With projected global temperature increase, there is general scientific consensus that the global hydrological cycle will also intensify. The combined impacts of increased temperature and evapotranspiration will affect snowmelt, runoff, and soil moisture conditions. The direct impacts of climate change on water resources will be embedded in natural climate variability. Changing temperature and precipitation patterns are likely to lead to the potential for more severe, longer-lasting droughts in certain areas of the U.S. and world.

Although we don't know exactly how climate change will affect regional water resources, it is clear that water resources for agricultural production are already stressed in many areas, independent of climate change, and any additional stress from climate change or increased variability will only intensify the competition for water resources. The recent drought in California demonstrates the potential impacts of climate change related to increasing frequency and intensity of droughts across the United States.

The best advice to those in the dairy industry regarding climate change may be to start addressing current stresses on water supplies and build flexibility and robustness into agricultural production and distribution system. Flexibility helps to ensure a quick response to changing conditions, while robustness helps people prepare for and survive the worst conditions. Decision-makers in any enterprise that depends on water need to be prepared for drought. Planning for drought involves answering questions such as:

"How will drought affect us?"

"Where does my water come from and who else uses or will use my water?"

"How will we recognize the next drought early enough to respond effectively?"

"What can we do to minimize losses from the next drought?"

What can the dairy industry do to reduce long-term vulnerability to drought? For farmers, this could mean implementing management practices that retain water in soil, exploration of alternative feeds and forages, and investment in high efficiency irrigation systems. Some management options will be comparatively easy to implement. Other options require substantial time and/or financial investment. Fortunately, many measures that reduce long-term drought risk also contribute to a healthier, more sustainable food and agriculture system, and prepare for other natural hazards.

The National Drought Mitigation Center offers many tools and resources for monitoring and planning for drought, including the U.D. Drought Monitor, Drought Risk Atlas, and Managing Drought Risk on the Ranch. The NDMC is a partner in the development of decision support tools found at agclimate4u.org. Further, the NDMC is a partner in key national collaborations to increase climate readiness and resiliency across multiple sectors and regions. Learn more at drought.unl.edu and drought.gov.

Tonya Haigh, National Drought Mitigation Center, University of Nebraska - Lincoln, 402-472-6781
thaigh2@unl.edu, Drought.unl.edu/ranchplan
Dairy products are basically a conversion of natural resources to protein. Natural resources such as water and soil are used for growing plant materials are converted into protein and calcium through the digestive tract of the cow. This conversion is not possible in all regions of the world due to lack of adequate water supply, soil quality to produce vegetation or crop or animal environmental growing conditions. As economies expand, facilities become an integral part in the conversion of natural resources to protein and calcium.

The focus on production efficiency began with the addition of bulk tanks, milking parlors, free stall buildings, artificial insemination and other advancements including facility design. The Clean Water Act in 1972 established environmental regulations resulting in inclusion of waste management in the facility design process. The dairy industry’s focus from 2015 to the future may include animal welfare. Facility innovation will be necessary as the complexity of design increases to merge production efficiency, environmental regulations and animal welfare needs.

Animal welfare as defined by the authors focuses the ability of an animal to live a “normal and healthy” life within facility domain. Many management decisions impact a facility’s ability to allow normal behavior include stocking density, feed space available, resting space and stall dimensions, milking routine, etc. Prudent facility design makes every effort to enable cows to live a normal life based on current research and science based recommendations. Facilities have a 20- to 40-year life span and design guidelines change. However, animal welfare maybe compromised by management and financial decisions in spite of utilizing scientific based knowledge.

Dairy facility design will adapt to utilize best design practices merging the overall demands of efficiency, environment and animal welfare. However, new and expanded knowledge through sound research will be necessary to form the basics of future “best design practices”. Critical areas where new science based knowledge is necessary include guidelines for socialization and exercise, soft cushion surfaces to reduce herd health problems, acceptable “over stocking” guidelines, solutions for removal of undesirable compounds in manure (i.e. antibiotics, phosphorus), dairying in climates outside the 40- to 50-degree latitude boundaries and future cow size. The facility design process will become more complex as the industry incorporates and balances new scientific information, processor demands and consumer preferences.

