

Improving the Economic and Environmental Sustainability of Dairy Forage Farm Systems

8 Examples showing the
\$1.5 billion

**IMPACT OF
RESEARCH**

at the
U.S. Dairy Forage Research Center
USDA-Agricultural Research Service

U.S. Dairy Forage Research Center

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IMPACT OF RESEARCH

- 1** Reducing excessive protein in dairy diets
\$740 million annually
- 2** Reducing excessive phosphorus in dairy diets
\$109 to \$180 million annually
- 3** Creating nutrient management tools
educational value
- 4** Reducing feed losses in bunker silos
\$150 million annually
- 5** Creating efficient rations for cows
\$260 million annually
- 6** Improving efficiency of grazing-based dairy systems
\$250 million annually



an estimated
\$1.5 billion saved
annually by
dairy farmers
across the U.S.*

* While an exact dollar figure cannot be determined, these estimates were calculated with scientific data and with reasonable assumptions as to the extent that these practices have been adopted.

Future Impacts

of Current Research at the U.S. Dairy Forage Research Center

- 7** Improving protein utilization of alfalfa
\$100 million annually
- 8** Improving fiber digestibility of forages
\$253 million annually

#1 Current Impact

Reducing Excessive Protein in Dairy Diets, thus Decreasing Atmospheric Ammonia

The Challenge:

Too much ammonia nitrogen in the air, some of it volatilized from manure (from barns, during storage, when spread on fields), and too much nitrate nitrogen in groundwater, some of it leaching from manure spread on fields, can be harmful to natural ecosystems and human health. The Clean Air Act has recently mandated caps on ammonia emissions from animal facilities.

The Research Response:

Can dairy cattle be fed less protein (so less nitrogen is excreted in manure) without affecting milk production efficiency?

Research Results:

Yes, dairy cattle can be fed less protein than previously thought without lowering production, thereby reducing the amount of nitrogen excreted in manure. Companion research demonstrates that reduced nitrogen in manure reduces ammonia emissions from barns and during manure landspreading.

Estimated Financial Impact:

- This reduction in dietary protein has saved the U.S. dairy industry at least \$740 million annually in reduced feed purchases for protein supplements¹.

Estimated Environmental Abatement:

- This reduction in dietary protein has reduced the nitrogen output in manure (especially urine, the source of ammonia) by more than 15%.
- Reduced manure nitrogen due to improved feeding decreases ammonia emission from barn floors by 15% and land spreading by as much as 50%.

More Details:

Dairy farmers have fed high levels of protein as a “risk management” strategy to avoid the chance of reduced milk production due to inadequate dietary protein. In the late 1990s, many high-producing dairy herds were being fed diets at more than 20% protein, with much of that protein coming from purchased feed such as soybean meal.

These high levels of protein were costing dairy producers lots of money. Additionally, when cows were fed more protein than they could use, the excess was excreted as urinary nitrogen, and this created a greater potential for 1) nitrogen to leach into groundwater when manure was spread on farm fields and for 2) ammonia nitrogen to volatilize to the atmosphere.

Research at the U.S. Dairy Forage Research Center sought to determine the optimal amount of protein needed in the diets of high-producing dairy cows. Results of a number of studies showed that there were no further increases in milk production per cow when feeding protein at levels greater than 16.5% of the diet. There were even indications in a few trials that overfeeding protein may actually reduce production slightly. Moreover, supplementing dairy diets with small amounts of essential amino acids, the protein building blocks that the cow can't make herself, will allow dietary protein to be fed at even lower levels.

Farmer surveys have shown that Wisconsin dairy producers with the highest levels of milk production have reduced the average protein contents of their dairy cattle diets by nearly two percentage units from 1998 to 2005. If extrapolated to the entire U.S. dairy herd, this would translate into an annual savings of \$740 million¹. It would also mean that less nitrogen from manure is finding its way into groundwater and the atmosphere.

¹ Based on 9.1 million dairy cows (NASS, 2010) consuming 50 pounds of dry matter per day over a 305-day lactation, and soybean meal at \$300 per ton.



