The Implications of Global Warming upon United States Dairy Herds: Effects on the Economics of Dairying and Stability of Herds with Low Genetic Diversity

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Abstract

Global warming (GW) is of real concern for the current U.S. agricultural industry. The agricultural industry has had a hand in emitting into the atmosphere. Severe heat spells seen nationwide and volatile climate shifts have pushed states such as California to implement governmental support to high impact areas due to dwindling water sources. Motivated dairy industry members have created plans to reduce dairy GHE contribution. Some research has suggested a benefit in GHG emissions from fewer cow-higher production approaches to dairy farmers. Most U.S. dairy cattle are specialized due to high inbreeding values created by selecting for few production traits of high genetic merit. Their reduced genetic diversity, which by definition aids in the survivability and adaptability of a species, is found to be a disadvantage when environmental conditions are not ideal. Utilizing crossbreeding to amplify genetic diversity at the genome increases the overall economic merit of the progeny. There may be potential in incorporating dairy operations which are both crossbred and pure bred. By shifting breeding program standards from genetic merit to economic merit dairy producers can better conceptualize the potential gains by implementing regionalized crossbred herds in the United States.

Key words: Global Warming; Green House Effect; Dairy Cow; Crossbreed

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Introduction

A Sensitive Industry:

The agricultural industry is facing tangible impacts due to severe heat spells and droughts. New crops cannot be grown and existing crops, i.e. forages, corn, and soybeans may not be sustainable as a result of the drought conditions. Snowfall across the Sierra Nevada in 2013 was too little to deepen the snow pack enough to allow any significant water collection in the reservoirs for agricultural land use, and rainfall has remained below normal throughout 2013 and is projected to decrease more for 2014 (NDMC, 2013). The reduced precipitation has prevented the growth of grasslands commonly grazed in California's Central Valley and forced farmers to buy expensive feeds to make up for the reduced forage availability, resulting in low profitability and ultimately forcing producers to sell animals. This shifts the supply and demand of impacted goods and makes them more expensive for consumers, causing substantial effects upon the everyday US citizen. Environment plays a key role in the intimate network of the agricultural industry. And, because environment is not controllable, it causes a wide range of volatility to the profit margins of all agricultural industries. How will these impending heat spells and droughts impact America's food supply? An up close evaluation of one of the most volatile and dependent industries in the United States is a justifiable place to start. California dairies pay homage to immensely fertile soils and ideal environment patterns to maintain highly efficient and profitable dairies. Dairies throughout the rest of the nation also rely on the weather systems of the country to make their efforts profitable. With environmental patterns changing, what is in store for the economic status of dairy producers? For example, changes in feed availability, the type and quality of feed able to be grown, water availability, and the incidence and impacts of heat stress are all realistic concerns. The vast majority of U.S. dairies share a commonality in that they breed high producing animals that are very closely related, this has lead to deficiencies in functional traits and causes low genetic diversity (Boettcher, 2001). The quandary of selecting high producing animals versus more functional traits has created a superior milking animal, while compromising on fertility, health traits, and disease resistance. As changes in the environment commence how will this impact such a highly specialized animal? Lastly, is there soon going to be a place for large scale industry cross bred herds? The "thriftiness" of cross bred animals just may become more valuable to the United States in the near future.

This work will explore the potential for industrial crossbred dairy herds due to environmental impacts of global warming localized to the United States.A review of current environmental events in the US and political responses to such events will be presented. Utilizing peer reviewed articles and scientific resources, an investigation of the recent history of earth's biosphere patterns and causes of current weather systems, particular attention to GHGs, will be presented. The individual animals will be evaluated for their abilities to survive such change; their inbreeding values and what that means for adaptability will be considered, the concept of diversity and what that means to the dairy industry will be touched on. The well being, health, and logistics of maintaining the "same" high producing animal in the changing climate will be assessed. In turn the usage of crossbreeding will be weighed related to sustainability in a changing environment, economic cost and viability. Lastly, approaches to implementing crossbreds in to the dairy industry will be reviewed.

Today (current events):

"Severe drought, help save water", it seems every motorist in the state of California this past January and February, has read this constant warning across the electronic boards on the freeways. Some may ask why have a public service announcement displayed over the "parking lots" of California? Others may brush off the substitute for theirordinarily displayed length of time to the next interchange. However, this water shortage warning, regardless of how "real" it may be to the day to day life of the average citizen is prevalent and quite frightening. According to the Environmental Protection Agency (EPA, 2014), the global average surface temperature since 1901 has been steadily rising at a rate of 0.15 degrees Fahrenheit every decade. Since the 1970's, however,U.S. temperature has risen more quickly, at a rate of 0.36-0.55 degrees Fahrenheit every decade (EPA, 2014). The United States temperature average has been accelerating quicker than the global warming rate(EPA, 2014).Most temperature increases in the U.S. were observed in the North, West, and Alaska(EPA, 2014), and coinciding with temperature increase is the prevalence of droughts simultaneouslyoccurringin these areas. The drought status in California has been in a state of either extreme to severe conditions since December 31, 2013(NDMC 2013). In addition, droughts in the surrounding states varied from abnormally dry to exceptionally dry in 2013.Drought spanned from California reaching to Kansas and from Washington down to as far as the Texas-Mexico border(NDMC, 2013). Not to mention Eastern parts of the country such as New York and its surrounding states exhibited abnormally dry conditions in 2013 as well(NDMC, 2013).The increase in surface temperature and the incidence of drought in some states has pushed government intervention. It has become inevitable in the battle to determine water distribution and preservation, particularly in California.

