leaders in FY 2013 was to create a coherent path forward for the U.S. Dairy Forage Research Center. The result, the National Dairy Forage Road Map, was shared with ARS administrators, USDFRC stakeholders and research collaborators. The Road Map opens with the following:

"Since 1981, ARS researchers at the U.S. Dairy Forage Research Center (USDFRC), Madison, WI, have been developing knowledge and tools to enhance sustainable and competitive dairy forage systems that protect the environment, promote animal health, and ensure a safe, healthy food supply. The USDFRC is the only ARS unit with the mission of improving forage use by dairy cattle.

"Through the years the USDFRC has successfully navigated through a changing landscape by updating CRIS projects, adding staff, and building the Environmentally Integrated Dairy Management Research Unit, Marshfield, WI. More recent changes have prompted the USDFRC to ask, "Is it time to create a new road map to help us navigate through these changes and beyond?" This is an attempt to do that – to create a road map for dairy forage research based on what we know are critical concerns facing the industry at this time – realizing that this road map will need to change, too, as the years advance.

"This new road map is also being designed to include other drivers. The USDFRC has had several collaborative relationships with universities, other ARS units and private industry in the past. As updated research goals are placed on this new map, there is a concerted effort to find research partners who can leverage the work of the USDFRC and help provide the dairy forage industry with additional research results in a more timely manner."

Click here to view the entire document.

The destination:

To cover more ground with forages and create more economically and environmentally sustainable dairy forage farm systems.

The vehicles:

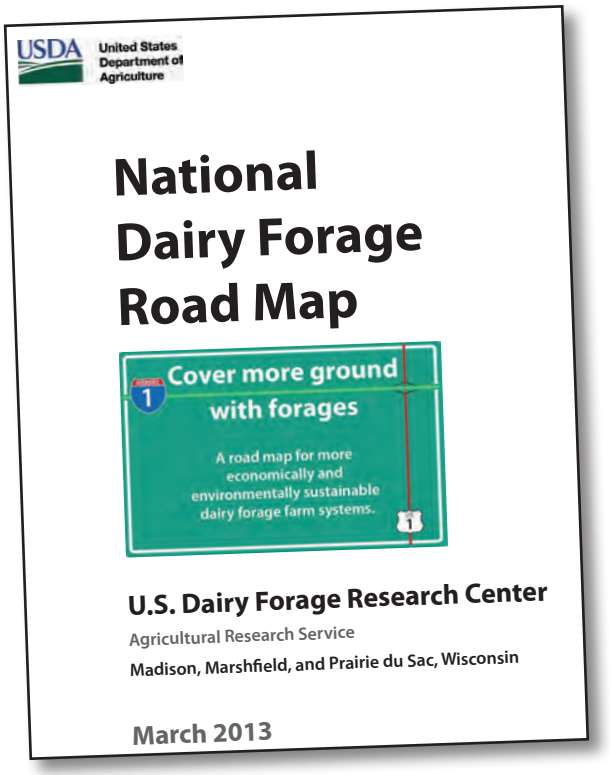
Forages: Improved forage plants and systems
The cow: Better utilization of forages in dairy cattle diets

The main research highways:

1. Modify plants to improve nutrient availability
2. Develop new cropping & pasture systems
3. Improve harvest & storage systems
4. Improve nutrient utilization by cows
5. Reduce nutrient escape to the environment
6. Develop new bioenergy & bioproduct uses

The drivers:

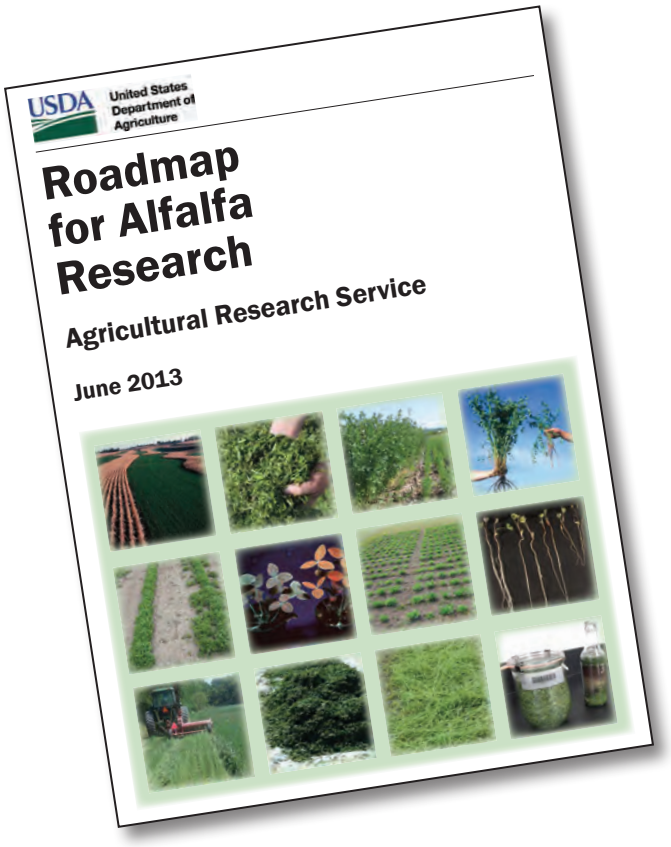
U.S. Dairy Forage Research Center scientists
Other ARS researchers
Consortia with public and private partners
Collaboration with public and private partners
Dairy/forage stakeholders (producers/industry)



Roadmap for Alfalfa Research

U.S. Dairy Forage Research Center Director Neal Martin and Research Leader Ron Hatfield played key roles in initiating and writing the Roadmap for Alfalfa Research which outlines many research goals for all Agricultural Research Service scientists working with alfalfa. The Roadmap opens with the following;:

"Alfalfa is the most widely cultivated forage legume worldwide and is the fourth most produced crop in the U.S. In economic value, alfalfa ranks among the top three field crops in 26 states and is grown in all 50 states (Figure 1). Its value rests on both domestic and export markets. Alfalfa currently contributes more than $10 billion per year to the nation's farm economy, primarily through its use as an animal feed.



"In addition, alfalfa provides many environmental services to farmers and to the public – benefits that are often overlooked. Those services diversify farming operations and help mitigate cropping system risk by providing nitrogen through biological fixation, reducing soil erosion, improving nutrient capture from annual crop fields, preventing nitrogen and phosphorus loss to surface and ground water resources, breaking of pest life cycles, and increasing soil carbon sequestration.