#2 Current Impact

Reducing Excessive Phosphorus in Dairy Diets, thus Decreasing Phosphorus Runoff

The Challenge:

Too much phosphorus in surface water runoff, some of it coming from manure spread on farm fields, contributing to excessive algae growth in bodies of water, reducing water quality for fish and humans. The Clean Water Act mandates reduction in phosphorus from agricultural runoff, a non-point source of pollution.

The Research Response:

Can dairy cattle be fed less phosphorus (therefore less phosphorus excreted in manure) without harming reproductive performance and milk production efficiency?

Research Results:

Yes, phosphorus can be fed to dairy cattle at lower levels, thereby reducing the amount excreted in manure. Phosphorus in runoff from fields that receive manure from cows fed a phosphorus adequate diet is much less than from fields receiving manure from cows fed excessive levels of phosphorus.

Estimated Financial Impact:

- This reduction in dietary phosphorus has saved the U.S. dairy industry an estimated \$109 to \$182 million annually¹.
- Feeding less phosphorus also means that less acreage is required to spread dairy manure, thereby helping dairy producers meet new manure land spreading standards.
- The value of improved water quality due to reduced phosphorus runoff is enormous.

Estimated Environmental Abatement:

- This reduction in dietary phosphorus has reduced the phosphorus content of manure by about 15-20%.
- These reductions translate to about 27 percent less phosphorus in runoff from manure after it is applied to land.

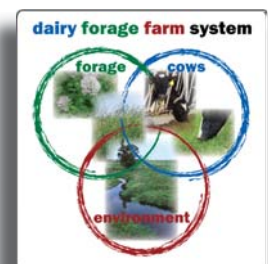
More Details:

Historically, dairy farmers tended to “err on the high side” when feeding minerals and fertilizing fields because minerals such as phosphorus were cheap and the environmental consequences were unknown. However, when excessive amounts of phosphorus in surface water became an environmental policy concern in the 1990s, runoff from farm fields was cited as a major contributor. At that time, surveys indicated that U.S. dairy producers were feeding lactating cows well in excess of the recommended amount. Strong beliefs that extra dietary phosphorus improved reproduction (held by nutritionists, veterinarians, and producers) encouraged excessive feeding of phosphorus just to be on the “safe side”.

Researchers at the USDFRC challenged this long-held belief by conducting a large-scale study of 267 early-lactation cows. This study unequivocally demonstrated that feeding phosphorus in excess of recommendations did not improve milk production or reproductive performance. Companion field trials demonstrated that reduced phosphorus feeding also reduced runoff phosphorus.

The convincing conclusions from these experiments contributed greatly to reductions of dietary phosphorus in the U.S. dairy herd. Results of local surveys, analyses of total mixed rations submitted to testing laboratories, and feedback from extension specialists and the feed industry, suggest that the level of dietary phosphorus fed to the U.S. herd has been reduced from an average of about 0.48% in 1999 to about 0.40-0.42% presently.

¹Based on 9.1 million total dairy cows in U.S. (NASS, 2010). Annual savings estimated to be \$12 to \$20 per lactating cow.



#3

Current Impact

Creating Nutrient Management Tools

The Challenge:

Escalating fertilizer and feed costs, great variation (and recent precipitous decline) in milk prices, and increasing regulations to reduce nutrient loss have created new economic and environmental pressures to improve nutrient use in dairy production.

The Research Response:

How can dairy producers improve nutrient use efficiency? The U.S. Dairy Forage Research Center response has been 1) to develop tools and recommendations about how to integrate dietary, livestock management, and manure handling practices into comprehensive nutrient management programs, and 2) to identify management practices that bring dairy farms into better nutrient balance while maintaining farm productivity and profitability.