California Politics:

California is the number one production state in the agricultural industry and has the most dairy animals, thus contributing the highest volume of raw milk material to the United State and in exportation. In 2012, California's top ten highest economic valued agricultural commodities included milk at number one, $6.9 billion, cattle and calves $3.3 billion, and hay $1.2 billion (CDFA, 2012). Government statistics also showed that California produces almost half of U.S. fruits, vegetables, and nuts for the entire nation (CDFA, 2012). California agriculture is of great importance for the nation and changes in California production can negatively impact the entire nation. In December2013, Governor Jerry Brown assembled a drought task force to monitor the drought conditions in California(Fuchs, 2014). The following month, GovernorBrown announced that California was in an official state of emergency and indeed it is the worst drought and highest temperatures in recorded history for the state (Fernandez, 2014). The Governor's statements were consistent with the figures on the Environmental Protection Agency's site, showing that since recorded history of global surface temperature (1901), about 113 years, the state has never been in such a condition (EPA, 2014). As recently as February 2014, Governor Brown proposed a solution to the heat and drought effecting California - a "drought package" to relieve severely impacted areas in the state(CA.Gov, 2014).The package ($687.4 million) will be dispersed for purposes such as water management, collection, transportation, aiding areas at risk for running out of drinking water, food and housing assistance, and variousrelated projects(CA.Gov, 2014 and Calefati et al, 2014). Besides Governor Brown passively mentioning a need to aid farmers, there have been no concrete sections in legislation developed. A website that helps farmers findaid has been developed. President Obama announced that the ranchers and farmers affected by the current conditions can sign up for assistance by April 15, 2014(USDA, 2014). Termed the "2014 Farm Bill livestock disaster assistance programs", those accepted onto the program will receive a portion of 100 million that has been slotted for impacted farmers, in addition to another 50 million dollars has been gathered to distribute to those who suffered losses in years up to 2012 (USDA, 2014). It appears the government, federal and state, is trying to be active in relieving the current disaster and finding solutions that can help potentially for years to come. While these goals are theoretically good, resting on the hope of a successful execution of the proposed ideas is risky. These are living and changing proposals. Website resources designed to help farmers may not actually help. For example,if there are baseline qualifications set to determine if a farmer is “in need”,this may block assistance to farmers who are, in reality, in need because the baseline says they don’t qualify.Overall, this is a distribution issue between the aid money and the water. Who is going to get what and who will make these ultimate decisions? Close attention must be paid to the implementation of the proposal and intervention may be required with distribution of the dwindling natural resources. Allotment to all parts of California needs to be intellectual, realistic, and fair. The most important factor is that none of these political initiatives can change the fact that there is a drought, water is sparse and there is direct competition between farmers and residential distribution of a decreased water supply.

Is this “package” a solution to the underlying problems causing the devastating conditions in California? Only time will tell.Sections in the proposal include details on reducing green house emissions and utilizing efficient and environmentally friendly water collection, processing, and distribution methods(CA.Gov, 2014). This indicates an intendedfocus on being environmentally responsible. Much of the proposal included these “green” ideas and showed motivation to reduce the focal cause of the droughts and heat spells, green house gases.On the contrary, criticisms have arisen from political leaders such as Senate Republican leader Bob Huff, who highlighted the lack of funding towards the construction of more water collection facilities in California (Calefati et al, 2014). He questioned how can the state move forward, with a considerable likelihood of more droughts in the future, without creating additional methods for catching water?A word that repeatedly shows up in a variety of political announcements about the proposals by federal and state figures has been “relief”. Aid to areas of greatest impact is all good and necessary, but it implies that the conditions are short-lived. Considerable evidence points to a nationwide climatic change. While the relief may be temporary,it is only natural to be concerned that a band aid is being placed over a gaping wound.Nevertheless, California’s developing governmental approach in dealing with the current conditions may set the tone and provide legal precedence forother states and how they implement their own plans for coping with the weather changes, particularly as it relates to agriculture and farming in each state.

A “New Normal”?