"To capitalize on these benefits while improving alfalfa's value as a premier animal feed and also developing additional end uses, the Agricultural Research Service (ARS) will follow three routes: 1) genetic improvement of alfalfa, 2) innovations in harvesting, processing, and new products, and 3) quantifying environmental benefits of alfalfa. Research will be conducted at nine ARS research units (Addendum 2, page 11) across the nation with industrial, university and other collaborators. This "roadmap" was developed to clarify the USDA-ARS alfalfa research vision for the future, starting with current five-year project plans."

Click here to view the entire document.

Research accomplishments

The following summaries of research were taken from the 'accomplishments' section of the AD-421 annual reports that the researchers write for each of the seven CRIS (Current Research Information System) projects in FY 2013.

Rapid DNA-based paternity testing assay for alfalfa will speed rate of alfalfa improvement

Alfalfa is one of the most widely grown crops in the United States. In alfalfa variety development programs, the pollen donors of plants being evaluated are most often unknown. This lack of paternal identity leads to slower improvement in alfalfa variety development.

USDFRC scientists conducted research in collaboration with an alfalfa breeding company to develop a low-cost rapid DNA-based paternity testing laboratory assay for alfalfa, including necessary computational software. This new technology has the potential to double the rate of alfalfa variety improvement over existing breeding methods. Alfalfa breeding companies are researching how best to incorporate this new assay into their breeding programs. It is estimated that this technology may be used by a majority of alfalfa breeding companies within the next few years.

Heathcliffe Riday, research plant geneticist

Condensed tannins are found naturally in birdsfoot trefoil (above) but not in alfalfa.

Forage growers gain assurance that propionic-acid-based preservatives work with large rectangular bales

Past studies have shown clear benefits (reduced heating, better preservation of nutrients) from applying propionic-acid-based preservatives to alfalfa hay made in 100-pound small-rectangular bales, but their effectiveness within large-round bales has been disappointing.

USDFRC scientists, in partnership with the University of Arkansas and the University of Wisconsin, wanted to determine how propionic-acid-based preservatives performed on large-rectangular bales because these bales are formed with a different packing mechanism (plunger) than round bales. The research showed that acid preservative limited spontaneous heating in these hays, and results were impressive, regardless of initial bale moisture.

Modest benefits also were observed for post-storage nutritive value of hays, as well as apparent digestibilities of dry matter and organic matter in growing lambs. These results suggest that spontaneous heating can be limited, and nutrients can be preserved, by using these preservatives within large-rectangular bale packages.

Wayne Coblentz, research agronomist/dairy scientist

Condensed tannins reduce ruminal protein degradation

Although alfalfa and other legumes are known for their high crude protein concentrations, this valuable nutritional resource often is utilized inefficiently by dairy cows. An environmental burden is then created when unused protein nitrogen is voided from the cow (primarily in the urine). Condensed tannins, which are found naturally in birdsfoot trefoil but not in alfalfa, may improve the efficiency of protein use by slowing and/or limiting protein degradation in the rumen.

USDFRC scientists evaluated 24 alfalfa and birdsfoot trefoil hays and silages in order to estimate the amount of protein degradation in the rumen. Protein degradation decreased by 3.2 to 4.6 percentage units of crude protein for each percentage unit of condensed tannin in the forage. Within the limits of this experiment, condensed tannins modestly limited protein degradation in the rumen, and they may offer potential for improving the efficiency of crude protein use within ruminants.

Wayne Coblentz, research agronomist/dairy scientist
John Grabber, research agronomist

Improved reed canarygrass cultivars and hybrids are not responsible for invasive properties of the species

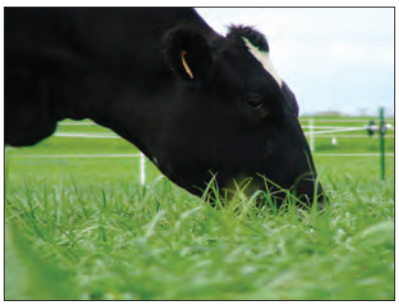
During the 20th century, reed canarygrass became classified as an aggressive invader of sensitive wetland areas throughout temperate North America. USDFRC scientists demonstrated the existence of three distinct races of reed canarygrass: a nearly extinct North American race, a European race that was brought by immigrant farmers in the 19th Century, and an Asian race that arrived during a past glaciation event over the Bering Land Bridge.

Using DNA markers, ARS researchers showed that nearly all samples of reed canarygrass collected from hundreds of wetland and upland sites in temperate North America trace to the European race. Less than 1% of modern samples can be classified as native North American types. Agronomic evaluations demonstrated that bred cultivars and hybrids that were developed for grazing livestock were no more aggressive than wild accessions, indicating that forage breeding and hybridization were not responsible for the aggressive and invasive properties of this species.

Michael Casler, research plant geneticist

Grazing intensity and timing impact pasture production

Inappropriate grazing management reduces the productivity, sustainability, and profitability of cool-season, pasture-based livestock farms. USDFRC scientists demonstrated that maintaining an adequate residual grass height after grazing increases pasture productivity and increases the probability of plant survival. Management guidelines developed from this research will improve the reliability of pasture production and improve profitability by reducing the need to feed conserved forages because pasture forage is inadequate.



Maintaining an adequate amount of grass after grazing increases overall pasture productivity and persistence.

Geoffrey Brink, research agronomist

Sparse-flowering orchardgrass has potential to simplify spring grazing management

Orchardgrass is a critically important grass in management-intensive rotational grazing systems in temperate regions of the USA. However, early and excessive flowering creates management issues by reducing acceptability and intake of forage to grazing livestock.

USDFRC scientists led efforts to show that recently developed sparse-flowering orchardgrass varieties have 57% fewer flowers compared to normal-flowering varieties. This difference was stable across 21 locations in temperate North America indicating that this trait is highly repeatable and predictable. The reduction in flowering was associated with a 25% reduction in first-harvest yield, but a 3% increase in most forage quality traits.

The use of sparse-flowering orchardgrass varieties may be an effective mechanism to increase intake and simplify spring grazing management for some management-intensive rotational grazing systems in temperate regions of the USA.