Research Results:

The decision-support tools, guidelines, manuals, maps and other products derived from the U.S. Dairy Forage Research Center's nutrient management research have been adopted by 1) dairy producers and their feed and crop consultants, 2) educators involved in nutrient use training, 3) decision-makers working to develop guidelines and regulations for improving nutrient management, and 4) university students, many of whom will be researchers, conservation program staff, or consultants assisting farmers with nutrient management in the future.

Estimated Financial Impact:

- Reduced feed costs due to better feeding strategies.
- Reduced crop costs due to less fertilizer needed (more manure nutrients captured and recycled).

Estimated Environmental Abatement:

- With integrated dietary, livestock management, and manure handling practices put into place, fewer nutrients such as nitrogen and phosphorus are entering the soil, water, and air.
- Farmers have more accurate tools and recommendations to help them meet the requirements of the Clean Water Act and the Clean Air Act.

More Details:

- Researchers determined how forages, protein and mineral supplements impact manure nutrient excretions, and their transformations in air, water and soil. As a result, the Natural Resource and Conservation Service (NRCS) and state extension services have incorporated feed management into manure management curriculum, comprehensive nutrient management plans (CNMPs) and best management practices (BMPs). Dairy producers are now formulating rations that reduce costs and facilitate environmental compliance (manure phosphorus spreading and ammonia nitrogen emissions).
- The SurPhos model was developed to predict manure and fertilizer phosphorus transformations and loss in runoff. This first-of-its-kind model is now used in the Wisconsin phosphorus index and in other nutrient management/water quality models designed to identify farm areas at risk to lose phosphorus and practices to reduce its loss.
- Research directly on commercial dairy farms revealed that technology adoption impacts feed use efficiency and manure production; that herd management impacts manure collection, nutrient buildup in outside dairy cow holding areas, and manure application to cropland; and that ammonia emissions from commercial dairy farms vary seasonally. These findings are now being used in research, extension and cost-sharing efforts.



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#4

Current Impact

Reducing Feed Losses in Bunker Silos

The Challenge:

As dairy producers make a major shift to ensiling feed in large bunkers and piles, replacing the more traditional tower silos, more feed is being lost to spoilage and decomposition.

The Research Response:

How can these losses be reduced without losing the efficiencies gained from bunker silo usage? (Speed of harvesting and filling, reduced capital costs, etc.)

Research Results:

The greatest silage losses occur when silage is not packed densely and/or not covered properly; both allow too much oxygen into the silage so that spoilage microorganisms grow on the silage, using up the most nutritious parts of the silage before the cows can. Recommendations for packing and covering bunker and pile silos, along with spreadsheet tools to evaluate packing techniques, have been developed for and disseminated to dairy producers and consultants.

Estimated Financial Impact:

- With well-managed bunker and pile silos, as little as 10% of feed is lost; with poorly managed bunkers and piles, losses can be as high as 40%.
- Every ton of as-fed silage saved is worth \$30 to \$80, depending on type and quality.
- In the U.S. livestock industry, reducing feed losses from bunker and pile silage five percentage points translates to an annual savings of about \$150 million¹.

Estimated Environmental Abatement:

- When less feed is lost, less land is needed to feed the same number of cows. This may allow environmentally vulnerable land to be taken out of production or make productive land available for other crops and uses such as biomass for bioenergy. Also, fewer inputs such as fertilizer and fuel are needed to produce crops.
- When silage quality improves due to improved packing density and covering, there is also an increase in the amount of protein in the feed that is available to the cow. Therefore, less nitrogen is excreted in the manure and potentially finds its way into soil, air, and groundwater.

More details:

As the number of bunker and pile silos increased in the U.S., it was apparent that there was a wide variation in silo management. A collaborative effort between the U.S. Dairy Forage Research Center, the University of Wisconsin and county extension agents surveyed bunker silo management practices and densities across Wisconsin. The range in densities varied by a factor of three from the lowest to highest densities, a much wider range than expected. The survey indicated which practices were important to achieving a high density, led to spreadsheet tools to help farmers obtain high silage densities, and sparked an interest across the U.S. in silage density. Subsequent research at pilot and field scale has confirmed the importance of the factors found in the survey. The spreadsheets are now available in three languages and being used around the world.