In 2008, Australia faced a severe water shortage. The weather authorities refrained from calling the condition a drought because “it implied the condition was temporary”. Instead, forecasters referred to the harsh environment as the “new normal”, implying that Australia would never again see the weather patterns of times past (Mckibben, 2010). Climate is distinguished from weather by length of time; the typical margin is 10 years defined by statistical averages of the weather (Kirtman et al, 2013).The EPA defines climate to be a period of time of about 30 years. Under either definition, climate is much longer than weather. Weather is typically defined by day to day patterns, and can measurespecific times as close as hour to hour reports, according to the Intergovernmental Panel on Climate Change’s (IPCC) definition (Kirtman et al, 2013).Over the past 30 years, a steady incline of the earth’s global surface temperature at 0.15 degrees Fahrenheit per decadehas been occurring. This is termed global warming (EPA, 2014). The United States surface temperature has risen at an even more rapid rate being on average 0.36-0.55 degrees Fahrenheit in this same time (EPA, 2014). Since climate is a decadal affair, it is apparent that the U.S. is experiencing an evolving climate, and not necessarily “freak” weather occurrences (Mckibben, 2010). Because warming temperatures can lead to volatile weather patterns, such asprecipitation changes, increased temperatures, melting of the polar ice caps, higher ocean levels, and ocean acidification, people will begin to see changes in their local weather patterns (EPA, 2014 and Kirtman et al, 2013). A prime example is the current severe and extreme drought status of California, while snow storms are simultaneously overwhelming the Midwest and East coast. Both scenarios are far removed from averageand devastating in their own right. Drought and intense heats will devastate agriculture due to lack of water and heat damage to crops and animals, while freezing temperatures are also destructive, damaging crops. The more volatile temperature and weather becomes in the U.S. the more motivation agricultural operations may develop toward adopting alternative production techniques and goals. Climate will ultimately dictate what can be grown and what agricultural goals can be accomplishedand, unfortunately,nature will need to be worked around, not the reverse. Australia’s careful approach to how they referred to their climate changes shows their understanding of what climate change is. Will the U.S. use a similar methodology in evaluating our own climatic events? How the U.S. decides to perceive these climatic events will be revealed in legislative decisions, industrial changes, agricultural developments and, most importantly, societal perception.

The Green House Effect & Global Warming:

The Green House Effect is a natural interaction of gases and aerosols, thermal rays from the sun, and the resulting biosphere (EPA, 2014). The Green House Effect essentially maintains the biosphere's temperature by trapping some degree of heat in earth's atmosphere, without which the earth would be uninhabitable due to freezing conditions(EPA, 2014). Essentially, without the green house effect earth's surface temperature would be around -17 degrees Celsius (Selvaraj, 2010). The green house effect is important to the planet; the gases in the atmosphere play key roles in how the heat enters and or remains in the atmosphere. Prior to the industrial revolution, global carbon levels sat steadily at around 180 – 290 ppm (Carbon and Climate, 2014). Since the industrial revolution of the late 1750's there has been a steady upward trend in the concentration of CO_2, N_2O, and CH_4 in the atmosphere.Data from Hawaii's renowned Mauna Loa facility also shows this steady upward trend for carbon. In 1960, atmospheric carbon was at 320 ppm and by 2010 it was at 390 ppm (Carbon and Climate, 2014 and IPCC,2012). An excess of certain gases, or an imbalance of concentrations, can become detrimental to the degree of heat entering and exiting the atmosphere. One of two scenarios will occur, cooling or warming, depending on the most prevalent gases and particles in the atmosphere. Certain gases and aerosols may block the entrance of heat into the atmosphere, while others will not allow it to exit due to absorption of long wave radiation and consequent redistribution of the waves into the atmosphere (EPA 2014). For the purposes of this paper, emphasis will be placed on Carbon dioxide, methane, nitrous oxide, and fluorinated gases. The length of time a particular gas molecule remains in the atmosphere is important to discern. Lifetime in the atmosphere is dependent on a molecule'sreactivity. In other words,reactivity refers to a molecule's ability to be reabsorbed into sinks (EPA, 2014). Sinks are systems that hold or utilize the gases. Oceans, land, plants, and organisms that consume these gases would all fall under the category of a sink. Due to the interaction with sinks, concentrations of these gases in the atmosphere fluctuate. Redistribution of gases within the biosphere occurs with land use changes.Certain common

GHGs will remain in the atmosphere for extended periods of time, and therefore extend the length of time for interaction with solar rays and infrared rays, further contributing to global warming. The amount of long wave radiation absorbed by each GHG varies.Some absorb much more than others and, therefore, knowing the concentrations of these gases in the environment becomes important. Asummary of key points about each of the gases of concern is displayed in Table 1.

Table 1–Characteristics of Common Green House Gases

	CO_2	CH_4	N_2O	Fluorinated gases (HFCs, PFCs, SF_6)
Human caused Origins	Fossil fuel combustion and Changes in land use.	Industry utilizing natural gas and petroleum, agriculture, waste decomposition.	Fertilizers (agriculture), burning of fossil fuels, Industrial production of fertilizers & plastics.	*Only human origins, created by industrial processes. (e.g. refrigerants, fire retardants, aerosol propellants)
Length of time in atmosphere - years (Chemical Reactivity)	5 – 200	12	114	SF_6 = 3,200 PFCs = 800 – 50,000 HFCs = 1 - 270
Heat absorbing capacity (Green House Warming Potential)	1	23	296	SF_6 = 23,900 PFCs = 6,500 – 9,200 HFCs = 140 – 11,700
Emissions in Atmosphere (2011)	84%	9%	5%	2%
Dairy Contribution to emissions *	Agricultural related Equipment running on fossil fuels or electricity. Land modifications for dairy use.	Manure liquid and dry storage, natural digestive processes (bacterial breakdown) of animals	Fertilizer production and usage in fields for growing forage. Dry manure storage	Minimal contributions Arguably refrigerants for milk storage