Michael Casler, research plant geneticist

Relationships between rain damage and alfalfa ensilability

The frustrations associated with conserving high-quality alfalfa silage during periods of unstable or inclement weather are widely known. Farmers often have to choose between cutting alfalfa knowing forage quality will be reduced by subsequent rain, or waiting for the rain to pass knowing that forage quality will be reduced by advanced maturity in the crop.

USDFRC scientists determined that the ensilability of alfalfa should be affected only minimally by single rainfall events applied to relatively wet forages, as long as these events are followed by rapid dehydration to moisture concentrations suitable for making silage. However, attaining acceptable silage fermentation with forages subjected to prolonged exposure under less than ideal drying conditions is likely to be far more problematic.

Wayne Coblentz, research agronomist/dairy scientist

New user-friendly phosphorus-loss model for cattle barnyards and feedlots helps reduce pollution abatement costs

Phosphorus loss in runoff from beef and dairy farms can pollute local lakes and streams, and barnyards and feedlots can be very high sources of phosphorus. USDFRC scientists developed and tested a user-friendly computer model that can quickly quantify how much phosphorus is lost from barnyards or feedlots each year.

Engineered barnyards at the USDFRC farm are used for research on runoff and leaching.

The model is being adapted by the Wis. Department of Natural Resources (DNR) for use in local adaptive management programs. These programs build partnerships between point source facilities and other landowners, municipalities, and private and public entities to reduce phosphorus pollution in compliance with local policies. The Madison Metropolitan Sewerage District estimates adaptive management can save them $185,000 per year to reduce their phosphorus pollution. The Wisconsin DNR estimates reducing phosphorus pollution could save the state $18.8 million over 20 years.

Peter Vadas, research soil scientist

Phosphorus loss in runoff from cattle lots quantified; loss from lots is small compared to field losses

Phosphorus loss in runoff from dairy farms can pollute local waters, but there is little information on how much loss comes from outdoor areas where cattle congregate and manure is not immediately collected. These outdoor cattle lots can range from densely stocked hard-surface barnyards to vegetated exercise lots with low stocking rates.

USDFRC scientists monitored phosphorus runoff for three years from the full range of dairy cattle lots. Annual phosphorus loss was a direct function of cattle stocking density in lots; phosphorus loss from densely-stocked lots was 6 to 19 times greater than from low intensity, vegetated lots. Per unit of land area, densely-stocked lots can have the greatest rate of phosphorus loss from a dairy farm, even more than on cropland.

However, even though densely-stocked cattle lots may be "hot spots" of phosphorus loss, and all types of outdoor cattle lots represent about 15% of the total land area on a farm, outdoor cattle lots contribute only 5% of total annual phosphorus loss on an average farm with the remainder coming from field runoff. Thus, targeting only cattle lots for phosphorus loss remediation may not dramatically reduce whole farm loss. Targeting cropland for phosphorus loss remediation remains a priority.

Peter Vadas, research soil scientist

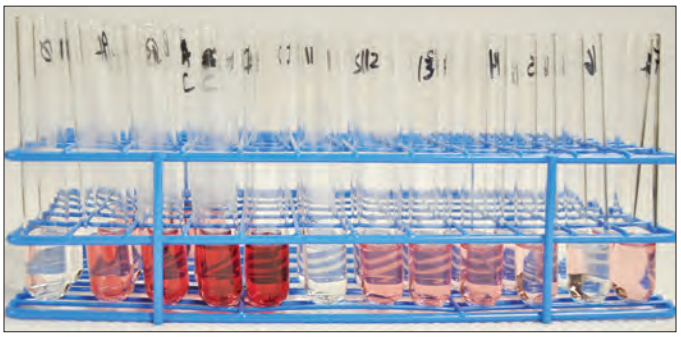
Improved starch assay in widespread commercial use to evaluate feed quality

Feed analyses are essential to determining the nutritional value of a feed relative to meeting an animal's nutrient requirements as well as for setting the commercial values of feeds. USDFRC scientists helped to develop and transfer to industry an improved method that more accurately and easily measures the starch content of feeds.

In a 12-month period, that assay was used by three commercial feed analysis laboratories to analyze a total of 282,537 samples with a total market value of $369,232. The method has also been widely adopted by commercial and research laboratories.

The starch assay is currently the focus of an Association of Analytical Chemists collaborative study to determine its suitability as an official method for regulatory purposes including feed nutritional labeling. The improved method gives the agricultural community a more reliable way to evaluate the nutritional and economic value of feeds.

Mary Beth Hall, research dairy scientist



An improved assay developed at the USDFRC more accurately and easily measures the starch content of feeds.

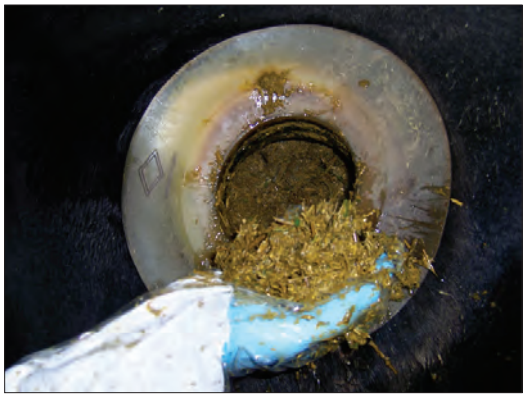
Bacterial communities in the rumen differ in high-efficiency versus low-efficiency cows

Milk production in cows is influenced by a number of factors including diet, host genetics, and the ruminal microbial community. Ruminal bacteria are directly responsible for the production of volatile fatty acids that are used by the cow as precursors for milk fat synthesis.

USDFRC scientists in collaboration with non-ARS colleagues, characterized the total ruminal bacterial community compositions and volatile fatty acid profiles in eight Holstein dairy cows. These cows were separated into high- and low-efficiency groups, and both ruminal solids and liquids were analyzed for total bacterial community structure. The researchers identified significant differences in bacterial community composition between high- and low-efficiency groups and between the solid and liquid fractions.

They also identified a core set of bacterial species shared among all high-efficiency cows, but no core set was found among all low-efficiency animals. Chemical profiles between high- and low-efficiency groups were similar, but propionic acid concentration was significantly higher in low-efficiency cows and succinct acid was significantly higher in high-efficiency cows. These data show that there is a specific ruminal bacterial microbiota associated with feed efficiency in dairy cows, but these differences cannot be detected by simple chemical analysis of ruminal contents.