Silage scientists have long recognized the importance of covering a silo well to minimize losses, but at one time less than half of U.S. bunker or pile silos were covered. Research on silo covers at the U.S. Dairy Forage Research Center and in other states has demonstrated the value of covering and has compared the merits of different types of covers. The 2009 *Hoard's Dairyman* Continuing Market Study found that, today, more than 93% of dairy farmers cover their bunkers.

¹ Assumes alfalfa and corn silage at \$60 and \$40/ton respectively; and that, of the silage made in the U.S. in 2009 (32 and 108 million tons; NASS), half was ensiled in bunkers or piles.



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#5

Current Impact

Creating Efficient Rations for Cows

The Challenge:

For dairy producers to make the best use of homegrown feeds and minimize purchased feeds, they need a system to accurately analyze feeds and blend them in a way to meet the energy and nutrient needs of the cow.

The Research Response:

How can we measure the fiber portion of each feed accurately and in a way that is useful for balancing cow rations?

Research Results:

A method for measuring neutral detergent fiber (NDF) in feeds was developed into an official method that is being used by forage testing laboratories across the U.S. and now around the world. A system for formulating dairy rations (the NDF-Energy Intake System) was developed to maximize forage use while promoting maximum milk production. The concept of physically-effective NDF was created, combining the chemical and physical properties of fiber, to meet the minimum fiber requirements of the cow.

Estimated Financial Impact:

- A 5% improvement in the estimation of the energy value of feeds, if used to formulate improved rations for the lactating dairy cows in the U.S., increases efficiency and/or productivity by \$260 million annually¹.
- The NDF method developed at the Center is used by 150 commercial testing laboratories in the U.S.; these labs, which analyze millions of feed samples annually for farmers and their consultants, are important to rural communities and the economic well being of their rural customers.
- The NDF method is a primary component used to estimate the RFV (relative feed value) and RFQ (relative feed quality) of hay samples. These indices of quality are used in buying and selling hay across the U.S.

Estimated Environmental Abatement:

- Every time rations are balanced effectively, feed utilization/efficiency improves, less undigested feed leaves the cow as manure, and fewer acres are needed per pound of milk produced to grow the cow's rations.

More details:

Fiber is extremely important to dairy cows. Whereas humans have very limited capabilities to use fiber, fiber is a major source of carbohydrates to the cow. However, fiber is the portion of a feed that is the most variable in digestibility to the cow. Most other components like proteins, fats and simpler carbohydrates (starch and sugar) are highly digestible.

Fiber influences how much a cow chews, and chewing produces saliva that buffers the cow's digestive system allowing it to work better. Finally, while lactating dairy cows eat a lot of food, the amount they can eat is usually limited by the amount of fiber in their diet. If the fiber content is too high, she won't be able to get enough energy and milk production will go down. So the farmer is faced with a balancing act of putting enough chewable fiber in the cow's diet so that her digestive system works well but also keeping the fiber content of the diet at a level that allows her to produce milk efficiently.

Research at the Center standardized the technique to reliably measure NDF in a wide variety of feeds and got it published as an official method that forage testing laboratories can use. That alone would not necessarily be useful; an analysis technique also has to be of value in predicting how the cow will eat and digest her diet. In this case, the research here has shown that NDF is perhaps the most important component of a feed that we measure on a routine basis, affecting the digestibility of a feed, how filling a feed is to the cow, and its energy content. NDF has become the key component used to balance dairy cow rations in the U.S. and in many other countries.

¹Based on 9.1 million dairy cows (NASS, 2010) consuming 1 lb less dry matter/day and a mixed ration costing \$140/ton.



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#6

Current Impact

Improving Grazing-Based Dairy Systems

The Challenge:

In the late 20th Century, pasture-based dairy production began to grow due to economic considerations and consumer demand. However, few grass and legume varieties were designed (bred) for managed intensive rotational grazing systems. Less is known about managing grasses and legumes in pasture-based systems compared to haymaking systems.