Sources: EPA 2014, http://www.epa.gov/climatechange/ghgemissions/gases.html, accessed March 07, 2014. Dairy contributions were projected by the author*. Heat absorbing capacity (green house warming potential) data gathered from Koneswaran et al, 2008, the absorbing capacity for fluorinated gases was gathered from the above EPA resource. Lifetime of carbon retrieved from IPCC https://www.ipcc.ch/ipccreports/tar/wg1/016.htm. Manure contributions from Owens et al, 2014. For the purpose of this work origins of the four GHGs are distinguished between human caused and agriculturally caused, granted agriculture is the product of human activity.

The gas with the most attention today is carbon dioxide (CO_2). Emission of CO_2 has drastically increased since the industrial revolution,due to human activities, also known as anthropogenic activity. Carbon Dioxide trumps all other common GHG emissions sitting at 84 percentof the GHGs in atmospheric concentrations in 2011(EPA, 2014).

Carbon can exist in manytypes of sinks. Only about 2 percent of global carbon is in the atmosphere, 5 percent exists in plants and soils, 8 percent in geologic reservoirs (fossil fuels), and the final 85 percent exists as ions in the ocean (Carbon and Climate, 2014). It appears that very little carbon is in the atmosphere, but when compared to its GHG counterparts, carbon has a higher total concentration. Carbon does absorb reflected long wave radiation from earth, and thus warms earth's surface. Yet, in comparison to the other prominent gases (see Table 1), it isn't a strong absorber. So it is the concentration and not necessarily the absorbability of carbon that makes it a leading GHG.

Another gas commonly attributed to the agriculture industry, particularly the dairy industry,is methane (CH_4). As seen in Table 1, the main source of CH_4 is said to be industry created, specifically petroleum and gas systems.The second largest U.S. contributor is agriculture, distinctively enteric fermentation which is natural bacterial activity in ruminant animals and manure, the third contributor is landfills expressly bacterial breakdown of decomposing materials (EPA, 2014). Methane has a shorter lifetime in the atmosphere, but can absorb long wave radiation at a rate 23 times that of carbon (EPA, 2014). So it is methane's absorption ability that makes it an important gas rather than the amount of time it spends in the atmosphere. Notably, between 1990 and 2011, the U.S. emissions of CH_4have reduced by 8 percent, interestingly enough it was credited to reduced industrial emissions and not agricultural practices (EPA, 2014).

Nitrous Oxide is another important GHG. Agriculturally, N_2O originates from the production anduse of fertilizers on crops. Soil management for crop use makes up 69 percent of total U.S. N_2Oemissions. The next highest contributor, at 9 percent, is industry and chemical production (EPA, 2014).Changes in degree of nitrogen released are actually greater than that of the Carbon cycle due to the wide scale use of fertilizers (Koneswaran et al, 2008). It is very apparent agriculture plays a huge role in N_2O prevalence in the environment. Soil has been oversaturated with nitrogen to promote crop growth and is carried away in runoff (Koneswaran et al, 2008).Nitrogen may also be produced by burning fossil fuels and by the production of plastic products (EPA, 2014). As seen on Table 1, N_2O has both a long lifetime in the atmosphere and high absorbability. For these reasons it makes it an important GHG component of the atmosphere.

The last of the four GHG players are a group of gases termed the fluorinated gases. These gases have lower concentrations in the atmosphere, at about 2 percent in 2011 (EPA, 2014). Fluorinated gas concentrations may be low but they have an extremely high absorption ability and long lifetime in the atmosphere. Fluorinated gases are solely created by humans. Fluorinated gases are chemicals used for various purposes such as refrigeration, aerosol propellants, or aluminum processing (EPA, 2014). Agriculture does not create these gases, though there may be an indirect relationship through agricultural use of products contributing to fluorinated gas emission.Fluorinated gases can be reviewed in table 1.

These four GHGs are all constituents to an array of variables which can contribute to global warming (GW). Other factors such as solar radiation, cloud coverage or atmospheric state, geomagnetic variation, and pollutants all play a role in warming (EPA, 2013 and Selveraj et al, 2010). However, it has been found when considering all of the variables that input into the

GHEthat the contribution by CO_2alone is 66 percent, and the addition of CH_4 and N_2O brings this value up to 75 percent (Selveraj et al, 2010). Re-balancing these concentrations to more manageable levels for sink exchange enables sink storage of the gases while maintaining concentrations in the atmosphere that will promote a balanced exit and absorption of long wave energy. Unfortunately, the solution is not quite that simple with a number of factors notably human population changes, making a single answer unrealistic. Population growth is estimated to be 9.6 billion by year 2050 (UN, 2013). does not allow for one single solution. Most research agrees that projections of future elevating emissions show a subsequent correlated increase in temperature.