Paul Weimer, research microbiologist



By studying the rumen microbes in partially digested feed, as shown above, researchers are learning some of the differences between cows with high versus low feed efficiency.

A measurement commonly used to evaluate rumen fermentation is not reliable

Organic acids are a very important energy source to the animal, and they are produced when rumen microbes ferment feeds. Since the 1940's, researchers in ruminant nutrition have used the concentration of organic acids in rumen fluid as an indicator of the effect of experimental treatments for enhancing or reducing fermentation of feed in the rumen.

However, recent findings by USDFRC scientists show that this approach can give misleading interpretations regarding the impact of treatments. The reason is that, for measurements to be valid for evaluating treatment effects, they need to be on the same basis. For concentrations, that means that they would need to be found in similar amounts of liquid in the rumen. In fact, the amounts of liquid in the rumen were shown to vary by up to 106 pounds, or 176% between the lowest and highest amounts within studies with lactating cows.

Because of this finding, new approaches will have to be found for evaluating the impact of treatments on the progress of ruminal feed fermentation, and conclusions drawn from past studies will have to be reconsidered.

Mary Beth Hall, research dairy scientist

More accurate assessment of nitrogen use will aid in reducing greenhouse gas emissions from the global dairy sector

The anticipated increases in global demand for food, especially for animal products, necessitate an urgent search for practices that enhance nitrogen use efficiency and reduce environmental nitrogen loss (ammonia, nitrate, nitrous oxide) from agricultural production. The International Panel on Climate Change (IPCC) requires member countries to determine and report agricultural greenhouse gas emissions.

In an effort to provide more accurate information for countries making these assessments, an ARS scientist from Madison, Wisconsin, was assigned to the Food and Agriculture Organization (FAO) of the United Nations, Animal Production and Health Division, for six months. He analyzed data on dairy cattle populations, feed, and milk production from 144 countries and determined more accurate values for nitrogen use efficiency and manure nitrogen excretion. These values may be used to estimate more accurately ammonia and nitrous oxide emissions from the global

dairy sector. The improved accuracy of manure nitrogen excretion calculations derived from this study should enhance regional, production system and global determinations of nitrogen loss from dairy farms during the collection, storage, and land application of manure, and it should more accurately reflect the amount of manure nitrogen actually recycled through crops and pastures.

J. Mark Powell, research soil scientist

Improved, more accurate assay developed to measure tannins in plant material

Condensed tannins have a unique role in numerous biological processes such as the release of nutrients from foods, feeds and decaying plant litter; the palatability and flavor of food and beverages; and the incidence of certain diseases in humans and animals. But scientists trying to better understand these processes have been hampered by the difficulty of accurately quantifying condensed tannins in plant materials.

Therefore, USDFRC scientists, in collaboration with scientists from the University of Reading, developed and tested an improved acetone-butanol-HCl assay that completely solubilizes and more accurately quantifies condensed tannins in forage plants. Ongoing studies are aimed at further developing the method for the analysis of extractable and insoluble forms of condensed tannins in a wide array of plant materials. It is anticipated that the improved assay will be widely used by scientists in a variety of disciplines to better understand the effects of condensed tannins on living systems and to improve the use of tannin-containing plants and extracts for livestock production and for promoting human health.

John Grabber, research agronomist

Genetic modification in corn lignin has value as model for further lignin research

In forages, modification of lignin (a cell wall component that gives plants support but restricts fiber digestion) could lead to increased utilization by ruminants. Even a modest 10% increase in cell wall digestion would lead to an increase in milk and meat production valued at approximately $350 million for U.S. dairies. USDFRC scientists have shown that corn lignin can be modified by a single enzyme change that is not part of the normal lignin pathway. This modification changes the composition of the lignin without changing the amount of lignin, the total biomass production, or the cell wall carbohydrate composition; only lignin composition is changed by this single gene down regulation.

Such plant materials can serve as models in research because they allow scientists to study how a single genetic modification affects a single trait. This modified corn gene is now being inserted into other plants to determine how it will alter interactions between cell wall composition and function (strength, lodging, insect resistance, total biomass production, and digestibility by ruminants) in these plants.

Ronald Hatfield, research plant physiologist

Discovery of a protein preservation system in perennial peanut opens the door for its wider use as a forage crop in southern U.S.

Ruminant animals such as dairy cows poorly utilize plant protein that is broken down during harvest and storage. It is estimated that it costs farmers over $100 million annually to supplement rations with the needed true protein because of protein breakdown in alfalfa, a major forage crop in the U.S.

However, alfalfa does not grow well in warm, humid climates. A researcher at Texas A&M University who was studying the use of perennial peanut as a forage crop in such climates consulted with USDFRC scientists as to why perennial peanut forage sometimes showed improved protein use efficiency when fed to lambs as haylage. The ARS researchers had previously demonstrated that, in red clover, reaction of *o*-diphenolic compounds with an endogenous polyphenol oxidase (PPO) enzyme prevents protein degradation when the forage is preserved by ensiling.

Upon further research, they demonstrated that this same mechanism is present in perennial peanut. This discovery of perennial peanut's protein preservation system opens the door for more research into its use as a forage crop in southern climates. Because it is difficult to grow alfalfa in the southern U.S. (while perennial peanut is adapted to this climate), perennial peanut forage could be an attractive alternative forage legume that sells for the same price as alfalfa without the transport costs that southern farmers now pay for alfalfa grown in cooler regions.

Michael Sullivan, research molecular geneticist

Maceration of alfalfa leaves improves protein capture in wet fractionation

When working with grains such as soybeans, corn, or cereal crops, the farmer separates the value streams (e.g., grain and straw) for different uses. If alfalfa leaves were separated from the plant's stem in a similar way, it could result in flexible uses of the crop, from customized leaf and stem blends in livestock feed rations to the opening of new markets for alfalfa's use in bioproducts and biofuels.

USDFRC scientists demonstrated a new 3-step process to accomplish this: 1) mechanical leaf separation during harvest, 2) dewatering the leaves, and 3) fermentation of the resulting juice. To quantify the effectiveness of different methods of leaf dewatering, they studied five dewatering treatments: maceration and four different levels of screw press back pressures.

Separating alfalfa leaves from stems at harvest is part of a 3-step process developed at the USDFRC.

They found that maceration did not affect the amount of water extracted, but did increase the protein concentration of the liquid press filtrate, or "green juice." All moisture levels of recovered solids (press cake) were successfully ensiled for use as livestock feed. These results suggest that leaf stripping combined with wet fractionation can potentially provide an alternative method of alfalfa harvest and use.