The challenge becomes during shifts in focus (production to environmental to welfare) is to develop sustainable systems. The authors’ experience is that many dairies were economically viable and adopted technologies to increase production efficiency. However, when required to address environmental concerns a portion of the dairies opted to transition to other food production practices. Transitioning from environmental to animal welfare focus is complex. The shift in focus will require the industry to balance demands on the facility footprint while a sustainable dairy industry.
Quantification of Energy Utilization in Dairy Cattle
Ermias Kebreab, University of California, Davis

The National Research Council recommendations for energy requirements in dairy cattle is used extensively around the world. The basis for the requirement calculation is also used in European countries such as United Kingdom for lactating dairy cows. The foundation for analysis utilizes key parameters such as metabolizable energy intake (MEI) at maintenance (MEm), the efficiency of utilization of MEI for 1) maintenance, 2) milk production (kL), 3) growth (kG), and the efficiency of utilization of body stores for milk production (kT). Traditionally, these have been determined using linear regression methods to analyze energy balance data from calorimetry experiments. Many studies have highlighted a number of concerns over current energy feeding systems particularly in relation to these key parameters, and the linear models used for analyzing energy balance data. Recently, Moraes et al. (2015) developed a multivariate framework for analyzing energy balance data from lactating cows and investigated potential changes in maintenance requirements and partial efficiencies of energy utilization by lactating cows over the years. The proposed model accounted for the fact that ME intake, milk energy output and tissue energy balance are random variables which mutually interact. The model was specified through structural equations which were implemented in a Bayesian framework. The structural equations, along with a model traditionally used to estimate energetic parameters, were fitted to a large database of indirect calorimetry records from lactating cows. Maintenance requirements and partial efficiencies for both models were similar to values reported in the literature. In particular, the estimated parameters (with 95% Credible Interval in parentheses) for the proposed model were: net energy requirement for maintenance (NEM) equal to 0.36 (0.34, 0.38) MJ/kg BW\(^{0.75}\) d, the efficiency of utilizing dietary energy for milk production (kL) and tissue gain (kG) were 0.63 (0.61, 0.64) and 0.70 (0.68, 0.72) respectively. The efficiency of utilizing body stores for milk production (kT) was 0.89 (0.87, 0.91). The increase in maintenance requirements in modern milk production systems is consistent with the literature that describes increased fasting heat production in cows of higher genetic merit. The increase in utilization of dietary energy for milk production and tissue gain was partially attributed to the changes in dietary composition, in particular to the increase in dietary ether extract to levels closer to levels currently observed in modern milk production systems. Therefore, the estimated energetic parameters from this study can be used to update maintenance requirements and partial efficiencies of energy utilization in dairy cattle using the metabolizable energy system. This will ultimately lead to ration formulation that meet but not exceed their requirements, thereby improving feed efficiency and enhance sustainability of the dairy sector.

Ermias Kebreab, address: 2111 Meyer Hall, Department of Animal Science, One Shields Ave., University of California Davis, Davis, CA, 95616, Tel: (530) 752-5907, email: ekebreab@ucdavis.edu
U.S. and global consumers have significant misperceptions about animal agriculture, and in particular about dairying and dairy products. One of these misperceptions is that cattle compete with humans for food, especially grain. This presentation provides quantitative evidence to counter these misperceptions, which can be used to provide factual evidence to consumers that may help them in their life-style choices and their support of government policy and regulations. The evidence also supports the concept that the most sustainable production system is a mixed crop and animal system in terms of minimizing the impact of agriculture on the environment and ensuring an adequate food supply in the future. In terms of resource utilization, dairy production is one of the most efficient systems for converting inedible plant mass into edible and nutritious meat and dairy products for human consumption. Augmenting this, sustainable intensification has the potential to minimize the global impact of increased dairy production on feed, water, and land utilization as well as reducing greenhouse gas emissions per unit of milk. In many places around the world, it is possible with existing management strategies and technology to increase milk production while decreasing the number of dairy cows and the feed and water required to support that production.