Global warming is just what it implies, the increase in global heat, also described as global surface temperature (EPA, 2014 and Selvaraj, 2010). Global warming is a characteristic of climate change, and is commonly related to the increase of anthropogenic green house gases. Because the green house effect is responsible for keeping earth's surface warm enough to maintain life, it is interlinked with global warming. Earth's surface temperature is projected to increase 2 to 11.5 degrees Fahrenheit in the next century (EPA, 2014). Although every individual who helps in reducing emissions is being environmentally responsible, results to these efforts will not be seen in their lifetime.

The Food and Agriculture Organization (FAO) sees global warming as a serious threat to the security of the world food systems due to the damaging effects of weather changes (FAO 2008). Global warming is correlated with changes in weather systems such as hurricanes, extended droughts, excessively hot temperatures, and precipitation changes all of which can impede agricultural endeavors(EPA, 2014).

Dairy Industry Actions and Options:

In 2006, the FAO reported that 18 percent of GHG emissions originate from livestock agriculture (FAO, 2006).The dairy industry has a responsibility to participate in efforts to reduce GHG emissions, particularly since large cattle operations produce considerable amounts of methane due to manure management,natural digestive enteric fermentation, and dairy waste water management. The growing population requires more food to sustain it, yet the food sources are indirectly contributing to global warming.

What is the solution? It appears some prominent players in innovations forthe dairy industry have viable ideas. By reducing the number of dairy animals while increasing production per animal,there is a decrease in the GHG output at industry level while increasing product volumes (Bauman et al, 2008, Capper et al, 2008, Capper et al, 2010, and Schotz et al, 2013). Average production in 1944 was 117 billion pounds of milk. Production increased to 186 billion pounds in 2007 which is a 59 percent increase in production (Capper et al, 2010). While production rose in those 63 years, the number of animals units decreased from 25.6 million (1944) to 9.2 million (2007) (Capper et al, 2010). By increasing production in animals it decreases the percentage of money aimed at basic maintenance of the dairy cows and directs most of the feed costs towards production.

Dilution of maintenance describes the interaction of fixed maintenance nutrient requirements against production nutrient requirements and their costs (Salfer 2007). As production increases, the gains dilute the maintenance cost and more money is expended towards production (Capper et al, 2011 and Salfer, 2007). Innovations in genetic manipulation, the widespread use of high producing Holstein Friesian cattle, feeding well developed total mixed rations (TMR), and usage of synthetic hormones such as rbST are a few reasons for the current high producing animals.

There has been a paradigm shift in how animal impact is measured.Capper and her colleagues recommend GHG emission impact is measured by unit of food output rather than by individual unit (Capper et al, 2010). Also, it is important to have an all inclusive measuring system including dairy replacement heifers, calves, and dairy bulls required to maintain the dairy system (Capper et al, 2010). This same concept is mentioned by Owens and coworkers, who identify it as “Life-cycle Assessments”, in which emissions are accounted for in all stages of the lifecycle, and include associated animals such as bulls (Owens et al, 2014).

A higher producing animal reduces the total amount of animals required to produce a set volume of output that in the past required more animals. For instance, one cow in 2007 can produce the same 60 pounds of milk produced by four cows in 1944 (Bauman et al, 2008 and Capper et al, 2010). This subsequently reduces the number of replacement animals, calves, and bulls needed to input into the dairy system. The fewer animals in the system, the less feed and water required leading to less manure output (Bauman et al, 2008).

Unit of output ismore accurate, depicting the actual emissions to product ratio, and doesn’t limit the data to animal units. Steinfeld and coworkers, center their ideas on livestock numbers only, and do not mention livestock output (Steinfeld et al, 2006).The authors suggest that, by 2050, livestock inventories must double to sustain the growing population. In contrast other work shows that increasing production per individual unit decreases the need for a growing number of livestock (Capper et al, 2008). By no means does this suggest that animal units will not need to increase to stay at par with the growing population’s demand for food. However, the projection may be an overestimate of the reality of necessary increase in animal units by 2050.

As technological advancements aid in the progression of dairy cattle production,sustainability,efficiency, and output will also change.

Another useful tool in reducing total industry GHG contribution to emissions, feed and water input, and manure output is recombinant bovine somatotropin (rbST). Typically perceived as a hormonal supplement toincrease milk production and metabolic efficiency, it by default also doubles as a sustainability tool. Bovine somatotropin is anaturally produced hormone by cattle.In its recombinant form rbST can increase milk production and makes milk synthesis more efficient. The idea is to use fewer high producing animals that can make more milk by better utilization of their current diet triggered by rbST. There is a consequent decrease in total feed requirements for dairy animals, lowering the dairy industry’s contribution the N_2O dilemma of runoff in crop production and soil erosion (Capper et al, 2008). Having fewer high producing animals will reduce fossil fuel use, electricity use, and crop demand therefore aid in reducing the dairy industries carbon footprint.