Matthew Digman, agricultural engineer

New fermentation process for alfalfa juice reduces time and inputs needed to obtain useful end products

"Green juice" produced by squeezing alfalfa leaves (part of a 3-step process designed to find higher-value uses for alfalfa) is rich in proteins (useful as animal feed) and sugars (useful in biofuel production); but it is difficult to recover either from the juice economically. One way to do this is to ferment the juice over a period of 3 to 21 days with bacteria already present in it; this produces a "brown juice" in which the sugars are converted to lactic acid. This acid fermentation precipitates the proteins from solution, facilitating their recovery.

Alfalfa "green juice" (right) can be fermented into "brown juice" which makes the sugars more available for biofuel uses; and it precipitates protein from solution, making it easier to recover protein for higher value uses.

USDFRC scientists have shown that the fermentation time can be shortened to as low as 8 hours by inoculating the juice with *Streptococcus bovis*, a bacterium from the cow rumen. In addition, a secondary fermentation of the brown juice can be initiated by adjusting the pH above 5.2 and inoculating it with another ruminal bacterium, *Megaspheara elsdenii*, which converts the lactic acid to a mixture of volatile fatty acids (acetic, propionic, butyric, and valeric) at concentrations substantially higher than amounts previously obtained with an alternative method (carboxylate platform for biomass conversion using "stuck" anaerobic digestion).

These volatile fatty acids can be recovered and converted to hydrocarbon and alcohol fuels using known chemical and electrochemical technologies. A major advantage of the fermentation is that it can be conducted without sterilization of the feedstock and without the addition of any other nutrients to the juice.

Paul Weimer, research microbiologist

Bacteria improves conversion of carbohydrates to fuel precursors

Megasphaera elsdenii is a bacterium from the cow rumen that is one of the few organisms known to convert carbohydrates and related compounds to five- and six-carbon volatile fatty acids which have potential value as fuel precursors. USDFRC scientists demonstrated that *M. elsdenii* could ferment up to 19 grams of lactic acid per liter to produce 9 grams of mixed volatile fatty acids per liter.

However, they also found that the bacterium ferments glucose poorly due to its ability to store up to 60% of the added sugars as glycogen. The researchers point out that redirection of glucose away from the

glycogen storage pathway may represent an opportunity to enhance production of two volatile fatty acids (butyric and caproic) which are easily extracted and can be converted chemically or electrochemically to hydrocarbons and alcohol fuels, with hydrogen as a major co-product.

Paul Weimer, research microbiologist

Human dietary changes impact the amount of land available for growing biomass for biofuel production

Fuels produced from biomass can potentially supply a substantial portion of current U.S. motor fuels, but there are concerns about having enough farmland to grow biomass, or the impact on the food supply when land is used to grow biomass for biofuels.

USDFRC scientists participated in a collaboration led by non-ARS scientists to examine existing and potential patterns of human food and animal feed consumption to estimate land required to grow biomass for biofuel production. If food consumption followed recommended USDA nutrition guidelines, current land could produce enough biofuels to replace half the U.S. gasoline consumption without affecting food supply.

If human protein consumption shifted from beef to poultry, which requires less land, about 60% of current gasoline use could be replaced by biofuels. This research provides consumers and policy makers with options for balancing food and fuel needs for U.S. citizens.

Peter Vadas, research soil scientist
Paul Weimer, research microbiologist

Mineral requirements are determined for yellow perch consuming plant protein-based feeds

Little is known of the nutritional requirements for growth of yellow perch in aquaculture systems; consequently, commercial feed formulations are based on nutritional requirements for rainbow trout, and these diets contain large quantities of fishmeal and oil that are too costly for other species. Plant proteins and oils are less expensive and more sustainable than fishmeal, but inclusion at high rates can reduce palatability, nutrient availability, disease resistance, fish performance and profitability.

Research at the Great Lakes Aquaculture Lab in Milwaukee (which is under USDFRC management) is focusing on the nutritional requirements of yellow perch grown in aquaculture systems.

USDFRC scientists conducted a nutritional study to determine the micronutrient (mineral) requirements for efficient growth in yellow perch consuming sustainable plant protein sources. Using a fishmeal-free diet provided by collaborators with the U.S. Fish and Wildlife Service, three diets were formulated with similar macronutrient content (40% crude protein/10% fat), but differing in how much mineral mix was added to the diets.

Fish fed the mid-level amount of mineral showed the highest feed intake and growth, suggesting that this mineral supplementation level is adequate for use with plant-based proteins. Researchers also compared fish fed the plant protein-based diet to fish fed a commercial fishmeal-based diet with a similar macronutrient profile. Overall, fish fed plant protein diets exhibited higher mortality (due to disease), lower feed intake, and lower growth rates. More research is needed to find adequate plant protein-based diet formulations for yellow perch.

Brian Shepherd, research physiologist (fish)

Rapid test for detecting the VHS virus in yellow perch has been completed

Viral hemorrhagic septicemia virus (VHSv) is one of the world's most challenging finfish diseases. A new and especially virulent strain (IVb) emerged in the North American Great Lakes in 2003, threatening fisheries, baitfish, and aquaculture industries. Previ-

ous diagnostic tests for VHSv have been inaccurate, prohibitively long and costly.

Researchers at the University of Toledo, in collaboration with USDFRC scientists located at the University of Wisconsin-Milwaukee, have developed a standardized reverse transcriptase polymerase chain reaction (StaRT-PCR) test that is specific to the VHSv pathogen, is rapid, and displays a higher range of accuracy and detection than existing tests.

In 2013, the StaRT-PCR test was converted to an easier-to-use real-time polymerase chain reaction platform using a two-color detection system. This new assay format will enable standard veterinary diagnostic labs to readily adapt this technology, and it will improve accuracy and reduce the time needed to reliably and cost-effectively detect the VHSv pathogen in economically- and ecologically-important finfish species. The assay is currently under regulatory review before it can be classified as an accepted method internationally.

Brian Shepherd, research physiologist (fish)

Specific genes of VHS virus differentially affect the fish immune system

Viral hemorrhagic septicemia virus (VHSv) is one of the world's most challenging finfish diseases. A new and especially virulent strain (IVb) emerged in the North American Great Lakes in 2003, threatening fisheries, baitfish, and aquaculture industries. In an effort to understand how VHSv invades the host fish, collaborating scientists at the University of Toledo previously found that two specific proteins of the VHSv pathogen negatively affect the immune response in fish, which enables the VHSv pathogen to infect and replicate within host fish cells.