Joanne Knapp, President, Fox Hollow Consulting, LLC, Columbus, OH 43201-3159, PH: (559) 788-9695, EM: joanne.r.knapp@gmail.com
EMERGING CONTAMINANTS IN DAIRY MANURE: HORMONES, ANTIBIOTICS, AND ANTIBIOTIC RESISTANCE GENES

K. F. Knowlton and P. P. Ray, Department of Dairy Science, Virginia Tech

Most water quality concerns associated with dairy farms focus on nutrients (nitrogen, phosphorus) that impair the health of aquatic systems or on pathogens that may lead to disease. In recent years, however, other potential contaminants are becoming of concern. Steroid hormones (estrogens, androgens, progesterone, and various synthetic hormones) contained in livestock manure have generated wide interest because of their endocrine disrupting effects especially in aquatic species. Estrogens, androgens, and progestogens have been detected in many US rivers. Similarly, the extensive use of antibiotics in animal agriculture and the development of antibiotic resistant bacteria are cause for concern. Antibiotics are excreted nearly intact and have been detected in very low concentrations in ground and surface water. This talk will focus on these emerging contaminants in dairy manure.

Steroidal hormones are produced endogenously, may be administered exogenously (although only in limited cases in dairy), and are excreted in urine and feces. The hormones in animal manure that have important environmental effects include estrogens (estrone, estradiol, and estriol), androgens (testosterone), and progestagens (progesterone). An estimated 49 tons of estrogens, 4.4 tons of androgens, and 279 tons of gestagens were excreted by farm animals in the U.S. in 2002. These estimates are uncertain as data available may not be sufficient for accurate calculation. In the dairy industry nearly all excreted hormones are endogenously produced; cows in late pregnancy excrete the most. The only exogenous use of steroids in dairy is in estrous synchronization protocols.

Antibiotics are used in the dairy industry for prevention (medicated milk replacer) and treatment of disease and their use clearly reduces morbidity and mortality. However the unintentional selection of bacteria that are resistant to powerful antibiotics could have important human health consequences. Nearly all of the administered antibiotics are excreted in manure (this is true in humans also), and these impact the microbes in manure and soil. Several studies have traced antibiotic resistant infections in humans back to exposure to treated animals. Thus, livestock operations are often cited as a reservoir for resistant bacteria.

The ultimate fate of manure nutrients is strongly influenced by how that manure is removed from the animal facility, how (and whether) it is stored, and how and where it is land-applied; the same is true of steroidal hormones and antibiotics. Degradation of these compounds is influenced by exposure to air and sun, temperature, moisture, and soil properties. Conventional manure handling systems are not designed to treat manure but during prolonged storage, the degradation of hormones and antibiotics can occur, especially under aerobic conditions. Because manure is land-applied rather than discharged directly into waterways, the likely risk of these pollutants from livestock farms should be lower compared to similar compounds discharged from wastewater treatment plants.

The environmental effects associated with hormones and antibiotics from animal agriculture have induced great interest and concerns in scientists, governments, and the general public. More research is needed on the fate of these compounds in manure and to develop effective approaches to reduce loading of these compounds from dairy farms.

Katharine Knowlton, the Colonel Horace Alphin Professor of Dairy Science, Virginia Tech, Blacksburg, VA 24061, PH: (540) 231-5287, EM: knowlton@vt.edu
While the term “Sustainability” is reasonably recent, dairy farmers and processors have been pursuing the goals of sustainability for decades under the terms “stewardship” and “efficiency”. The present industry wide goal of reducing the carbon footprint of producing a one-gallon container of milk 25% by the year 2020 is based on using data from calendar year 2007 as the baseline. If however we were to use 1944 as the previous baseline year, the industry has already drastically improved performance and sustainability on a wide range of metrics. A few examples comparing 1944 to 2007 are that 90% less cropland and 65% less water were utilized, and 63% less carbon was emitted in the production of that gallon of milk.

Prairie Farms involvement in the current effort began when I was asked to join a number of industry leaders in forming what was then called the Carbon Council and conducting an “Innovation Laboratory” to ascertain what was possible, define goals, and identify projects and strategies. The Innovation Center for U. D. Dairy and all of its amazing work to date grew from that modest beginning.

Since that time Prairie Farms has been involved in piloting and implementing many of the strategies originally conceived, studied and grown by the efforts of the Innovation Center. The most promising to date have been the FarmSmart tool, real time energy and production measurement for monitoring and controlling key performance indicators, and the utilization of an innovative computer control system for our refrigeration systems.