Data from Capper and her colleagues showed that in a system with 96,600 animals on rbST there would be an estimated reduction in feed by 721,000 tons, reduced manure by 874,000 tons, and in consequence the carbon footprint of the cattle involved would be reduced by 532,000 metric tons. These numbers demonstrate the value in the widespread use of rbST in the cattle industry, not only for productive gains but also to reduce GHG emissions and environmental degradation consumed. The next step would be to convince consumers that even before they ever consumed milk from rbST treated cows that they had always consumed milk with naturally producedbST.Consumer perception ultimately drives the success and profitability of what practices can be implemented on a dairy.

Manure management and utilization has been a hot topic in the industry due to the high level of GHG emissions from this area. However, tools developed to collect emission such as methane have not been widely utilized. Due to lack of financial viability, systems such as digesters just don't pay for themselves. And without outside financial support cease to be continued. To meet U.S. goals in reducing GHG emission, focus must be placed on reducing total agricultural GHE particularly in dairy manure management(Owens et al, 2014). A large majority of GHG emissions in dairy manure management are produced from liquid management, due to microbial activitieswhich thrive in these environments (Owens et al, 2014).

Innovations that tackle liquid waste emissions will diminish a huge area of the dairy sector's contribution to emissions. Creating solutions for the other dry manure waste areas will also be of environmental benefit. Utilizing manure as crop fertilizer has its advantages and its potential challenges.By reducing the need for inorganic synthetically-produced fertilizers, N_2O emission is reduced. However, sufficient use of manure as fertilizer to meet the nitrogen (N) needs of the crops would over saturate the soil with phosphorous (P),and create an unbalanced N:P ratio (Capper et al. 2008). Nitrogen and phosphorous have a lot of attention in the United States, as they both can become oversaturated in the soil and enter ground water.As a resultcaution must be taken with alternative fertilizer strategies(Owens et al, 2014). Manure usage in crops or (potentially)rangeland can aid in the land sequestration of carbon. This would stimulate the land's sink capacity and reduce atmospheric carbon (Owens et al, 2014).

Development of legislation and a political push to open up the doors for manure usage on rangeland may aid in reducing the atmospheric emission of carbon. Creating a budget to economically sustain the use of digesters for liquid dairy waste has massive advantages since

Owens et al. (2014) data shows the largest majority of GHG emission is coming from liquid manure management.

Industrial Goals

Today, the main purpose of American dairy breeding programs is increasing production and selecting traits that improve production. Getting the most out of individual cows enables more products, for fewer animals and therefore less total GHG emissions as the Capper data displays. The combination of higher volumes and fewer cattle is arguably a win-win for the industry and the environment. It seems the only direction much of the industry looks is forward, forward movement, greater gains, and even more efficient animals. Mark Armfelt, a Doctor of Veterinarian and a representative of Elanco, describes the objectives of the current dairy farmer. He suggests that the producer wanted more milk, but was not asking for more cows. He was asking for more milk from the high producing cows he already had (Armfelt, 2013).

Many innovations have made that producer's herd what it is today, yet other refinements could aid in an even higher production level per animal. Armfelt proposes refinements in areas such as restricting days in milk (DIM), intensive culling of low producing animals and replacing them with high producing animals, utilizing high quality forage, continuing to breed to high quality stock, use of rbST, and employee management (Armfelt, 2013). Fine tuning these areas could, in turn, increase production. For instance, diligent employees could add 6-8 pounds of milk to the tank per cow, increased forage quality may add 5-10 pounds of milk per cow, and aggressive culling may add 2 pounds of milk to the tank per cow (Armfelt, 2013). Seemingly small, but when these numbers are applied to a 3000 head dairy, there are major increases in the volume of milk gained in the milk tank. Employee management alone, consider a moderate gain of 7 pounds per animal, will add 2,100 pounds daily to the milk tank. Combining these different techniques could provide even more gains. But is this possible? According to Armfelt the answer is yes. The producer he describes in the article within two years went from 25,000 per year to 30,000 per year by implementing a combination of these solutions. Rather, the question is, is it practicable? Environmental capacity may encumber these productive goals.

Imagine the production curve for a typical Holstein dairy there is a maximum productivity that can be reached (lactation number will change the maximum value). The curve is not stable by any means, it fluctuates rising or falling depending on variables. Certain variables can be classified as controllable and can be manipulated, consider the manipulations Armfelt (2013) recommended. In addition, there is potential in cooling systems, transitional management, heifer management, etc. The major uncontrollable variable, or limiting factor, is environment (Mukherjee et al, 2012). It can be day to day weather or a climatic shift that might impact an animal for a day, potentially longer. Consider the hypothetical scenario of moving cattle from a dairy farm in California's Central Valley to Wisconsin. The climates are completely different. The lower average temperature in Wisconsin may improve production, and maybe the cattle produce 5 more pounds per day due to reduced heat related complications. The significant climatic shift had a positive effect on production, granted change can cause a shift in either direction. For the purposes of the paper the focal uncontrollable variables are weather and climate, it is noticed that feed quality and availability, water availability, milk market prices and a plethora of other uncontrollable variables apply. Yet, these are circumstantial and when zoomed out and analyzed they all lead to the environment and often to one another, similar to a dependent ecological network.