The Research Response:

The U.S. Dairy Forage Research Center added two new positions and refocused a third position in order to meet the rising public demand for research on grass-based systems. The Center is not only breeding new pasture varieties, but also testing them with animals – both in terms of how the animals perform on the new varieties and how the plants perform under various types of grazing management.

Research Results:

This emphasis on pasture research has resulted in specific management guidelines graziers use to improve their efficiency. And USDFRC plant breeders currently have three grass and seven legume varieties and germplasm in some stage of commercial development; these should be available to farmers between 2012 and 2016.

Estimated Financial Impact:

- New varieties of grasses and legumes with improved digestibility will allow grazing-based dairy cows to produce about \$130 million in more milk annually¹.
- The value of the extra pasture grass available to cows, when improved management practices are implemented, is about \$120 million annually for all U.S. grazing-based dairy farms².
- Low-input, low-capital pasture-based systems are an excellent way for young people to begin dairying.

Estimated Environmental Abatement:

- Healthy pastures do a better job of reducing soil erosion and improving soil quality.
- Pastures sequester more carbon compared to row crops.

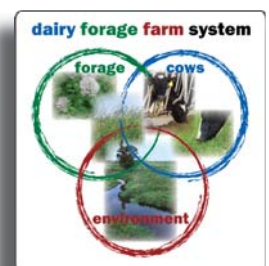
More details:

In the past, grasses and legumes have been developed with hay production, not grazing, in mind. Since the market for pasture grasses and legumes is relatively small (but growing), and because grazing research requires long-term resources, there is very little commercial breeding for them. The U.S. Dairy Forage Research Center fills this void.

- The legume breeding program emphasizes clovers and other non-alfalfa legumes for use in pasture-based systems as well as haymaking systems. New varieties of red clover, kura clover, and birdsfoot trefoil are currently under development. Active collaborative testing and variety development projects exist with commercial seed production companies which will lead to commercial varieties being available to Wisconsin farmers in the next few years.
- A grass breeding position was added to the Center, and a new forage grass species was discovered and developed. Meadow fescue will help grass-based farmers produce milk and meat more efficiently due to its superior digestibility and drought tolerance. An improved variety of meadow fescue should be available to farmers by 2012. Varieties of orchardgrass and reed canarygrass are also being developed with grazing systems in mind.
- A pasture management program was added to the Center. Guidelines were developed for producers that incorporate knowledge of cool-season grass response (productivity, yield distribution, nutritive value, persistence) to critical aspects of grazing management.

¹ Based on 50,000 acres of improved pasture, a 5% increase in digestibility leading to 8 lbs more milk/cow/day, 15 cows/acre, 150 days of grazing, and milk at \$14.50/100 lbs.

² Based on a 20% increase in pasture dry matter (800 lbs/acre) valued at \$9.25/100 lbs or \$74/acre and 8,145 grazing-based dairies averaging 200 acres of pasture.



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#7

Potential Impact

Improving Protein Utilization of Alfalfa

The Challenge:

Alfalfa is a high protein producing forage. Unfortunately, much of this protein can degrade when ensiled, making it unavailable to the cow – she can't use it to produce milk or maintain her body. This reduces both the economic and environmental sustainability of dairy farming.

The Research Response:

Can we redesign alfalfa so that less of its protein is degraded during ensiling and more is available to the cow?

Research Results:

Researchers at the U.S. Dairy Forage Research Center discovered a trait in red clover that makes its protein much less susceptible to degradation during ensiling compared to alfalfa. A gene for this enzyme has been successfully inserted into alfalfa. Research is now concentrating on finding the best way to add the appropriate substrates that are needed for this enzyme to work efficiently.

Estimated Financial Impact:

- If alfalfa is redesigned for improved protein utilization, dairy farmers could reduce the amount of protein supplements they need to purchase.
- A 25% decrease in protein degradation during ensiling of alfalfa would save an estimated \$100 million¹ per year for the U.S. dairy industry by reducing the amount of protein supplements fed.