One of these proteins, the VHSv M, has been assessed in detail. Additional ARS-funded research has identified a potential mechanism for how this viral protein reduces the fish immune response following pathogen exposure. Additionally, researchers have identified a naturally occurring mutant that differs from the Great Lakes type IVb strain M protein by only one amino acid; this mutant significantly alters activity in supporting viral replication and host inhibition.

Other viral proteins will be studied to better understand their involvement in impeding or promoting the viral detection and response pathways in fish.

Brian Shepherd, research physiologist (fish)

Staff changes in FY 2013

January 2013

Glen Broderick, research dairy scientist, retired after 32 years with the U.S. Dairy Forage Research Center. Dr. Broderick was known internationally for his dairy nutrition work, specializing in protein utilization. During his career Dr. Broderick conducted 89 animal trials, published 118 peer-reviewed articles and advised 23 graduate students.

Neal Martin, director of the U.S. Dairy Forage Research Center, retired after 13 years in this position. Previously an Extension forage specialist with the University of Minnesota, Dr. Martin, a.k.a. "Mr. Alfalfa," dedicated his career to promoting the environmental and nutritional benefits of perennial forages.

Antonio Faciola, who worked in the Broderick lab for 10 years as an intern, a graduate student and a post-doc, left the U.S. Dairy Forage Research Center and began a new career as an assistant professor of animal nutrition at the University of Nevada, Reno.

Passing the staff. USDFRC research leaders served as acting center director beginning in January. In May, Ron Hatfield (right) handed over the staff to Rich Muck. Wayne Coblentz took over in September.

February 2013

Joe Halinar began his employment at the U.S. Dairy Forage Research Center as a biological science lab technician in Michael Casler's lab.

March 2013

Jessica Sherman joined the U.S. Dairy Forage Research Center as a biological science lab technician for Bill Jokela in Marshfield. Previously she worked as a Faculty Associate at the University of Wisconsin-Stevens Point in the soils and waste resources discipline.

May 2013

Matthew Digman, research agricultural engineer for 2 years, left the U.S. Dairy Forage Research Center to take a job with Kuhn North America in Brodhead, Wisconsin. Dr. Digman had been researching alfalfa leaf separation at harvest and subsequent dewatering and fermentation of the leaves.

Kevin Free, maintenance manager at the Environmentally Integrated Dairy Management Research Unit in Marshfield, left for a new job after serving 2 years in this capacity.

June 2013

Mark Haberman, building manager for the U.S. Dairy Forage Research Center in Madison since 2008, left in order to move to Florida where his wife had secured a new job. In his 5 years at the Center he made many appreciated improvements in managing the building and the vehicle fleet.

July 2013

Jamie Boyd, a post-doc working in dairy cattle nutrition, finished a 4-year term at the U.S. Dairy Forage Research Center and began a new job as an assistant professor at Berry College in Rome, Georgia.

Christopher Rees, a biological science lab technician for Brian Shepherd at the Great Lakes Aquaculture Lab in Milwaukee for 7 years, moved on to a job as a fish biologist (invasive species management) with the USGS in La Crosse, Wisconsin.

Technology Transfer Report

Each year the Agricultural Research Service compiles a list of technology transfer activities – ways that ARS research and technology is being transferred to and used by the public. These are the activities that were reported by the U.S. Dairy Forage Research Center.

Posted APLE (Annual Phosphorus Loss Estimator) modeling tool for predicting phosphorus loss in runoff on web site where it was downloaded by 350 customers from 48 states and 33 countries.
VADAS

Articles about APLE (Annual Phosphorus Loss Estimator) were featured in ARS Magazine, Soil and Water Conservation Society Newsletter, Texas State Soil and Water Conservation Board Newsletter, National Hog Farmer, Feedstuffs Magazine, and Livestock & Poultry Environmental News (May, 2013).
VADAS

Posted "Rumen Microbiology and its Role in Ruminant Nutrition" textbook (by the late ARS researcher James B. Russell) on web site where it was downloaded by 888 customers from 52 countries.
WEIMER

Coauthored four Focus on Forage fact sheets with University of Wisconsin Cooperative Extension Service: "Grazing management for fall-grown oat forages," "Propionic acid preservatives for hay," "Effects of rain damage on wilting forages," and "Forging a partnership with a custom operator."
COBLENTZ, DIGMAN

Helped develop and transfer to industry an improved assay that more accurately and easily measures the starch content of feeds. The method has been adopted by commercial feed analysis laboratories and is currently being studied by the Association of Analytical Chemists to determine its suitability as an official method for regulatory purposes, including feed nutritional labeling.
HALL

Developed and tested a low-cost, rapid, DNA-based paternity testing laboratory assay for alfalfa (including necessary computational software) that is now being used by alfalfa breeding companies. One huge advantage of this assay is that it has low set-up costs so it can be used by smaller plant breeding companies which are common in the forage industry.
RIDAY

Article on Annual Phosphorus Loss Estimator was feature in Agricultural Research magazine.

Rapid, DNA-based paternity testing laboratory assay for alfalfa is being adopted by seed companies.

Developed and tested a user-friendly computer model that is being adapted by the Wisconsin Department of Natural Resources for use in local adaptive management programs. The model can quickly quantify how much phosphorus is lost from barnyards or feedlots each year.
VADAS

Conducted an analysis on nitrogen use in the global dairy sector that is currently being used by the International Panel on Climate Change to help member countries determine and report more accurate values for nitrogen use efficiency and manure nitrogen excretion and consequently make more accurate estimates of ammonia and nitrous oxide (the most potent greenhouse gas) emissions.
POWELL

Authored two chapters for *Cool Forages* book. "Benefits of Perennial Forages in Rotations" and "Manure on Alfalfa."
JOKELA, RUSSELLE

Developed and transferred to industry (via a confidentiality agreement) an algorithm for gender identification in yellow perch. The related publication was distributed to Extension agents, state fishery managers and other stakeholders.
SHEPHERD

Transferred specific method and technique for use of passive integrated transponder (PIT) tags to an aquaculture industry stakeholder.
SHEPHERD