David E. Lattan, Vice President - Engineering, Prairie Farms Dairy, Inc., 1100 Broadway, Carlinville, IL 62626
dlattan@prairiefarms.com, www.prairiefarms.com
An enduring US dairy industry will be underpinned by crop production systems that are economically, environmentally, and socially sustainable. Land use for production of perennial and annual forages and grains for dairy cattle must evolve in response to environmental sustainability issues: maintenance of soil quality, soil phosphorus and water nitrate concerns, climate change with associated temperature and moisture changes, and desired reductions in carbon and water footprints. Predicted changes in climate in the coming decades will likely challenge current dairy production systems, particularly the historical western migration of dairy production and cropping practices. Cattle feeding strategies will need to capitalize on genetic and management innovations that enhance forage and grain nutritive value together with targeted use of by-products and regionally specific feeds. Improved on-farm or regional integration of feed production and manure utilization is needed. Threats to reliable crop production, and therefore profitable feeding of dairy cattle and a sustainable industry, will be potential competition for biofuels, water availability and quality, land availability, and climate change. Development of forage, crop, and grazing land alternatives under regional dairy production systems needs to focus on increasing crop and forage yields and the digestibility of the crop fiber, protein, and starch. Crop rotations that optimize the ecosystem to enhance land utilization will create the economic, environmental, and social resilience needed to achieve the greater crop production necessary to meet the demands for milk production by 2050.

Neal Martin, Former Director US Dairy Forage Research Center, USDA-ARS, Howard, OH 43028, PH: 740-507-4398, EM: darforage13@gmail.com
Impacts of US Dairy Production on Water Resources
Marty Matlock, Greg Thoma, Jack Cothren, John Wilson, and Eric Cummings; University of Arkansas

Water resource impacts from US dairy production include water quantity and water quality. These impacts are location-specific; they occur at the water basin, watershed, or groundwater shed scales. Analysis of the impacts of US on-farm dairy production on water resources requires understanding the potential risks from water scarcity and the risk of dairy production’s impact on water pollution processes within watersheds. The primary water-utilization challenge for dairy producers is irrigation for growing feed rather than on-farm use. The most water stressed areas of production in the US occurs in California and to a lesser degree in other western states. The potential impacts on local water quality is P loads; eutrophication is more likely to occur from feed production than from on-farm dairy activities. A basin-level assessment of Mississippi River Basin nitrogen loads to the Gulf of Mexico illustrate the utility of this approach. Dairy producers have significant opportunities to control risks from water quantity and quality impacts through implementation of existing best management practices.

Author Contact: Marty D. Matlock, PhD, PE, BCEE; Professor of Ecological Engineering in the Biological and Agricultural Engineering Department; Executive Director, UA Office for Sustainability; 233 Engineering Hall, University of Arkansas, Fayetteville, AR 72701
mmatlock@uark.edu

Global animal protein production is projected to double from its year 2000 levels by 2050 and the majority of this livestock production growth will occur in the developing world. Satisfying these upcoming animal protein demands will pose a challenge to the environment. Much of the growth in the global livestock sector will occur in areas that are currently forested (i.e., parts of South America and South East Asia), which will create pressure to rely on deforestation to facilitate increased livestock production. It has been well established that significant reductions of carbon sequestering forests will have large effects on global climate change; therefore, avoiding deforestation is paramount.

By examining the historical trends in livestock production in the developed world, it becomes clear that there has been a marked improvement in efficiency, leading to reductions in numbers of animals required to produce a given amount product that satisfies the nutritional demands of society. For example, researchers at Cornell University [Capper, J.L., R.A. Cady, and D.E. Bauman. 2009. The Environmental Impact of Dairy Production: 1944 Compared with 2007. J. Anim. Sci. 87:2160-2167] found that compared to 1944, the 2007 U.S. dairy industry reduced its greenhouse gas emissions per unit of milk by 63%. This reduction was achieved through improved nutrition, management, genetics, etc. born through scientific research that has led to dramatic improvements in milk production per cow. This type of intensification of livestock production provides large opportunities for climate change mitigation and can reduce deforestation to establish pastures, thus becoming a long-term solution to more sustainable livestock production. Today, researchers throughout the world focus on how advanced biotechnologies, improved genetics, nutrition, and comprehensive waste management already utilized in most parts of the developed world can be applied effectively worldwide.

While the extraordinary reduction in the U.S. dairy industry’s carbon footprint may be viewed by some as a vindication of modern production practices, attention should be given to the areas of opportunity that still exist, including transition cow management, lameness, and reproductive failure. Improving these and other areas on U.S. dairy farms should allow for further reductions in carbon footprint per unit of milk, and these areas often intersect with another hot issue that livestock industries face: animal welfare.