As Armfelt (2013) showed, significant financial gains can be made by manipulating controllable variables. Certain variables may improve to various degrees regardless of a high temperature humidity index (THI), such as labor management, and culling. However, the ability to provide high quality rations may not be possible when high heats impact crop quality.In this situation, water availability due to drought will cause crop values to spike. It would be unlikely the producer could afford or obtain such high quality forage while simultaneously experiencing high cost in heat stress related reproductive problems. In addition, the gained values by incorporating other manipulative techniques in herds facing severe heat conditions will not be at the higher end for gains, and may not be significant at all. Adaptations for cooling animals, such as soakers and fans, allow dairying to be productive in warm climates (Mukherjee et al, 2012). Data shows that when utilizing these adaptations, hypothetically, $106, 830 gains per year could be seen (Mukherjee et al, 2012). Including freestalls with the other two adaptations would increase this value by $55,801. Although these are great gains for a producer, the current conditions in the U.S. should be considered when planning for high temperature adaptations. Are sprinklers and or soakers going to stay an available adaptation tool for a state such as California who is facing severe and extreme droughts? Even if producers continue utilizing sprinklers or soakers it could be regulated. Maybe the recommended length of time and temperature at which sprinklers/soakers turn on will have to be adjusted to meet future water regulations.These changes may fall short of the dairy animal’s needs, and the positive benefits of environmental adaptations may decrease. Global warming has created quite the predicament for dairy farmers. It is apparent that water allocation to agriculture is not necessarily the highest priority for political legislatures. That said, where do we go from here?

Diversity and Inbreeding: Modern Cattle Sensitivities

Diversity is often thought of as different plants and animals all linked together in an ecosystem, typically reliant on the other for some degree, if not all, of survival.Diversity is equivalent to stability, including genetic diversity. Today much of the agricultural industry relies on a technique of developing highly specialized monocultures. For example, the production of just one type of crop, such as king corn or soy beans in large volumes. Monocultures are biologically unstable, in essence weak;they require constant intervention to maintain, because it will naturally revert back to what was more successful for survival, diversity. Intervention refers to the producer's hands at work, this is what enables the survival of the system utilizing tools such as herbicides, fertilizers, land development, medicines for livestock, or specialized housing structures all keep production high and protect producer investments. Monocultures feed a lot of people; they produce massive amounts of food utilizing specialized crops which is why they dominate the agricultural industry.

Genetic diversity,the genetic makeup of a species, is less visible. Genetic diversity is the total amount of genes or alleles in a population and is measured by the frequency of genes,or alleles, in a group (Freeman et al, 2014).Notter defines allelic diversity as the total frequency of the entire range of adaptive alleles in a species (Notter, 1999). Freeman and his colleagues describe the significance of genetic diversity:

"Genetic diversity is important because it represents the adaptive capacity of a population or higher taxonomic group – the ability of that group to persist over time despite changes in the environment." (Freeman et al, 2014)

Adaptability of a species to change in their environment can dictate what group survives and which does not; it enables the most suitable genes for an environment to thrive, while the less suitable genes are lost. This is natural selection, described as individuals in a population having particular characteristics that produce more offspring than individuals without those characteristics (Freeman et al, 2014). In the instance of industrial agriculture, there has been a large digression away from the natural approach for selection. Selection is not dictated by what trait survives best but instead, by what traits produce the most and highest quality product.This is due to the rapidly growing human population and the expectations of consumers.Producer intervention has made this possible.Selection strategies have reduced the frequency of the total allele potential to the few alleles that are most desirable. This is a prevalent situation in the U.S. dairy industry.

As of December, 2013, the current Holstein inbreeding percent was 6.05 (CDCB, 2013). There has been a 1.5 percent increase since 2000 (CDCB, 2013). Inbreeding trends began around 1962, at 0.06 percent and since then has increased to what it is today (CDCB, 2013). The dairy industry is dominated by the high producing Holstein Friesian breed,because high production equates to greater profit and more product availability to the consumers. Professor Cassel explains that,when an inbred animal is genetically superior (most often the case) and consistently transmits those traits to its offspring, it is of high genetic merit (Cassel, 2009). Professor Cassel also points out the benefit of consistency, because highly inbred animals are more likely to produce predictable germ cells,this gives producers a better idea of what they will get out of their animals (Cassel, 2009). In consequence, inbreeding lowers allelic frequency, thus reducing genetic diversity of inbred individuals (Cassel, 2009). They do not have the full potential alleleset that a more genetically diverse individual has, due to specific alleles being selected. In addition, the incidence of recessive allele frequency raises, and the probability that negative recessive traits will be seen becomes higher(Bjelland et al, 2013 and Cassel, 1999).This dilemma is further exacerbated bythe prevalent availability of reproductive technologies as advanced as cloning, utilization of embryo collection, and the more common use of artificial insemination in current herds.

Most semen companies have a select number of sires that they collect from, and when they approve new sires to their stock they are often related to the older popular sires. Trying to breed non related animals becomes difficult, due to incompleteness of pedigrees and growing relations of animals nationally and internationally (Caraviello, 2004).Caraviello mentions that mating unrelated animals may not be a sure possibility, because much of the available pedigrees and animal history are not documented (Caraviello, 2004).It is possible to choose supposedly unrelated animals for mating that are, in fact, distant relatives.