Presentations, seminars and workshops

Organized and presented at educational seminar series for World Dairy Expo, Madison, WI, with 300 producers, industry stakeholders and ag media reps attending the six seminars. (10/3-5/2012)
BOCHER, MUCK, BRODERICK

Presented 3 talks to about 150 people at the joint meeting of the American Society of Agronomy/Crop Science Society of America/Soil Science Society of America. (10/21-24/13)
COBLENTZ

Contributed to a round table discussion and gathering of 23 industry reps (Wisconsin Aquaculture Association) and university, state and federal researchers to identify research and economic needs for Wisconsin aquaculture producers. (10/24/12)
SHEPHERD

Gave 3 talks to more than 200 Wisconsin producers describing how grazing management and drought interact to impact pasture productivity and persistence. Iowa County Drought Workshop (11/14/12), Wisconsin Grazing Conference (1/17/13), and Columbia/Dodge Winter Grazing Meeting (2/14/13).
BRINK

Presented to 50 producers and industry stakeholders at American Forage and Grassland Council Annual Conference. (1/6/13)
COBLENTZ, MUCK

Presented to 140 crop advisors, Extension educators and state and federal agency staff at the Wisconsin Crop Management Conference. (1/16/13)
GRABBER

Richard Muck presents information about silage inoculants to more than 75 farmers and industry representatives who visited the Dairy Forage Seminar Stage hosted by USDFRC at World Dairy Expo in October 2012.

Presented to 150 producers, industry reps and Extension educators at the Midwest Forage Association Symposium. (1/22/13)
MUCK

Presented to 135 producers, industry reps, Extension agents and researchers at the Aquaculture America meeting for the World Aquaculture Society. (2/22-25/13)
SHEPHERD

Presented to 150 producers and industry stakeholders at the Idaho Hay and Forage Conference. (2/28 and 3/1/2013)
COBLENTZ

Presented to 50 nutrient management planners, Extension educators and state and federal agency staff at a conference, "Waste-to-Worth: Spreading Science and Solutions." (4/4/13)
JOKELA

Presented APLE (Annual Phosphorus Loss Estimator) modeling tool for predicting phosphorus loss in runoff at two meetings attended by approximately 100 producers, extension, regulatory, and university personnel in Denver, CO (4/3/13) and Des Moines, IA (6-25-13).
VADAS

Members of the Near Infrared Spectroscopy Consortium, the National Feed Testing Association, and the Association of Official Agricultural Chemists learn about USDFRC research related to forage and feed analysis.

Wayne Coblentz speaks to farmers, media reps and Extension educators at a research field day.

Hosted a seminar and discussion (3/20/13) and co-hosted a tour (5/14/13) for stakeholders interested in collaborative research regarding the interface of agricultural and conservation at a former munitions plant where the USDFRC research farm is located. The 25 people in attendance at both events included representatives of the Wisconsin DNR, the University of Wisconsin, and local organization.
BOCHER

Presented research results on topics related to forage and feed analysis to a group of 15 representatives from the Near Infrared Spectroscopy Consortium, the National Feed Testing Association and the Association of Official Agricultural Chemists. (6/3/13)
HALL, KARLEN, MUCK

With National Program Staff, organized a stakeholder workshop for yellow perch and walleye commodity groups that was attended by about 50 aquaculture producers, consumers, Extension agents and scientists. (7/27/13)
SHEPHERD

Gave talks and organized a nitrate testing exhibit for drinking water at the Marshfield (WI) Agricultural Research Station Field Day which attracted more than 50 farmers. (8-14-13)
COBLENTZ, JOKELA, BORCHARDT

Presented an invited talk at the American Chemical Society (ACS) National Meeting and received the award for the research article of the year for the AGRO Division of the ACS. (9/7-12/13)
GRABBER

Organized, co-hosted, and presented research at Switchgrass II conference in Madison, WI, to discuss the state of the art of prairie grass research. Expected 100 scientists and students interested in ecology, biomass production, and genomics of switchgrass and other prairie grasses. (9/10-12/13)
CASLER

Organized and hosted an educational seminar for 20 employees of the Wisconsin Department of Natural Resources (DNR) to educate them about agriculture in general and manure/nutrient management specifically. Used Nutrient Management Plan at research farm as a positive example. (9/6/13)
WALGENBACH, BOCHER

Presented to 30 Extension educators at the 7th Forage Teaching and Techology Conference . (9/6/13)
MUCK, COBLENTZ

Outreach, Diversity and Equal Opportunity

The USDA Agricultural Research Service encourages its employees to reach out to diverse audiences and to help foster the next generation of research scientists. These are the major Outreach, Diversity and Equal Opportunity (ODEO) activities conducted by U.S. Dairy Forage Research Center employees in FY 2013.

October 2: The U.S. Dairy Forage Research Center's ODEO committee organized an outreach activity for FFA students attending World Dairy Expo. The FFA Dairy Forage Quiz brought 650 students to the USDFRC display where they searched for the correct answers to the quiz questions. The event was organized by Lori Bocher. Also volunteering were Mary Becker, Jamie Boyd, Ben Duval, Kris Niemann and Jan Pitas.

More than 650 high school students participated in the FFA Dairy Forage Quiz at World Dairy Expo.

In addition to the above, Diane Amundson volunteered for the 4th grade school tours at World Dairy Expo, a program that attracts about 1,300 Madison-area students. And she enhanced the tour experience by creating a display on the feeds that dairy cattle eat, with emphasis on how cows eat many byproducts that otherwise would be landfilled.

January 15: Nine employees of the U.S. Dairy Forage Research Center (USDFRC) recognized the USDA's National Day of Service and Dr. Martin Luther King Jr.'s birthday by volunteering at a local non-profit, Second Harvest Foodbank of Southern Wisconsin. The volunteers learned about the organization's mission and spent two hours repackaging 1,598 pounds of food for distribution, which is equivalent to 1,332 meals, according to Second Harvest.

March 12: Wayne Coblentz hosted a group of 7 Boy Scouts and 6 parents/leaders at the Environmentally Integrated Dairy Management Research Unit in Marshfield. He engaged the Scouts in a discussion about how they would conduct research to compare "Wonder Hay" to regular hay. He also gave a tour of the research facilities.