Ultimately, ignoring the carbon footprint debate will not make this issue go away for those involved in the livestock industries. The actual science behind many of the current claims has been incomplete or lacking, and it is in the best interest of producers and consumers to have environmental claims made on solid, peer-reviewed scientific data. What is needed is sustainable intensification in animal agriculture, coupled with technology transfers, to supply a growing demand for animal protein while providing environmental stewardship by using sustainable and modern production practices.

Frank M. Mitloehner, Professor and Cooperative Extension Specialist, University of California, Davis, Department of Animal Science, One Shields Avenue, Davis, CA 95616, USA; Ph (530) 752-3936; fmmitloehner@ucdavis.edu
In my presentation, I present the challenges and opportunities that brands face in regards to new consumer demands placed on businesses these days. Thanks to a growing interest in transparency, responsibility and accountability – punctuated by seemingly unlimited access to information and discussion that the Internet and Social Media provide – companies have the opportunity to sell more than the rational benefits that their products contain. They can incorporate storytelling that highlights company practices that consumers find valuable in their quests to find companies they can align with – both in making purchase decisions and while building brand loyalty.

The problem is that the quickness of marketers to jump to these terms (sustainability is one of them, but others include natural, all-natural, GMO-free, organic, free-range, grass fed, cage-free, recyclable... and there are more...) means that it’s been up to marketers to determine what these labels mean – and often the application of the label means more to the company than what (if any) actual work is being done within those fields to increase production, protect the environment, contribute to a safe food supply, etc.

The dairy industry, because of its size and scale of production, and also because of the agricultural challenges that dairy farmers face, is an ideal industry with which to address concerns that consumers have regarding environmental protection and responsible food production. As we go beyond the dairy door and continue telling our stories of responsible farming, waste management and environmental stewardship, we can build the kind of long-lasting credibility that goes above and beyond the rational superfood benefits that milk provides.

My discussion aims to

- point out the absurdity of simply attaching a “sustainability” label for the sake of moving product
- define in simple terms what I think the highlights of “sustainability” are
- showcase examples of how we at fairlife are trying to tell our sustainability stories

Anders Porter, Director of Communications, fairlife LLC, 1001 West Adams Street, Chicago, IL 60607 anders@fairlife.com, 415-412-4821
Regulations on livestock manure land spreading practices were enacted during the late 1990's to protect lakes, streams and other surface water bodies from runoff and environmental contamination. The phosphorus risk index was developed and included manure application guidelines based on a combination of concentrations of P in manure, soil test P, and other factors. This is why we embarked on research related to relationships between dietary P, manure P and runoff P from manure-amended soils. During the early to mid-2000s policy shifted somewhat from water quality concerns to concerns related to emission of hazardous gasses from livestock operations. For the dairy industry, the main concern was the emission of NH₃, which is generated from the large amounts of urea contained in the urine excreted by dairy cows. This is why we embarked on research related to relationships between dietary crude protein (CP), manure chemistry and environmental outcomes, including gaseous emissions. More recently, research has expanded to include the greenhouse gases (GHG) methane (CH₄) and nitrous oxide (N₂O), and ways to enhance carbon (C) sequestration in soils thereby mitigating the effects of dairy production on global climate change.

Two recent global and national reports highlight the environmental implications of too much agricultural nitrogen (N). Along with global climate change, N use and loss can be said to be the next ‘big environmental issue’ that agriculture will be asked to address. The dynamic nature of N transformations in agricultural systems necessitates a broad understanding of possible tradeoffs between N use, N incorporation into products, and N conservation and N loss.

Nitrogen use efficiency and loss from dairy farms depend on several factors, including a farm’s stocking rate (animals per unit land area), which influences the type and amount of feed grown on a farm, feed and fertilizer purchases, manure management, N use efficiency, whole-farm N balances and environmental N losses. As stocking rate increases, nitrogen use efficiency declines and N loss increase. Tradeoffs can occur between feed N use, manure N excretion, crop N use and environmental impacts. The conservation of one manure N form may result in the loss of other manure N forms. For example, although corn silage yields more DM and feeds more cows than alfalfa silage, this shift in feeding practices and associated land management practice impacts manure chemistry and overall N dynamics on a dairy farm.
Describing a sustainable dairy industry usually encompasses several facets. We will usually think of environmental sustainability first—reduction of greenhouse gases, water, nutrient loading, etc. We might imagine sustainable farming systems such as crops grown given soil, climate and pests. We may include social aspects of sustainability such as fair treatment of farm workers and ethical care of animals. And, most descriptions would add economic returns to the mix. After all, if an industry cannot generate fair returns over the long run, then it is not sustainable.