Estimated Environmental Abatement:

- If alfalfa is redesigned for improved protein utilization, less land is needed to feed the same number of cows. This may allow environmentally vulnerable land to be taken out of production or make productive land available for other crops and uses, thus helping to preserve food security.
- Also, with more protein utilized by the cow, there would be less nitrogen excreted in manure and less nitrogen to potentially volatilize into the atmosphere or leach into groundwater when manure is spread on farm fields.
- A 25% improvement in protein utilization from alfalfa would mean a potential decrease of 0.4 million tons of nitrogen waste to the environment.

More details:

Alfalfa is the most commonly grown perennial forage crop in the U.S., and it ranks fourth in U.S. crop acreage (behind corn, soybeans and wheat). As a dairy feed, it is often referred to as the “Queen of Forages” due to its relatively good digestibility, palatability, and high protein content compared to other forages. It also has the ability to readily fix nitrogen which enhances its economic return in dairy farming systems because minimal outside inputs are required to produce it (i.e., no expensive nitrogen-based fertilizers).

However, the vegetative proteins of alfalfa are rapidly degraded during the ensiling process and also in the cow's rumen; this means that the cow can't capture much of the protein in alfalfa, thus requiring more protein supplements to be purchased. In addition, the unused protein leaves the body in the form of urinary nitrogen, the most polluting form of manure nitrogen.

¹Based on 35 million tons of silage at harvest, and soybean meal at \$314 per ton.



#8

Potential Impact

Improving Fiber Digestibility of Forages

The Challenge:

Lignin, a component of plant cell walls that make up the fiber portion of plants, reduces the amount of energy available from the plant by making it difficult for ruminants to break down cell walls and capture the energy (sugars and starches) inside those cells as well as carbohydrates in the cell walls.

The Research Response:

Can we reduce the amount of lignin or transform the type of lignin in alfalfa so that ruminants can more easily break down cell walls and capture more energy from the carbohydrates in the forage (sugars and starches)?

Research Results:

A long-term collaborative research effort has determined ways to alter lignin in plants, and a reduced-lignin alfalfa has been developed. Industry representatives are now working to commercialize this reduced-lignin alfalfa. It could be available to farmers by 2016-2017.

Estimated Financial Impact:

- Improving the fiber digestibility of forage by 10 percent would lead to increased production worth approximately \$350 million (milk and meat) while decreasing the level of grain supplements in the diet by 2 million tons; this would save U.S. dairy farmers about \$252.8 million annually because less corn would need to be purchased or grown to provide that energy to dairy cattle¹.
- Since undigested fiber leaves the animal as manure, improving fiber digestibility would also reduce by 2.8 million tons the amount of manure that dairy farmers need to collect, store and process – an ever increasing expense on dairy farms.

Estimated Environmental Abatement:

- Improving fiber digestibility in alfalfa would mean that more of the cow's energy needs could be met by this perennial forage and less corn (an annual row crop) would be grown.
- Alfalfa production is better for the soil (less soil erosion and better soil health); it requires no nitrogen fertilizer; and, when grown in rotation with corn, it provides much of the nitrogen needed by the subsequent corn crop.

More details:

For more than 20 years, the U.S. Dairy Forage Research Center has collaborated with several groups (national and international) to determine changes in lignin composition and structure and the resulting impact on plant development from down regulation of key enzymes in the biosynthesis of lignin building blocks. Center researchers determined the key role of cross-linking agents in decreasing cell wall digestibility and developed strategies (molecular genetics or selection) for improving forage digestibility through altering lignin synthesis and/or cross-linking.

The Center was also a founding member of the Consortium for Alfalfa Improvement (CAI), a group of government, private non-profit, and industry researchers dedicated to improving alfalfa for dairy cattle. This Consortium has developed an alfalfa with increased digestibility (5-10%) and improved animal performance.

¹Based on \$3.54/bu, 35.7 bu/ton or \$126.4/ton for current corn prices.