March 20: The USDFRC hosted a seminar and planning session for researchers interested in the intersection of ecosystem and agroecosystem management and research opportunities at the former Badger Army Ammunition Plant where the USDFRC research farm is located. The purpose was to form research collaborations among the new land owners of the former ammunition plant (USDFRC and Wisconsin DNR) and other interested parties. As a result of this meeting, a tour of the land was planned for May 14 (see report on next page).

April 11: The U.S. USDFRC hosted the Sauk County Institute of Leadership (SCIL) at its research farm on April 11 for an educational seminar on Agriculture and Natural Resources. The day-long seminar was one of nine in the SCIL program in which 15 community leaders learn about a variety of local, state, and national issues. Sharing the story of how USDFRC research seeks to improve the environmental and economic sustainability of milk production were: Lori Bocher and Rick Walgenbach.

Chris Rees visits with high school students at the National Ocean Sciences Bowl in Milwaukee, WI.

April 18: Chris Rees, Tim Paul and Jhonatan Sepulveda-Villet, ARS personnel at the Great Lakes Aquaculture lab in Milwaukee, (Dairy Forage and Aquaculture Research Unit), participated in a career fair at the National Ocean Sciences Bowl in Milwaukee. The career event was designed for students from across the nation to learn more about careers in the marine sciences by talking with current professionals. The 125 students attending the event were all winners of their respective regional competition. Rees, Paul, and Sepulveda-Villet set up an ARS careers display, visited with about

75 students, and gave them "*Your future career with ARS*" booklets.

April 23: Chris Odt and Dave Stevenson presented at the 2013 Science Night at Emerson Elementary School, in Madison. This annual event is organized by the school's teachers and the UW Institute for Biology Education: Adult Role Models in Science program. This year the evening attracted 350 students and family members. Dave and Chris held two sessions titled, "Fun with Chromatography." Sixty students and parents participated in two experiments: simple chromatography with M&M's and analytical chromatography with felt tip markers. There were numerous ooh's and aah's, and a number of students in both sessions said they wanted to be a scientist some day!

Learning about cows is fun at the Baraboo Circus Heritage Days.

April 26: Wayne Zeller spoke to 60 faculty and students at the Center for Biophysical and Biochemical Studies Noon Seminar Series at Northern Illinois University, DeKalb. In addition to speaking about the activities and analysis of plant polyphenols in agricultural research, Zeller talked to the students about careers in agricultural research, fielded many questions from future scientists, and handed out "*Your future career with ARS*" booklets.

May 9: Robin Ogden at the Environmentally Integrated Dairy Management Research Unit (Marshfield) presented for a group of 17 students from the Introduction to Veterinary Medicine class at D.C. Everest High School, Weston, WI. She and student employee Meridith Kruse explained how a cow's digestive process differs from human's, and they gave the students an opportunity to reach inside the rumen of a surgically cannulated cow at the unit's research farm which is operated jointly with the University of Wisconsin Ag Research Station.

May 14: The USDFRC co-hosted a tour at its research farm inside the former Badger Army Ammunition Plant, Prairie du Sac. This tour, designed to explore opportunities for collaborative research about the interface of agriculture and conservation, resulted from a March 20 planning session hosted by the USDFRC (see previous page). Geoff Brink served as a tour guide and presented information about his pasture research. Heathcliffe Riday explained his forage legume breeding research. The 25 people in attendance included representatives of the Wisconsin DNR, the University of Wisconsin, and local organizations.

May 18: The USDFRC reached out to 1,200 young people, their parents, and youth leaders at the Baraboo Circus Heritage Days, an annual event open to all organized youth groups in southern Wisconsin and neighboring states. The display highlighted how farmers are scientists and encouraged students to consider careers in agriculture. There were also hands-on activities, such as pouring water through different soils to see how they drain at different rates. Working at the event were Mary Becker, Lila Walters and her husband Jim Franke, and Ron Skoyen.

May 23: The Environmentally Integrated Dairy Management Research Unit (Marshfield) of the USDFRC worked with FFA members from Spencer High School to organize a farm field trip for approximately 50 third and fourth grade students. Robin Ogden helped the fourth grade students reach inside the rumen of a cannulated cow, and she explained how a cow's rumen allows it to eat many things that humans can't eat.

Robin Ogden helps a 4th grade student reach inside a fistulated cow's rumen.

Summer: For five weeks, the USDFRC mentored two high school students who were participating in the University of Wisconsin-Madison PEOPLE program – Pre-College Enrichment Opportunity Program for Learning Excellence. PEOPLE is a pre-college pipeline for students of color and low-income students, most of whom are the first in their families to potentially attend college. Wayne Zeller mentored Abert Vang, a high school senior from Milwaukee. Abert isolated condensed tannins from cocoa powder and white clover flowers as part of research to provide these materials for use in model ensiling experiments and for testing their ability to abate ammonia production from dairy manure. Heathcliffe Riday and John Raasch mentored Danielle Golden, also a Milwaukee high school student. She learned how to extract DNA from clover seeds, set up PCR for detecting genetic markers, and evaluated the results from several hundred seeds.

August 24: The USDFRC set up a display for a drive-through tour of the former Badger Army Ammunition Plant (BAAP) which includes the USDFRC farm (2,006 acres). The display described how the USDFRC has been improving the land and conducting relevant research at the site since 1980. The Wisconsin DNR organized the tour as part of its planning process for the future Sauk Prairie Recreation Area. About 840 cars participated in the tour.

September 18: Of the 24 high school students attending Scientist for a Day, 19 said they were more likely to consider a career in agricultural or scientific research. "I already planned on going into agricultural research, but now I have a better idea of what specifically I want to do," said one student. At the day-long, hands-on program, USDFRC research scientists and technicians led the students in four activities related to sustainable agriculture: Measuring the phosphorus runoff from various barnyard surfaces; hand-packing silage to gain an idea of the importance of packing density when making silage; learning about genetically modified plants; and studying the rumen contents of lactating cows. Participating in the program were: Diane Amundson, Jon Bleier, Lori Bocher, Geoff Brink, Lisa Koch, Kris Niemann, Jan Pitas, Jim Richmond, Meagan Ritchie, Mike Sullivan, and Peter Vadas.

Measuring phosphorus runoff from various barnyard surfaces with Peter Vadas.

Learning about the importance of packing density when making good silage with Geoff Brink.

Studying the rumen contents of lactating cows with an emphasis on fiber digestion and particle size with Jan Pitas.

Learning how and why plants are genetically modified for improved utilization in dairy cows with Mike Sullivan.