It is a trivial conclusion that if the adoption of a more environmentally or socially conscious practice incurs economic costs greater than consumers are willing to pay for, then participants in the supply chain would not adopt such a practice. However, some practices which appear to be sound at a first round effect, can have negative implications in the future. Several such decisions of the past are causing economic pressures on the industry today and are highlighted by looking back at three states that have been the number one milk producing state currently or in the past.

The relentless pursuit of greater yields in milk per cow has also been touted as an obvious solution to reducing the carbon footprint of milk production. After all, a cow must consume a fixed amount of feed to maintain her body and support pregnancy. Although every hundredweight of milk produced requires an additional amount of feed, the more she produces, the more dilution of the fixed feed requirements per unit of milk production.

Diluting these fixed feed requirements would also seem to dilute some of the fixed costs associated with milk production and thus be more economically viable. However, there are complications that illuminated by geographic shifts in milk production. High yielding dairy cows are not compatible with the hot and humid climate of the southeastern United States. Loss of dairy in this region has meant loss of infrastructure and increased costs of production for remaining producers. The loss of milk in the Southeast also means that bulk milk shipments or packaged milk must move much longer distances to supply the region with additional environmental stress from the transportation.

Large farms can be very efficient by spreading their fixed costs too. Sometimes, pursuit of this efficiency in an uncoordinated supply chain leads to an overshoot of regional needs. Dramatic increases in milk production in Western states has created surpluses which have driven down the value of milk in that region. Many producers have complained that this pursuit of scale efficiency has led to a loss of economic viability for farms.

Although large farms have found economies of scale, this intensive business model has also found other implications which challenge economic sustainability. Their relatively high variable costs means that they can be the first to react to high price incentives with more milk production, but may have to be the first to contract production when milk prices fall. This “balancing” function of such a farm model can be costly in its own right.
The Convention on Biological Diversity defines biotechnology as any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific use. By that definition almost every technology used in dairy production is a biotechnology. Biotechnologies have directly benefitted the three core scientific disciplines of animal science - genetics, nutrition, and health.

“Modern” biotechnologies are an arbitrarily defined subset of biotechnologies that involve “the application of in vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection.” This subset includes the controversial breeding method known as genetic engineering (GE) that results in the ill-defined category of genetically modified organism (GMOs).

One important area where biotechnology intersects with dairy production is in the development of GE crops. Since their introduction in 1996, GE crops have been rapidly adopted by farmers globally. In 2015 they were grown by over 181 million hectares by 18 million farmers globally, more than 90% of whom were small-scale farmers in developing countries. It is estimated that 70-90% of harvested GE biomass is fed to food producing animals. On average, the global adoption of the first generation of GE crops has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%. The second generation of GE crops in the pipeline is being specifically modified to target nutritional feed traits including low phytate content, improved amino acid content and digestibility, and enhanced oil content.

There is also work being done to develop GE animals. This includes “traditional” genetic engineering where a gene that imparts a desired trait is brought in from a different species, but also genome editing where precise changes in the bovine genome can be achieved to result in a desired phenotypes such as polled (hornless) or disease resistance. Several groups are working on the development of GE animals that are resistant to a variety of diseases. Despite the fact that development of techniques to genetic engineer animals preceeded the development of methods to modify crops, no GE animals have been approved for food production anywhere in the world.

Many animal biotechnology applications, including GE animals would seem to align with many sustainability goals including improved animal well-being, efficiency and reduced environmental footprint. The thousands of SNP markers discovered through livestock sequencing projects, the information obtained from numerous genome wide association studies, the discovery of causative SNP (QTNs), the development of genomic selection statistical methodology to include molecular data in genetic merit estimates, genome editing techniques, and transgenic technologies are all useful individually. But collectively, they offer a powerful approach to accelerate real genetic change in our food animal species to the advantage of food security and agricultural sustainability globally.
Public interest in the welfare of farm animals is on the rise, but people working with these animals possess few mechanisms to discuss contentious issues with others in society. We review recent research using our Cow Views platform that creates virtual town hall meetings. This platform allows farmers, industry experts and the public to discuss controversial issues pertaining to dairy production, and provides a mechanism that enables different perspectives to surface regarding these issues. We discuss three issues: pain control for disbudding, pasture access, and early separation of cow and calf. For each issue we used qualitative analysis to identify key themes raised by 100’s of participants, including producers, veterinarians and people not working in agriculture. This analysis shows the diverse values that participants bring to the issue (e.g. some proponents of pasture access emphasize the importance of natural behavior while some opponents emphasize the importance high levels of production), differences in beliefs about the ‘facts’ around an issue (e.g. some proponents of early cow-calf separation believe that the practice improves cow and calf health and some opponents believe the opposite), and perceived barriers to changing practice (e.g. some opponents of pasture believe that there are no means of providing pasture access while maintaining milk production). Open discussion of contentious issues among farmers, industry professionals and the general public is an important step in the development of practices that better meet public expectations. The analysis of this discourse can also help identify priorities for research by animal welfare scientists, including science to address the competing factual claims and the development of management solutions that address the values of both farmers and the general public.

Marina Von Keyserlingk, Professor, University of British Columbia, Animal Welfare Program, Vancouver, BC V6T 1Z4, CANADA, PH: (604) 822-4898, EM: nina@mail.ubc.ca
Genomic selection has revolutionized dairy cattle breeding programs over the past seven years. More than 1.1 million bulls, cows, heifers, and calves have been genotyped to date in the U.S. and Canada, and tens of thousands of additional calves are tested each month. The process is simple – build a reference population of animals with genotypes and performance data, estimate the single nucleotide polymorphism (SNP) effects, test some new calves, compute their genomic predicted transmitting abilities (GPTA), and make selection decisions. Reference animals must be closely related to the selection candidates, and thus far success with predicting useful GPTA for crossbred animals has been elusive. Genomic tests have varying numbers of SNP, and low density (3K to 20K), medium density (50K to 150K), and high density (620K to 777K) options range from about $40 to $250 per animal. These SNP markers are not the functional mutations affecting health, production, or fertility, but rather anonymous “mile markers” along the chromosomes that are inherited in tandem with the underlying and unknown functional mutations. Low density genotypes are imputed to high density (for free) by the Council on Dairy Cattle Breeding prior to computing GPTA, a process that is now carried out weekly. Results have been seamlessly integrated into selection tools, such that producers can compare the genetic merit of young calves with that of older cows that have not been tested. Genomic selection works as advertised, and in studies involving the UW-Madison herd and a nearby commercial dairy, the difference in first lactation milk yield between the top and bottom quartiles of cows sorted by their GPTA at 12 months of age was approximately 5,000 pounds. Genetic progress in the major dairy cattle breeds has doubled (at least), due largely to halving of the generation interval for sires of young artificial insemination (AI) bulls and sires of replacement heifers. Selection for novel traits that are difficult and expensive to measure is now possible. For example, selection for feed efficiency in a traditional progeny testing program would require measurement of 150,000 phenotypes per year and would cost roughly $30,000 per young bull, whereas one can build a reference population and apply genomic selection for about $225 per bull – while also testing three times as many young bulls and cutting the generation interval by two-thirds. Decisions regarding replacement heifers, such as keeping versus culling, breeding with sexed versus conventional semen, breeding with dairy versus beef semen, and so on, are ideally suited to genomic testing due to its ability to group animals effectively based on predicted genetic merit. Herds that want to capitalize on this technology should have a standard operating procedure (SOP) for replacement management decisions to ensure consistent and optimal decision-making. The potential impact of genomic selection on the sustainability of U.S. dairy operations is huge. Implementing strategies such as culling the poorest 15% of heifer calves and improving residual feed intake (a measure of feed efficiency) by 1.5 pounds per cow per day would save dairy producers roughly $800 million annually while reducing methane production by more than 65 gigagrams \((g \times 10^9)\). The impact of the next generation of technologies, including whole genome sequencing and gene editing, is still unknown, and implementation of the latter will require significant regulatory discussions.