Consequences of the high producing Holstein Friesian can be substantial, particularly in less than ideal conditions, spawned from the breeding compromise in type traits for production traits. Heat stress can cause an annual loss of $897 million to $1500 million per year for an operation (St-Pierre et al, 2003). It was also found that late lactation animals exposed to high heats experienced heat stress, birthed calves with a lower birth weight and had reduced production (Collier et al, 2008). Lower birth weights and production both reduce the financial gain out of both cow and calf. Heat stress for cattle begins at about 24 degrees Celsius the comfortable range for cattle is between 2 and 24 degrees Celsius (Johnson et al, 1976). Johnson and his team members remark that production is impacted at a temperature of 27 degrees Celsius (Johnson et al, 1976). It is the combination of heat in the environment and the animal's inability to dissipate metabolic heat that causes an animal to experience heat stress (West et al, 2003). Both Holstein and Jersey animals will experience heat stress to some degree, but milk losses aren't as extensive in the Jersey breed (West et al, 2003). Dry matter intake (DMI) is negatively impacted as temperatures rise. It was found that as temperature rose from 25 degrees Celsius to 32 degrees Celsius there was a consequent loss of 6.5 Kg/day of DMI in Holstein and a loss of approximately 6 Kg/day of DMI in Jerseys (West et al, 2003) .

Due to the potentialnegative impacts of inbreeding, the term inbreeding depression was coined. Inbreeding depressionis a problem that arises when there is little genetic variation between species causing more recessive alleles to be expressed (UET, 2014). The solution is to introduce variants of the same species which are not related (UET, 2014), but what happens when this is not an option? The dairy industry has great loyalty towards Holstein cattle. The gains and profitability that these animals have produced justifies the producer’s feelings. Breeders want pure Holstein herds,a logical goal due to sure gains from reliable seed stock. The state of inbreeding makes it difficult to continue following this path. Inbreeding losses may be measured by increased percentage of inbreeding (e.g. every 1 percent). For example, it was found that for every increase in 1 percent inbreeding, a lifetime loss of 23.11 dollars per animal is seen, a loss of 37 Kg of milk, and loss of 13.1 days of productive life is found (Smith et al, 1998). Calculating these numbers into a 3000 head dairy equates to 69,000 dollars lifetime loss and 111,000 Kg milk loss which definitely impacts finances for a producer. Inbreeding also impacts reproduction and fertility. Some losses are not ever seen. Consider the incidence of abortion of non viable embryos or fetuses, it has been suggested that cases of fetal failure may be linked to lethal homozygous alleles (VanRaden et al, 2011).Caraviello discusses a study done showingmaternal inbreeding depression found in Jerseys (Caraviello, 2004). Calves of inbred dams had higher rates of death loss (Caraviello, 2004). In Holsteins, every 1 percent increase in inbreeding is associated with an increase in age at first freshening by .36 days and increase in their calving interval by .26 days (Cassel, 2009). Caraviello data also displays the implications of mating schemes for Jersey cattle utilizing various inbreeding levels. He compared what that means for net merit and lifetime profit (Caraviello, 2004). The animals bred to have the highest net merit (inbred between 6.1 and 7.1) were not the animals with the highest lifetime profit (inbred ≤ 4.4). Highest lifetime profit was bred to maximize profit minus inbreeding depression, this technique turned out to provide the greater gains regardless of the lower genetic merit. Much of today's breeding strategies center around high genetic merit animals, but it seems there may just be potential to have less closely related animals even crosses that still have economically significant gains for a producer.

Crossbreds

In an ideal temperate environment that consistently remains below 24 degrees Celsius,Holsteins outperform any other dairy breed due to high genetic merit (Swan, 1991). However, when the environment is not within the ideal temperature range of 2 degrees Celsius to 24 degrees Celsius, production and reproduction begin to decrease sometimes dramatically. Large high producing animals naturally have higher internal temperatures due to the production of metabolic heat, which further exaggerates the reduction in performance caused by heat (West et al, 2003). Genetic merit means nothing when the environment does not allow for phenotypic expression of an animal's genome. A shift from placing a higher value on economic merit rather than placing value on genetic merit may not be too far away for the U.S. dairy industry. Touchberry data concluded that crosses of Guernsey with Holsteins showed a gain in income per lactation of 14.9 percent, and income per year was 11.4 percent greater than pure Holsteins, even though they produced less than their pure bred parents (Touchberry, 1991).

The main idea behind crossing pure Holstein's to other breeds is to create animals that may overcome stressful environments. While maintaining productive and reproductive gains. Potentially greater than what a Pure Holstein can produce. As the climate shifts there could be more profit in the gains achieved through a crossbred herd versus the productive and reproductive losses incurred by pure Holstein heat stress.Crossbreeding allows a phenomenon called heterosis to take place. Heterosis is defined as a tendency of a crossbred individual to show qualities superior to those of both parents. Also known as hybrid vigor. Heterosis is the combination of interactions within or between loci and can be dominant or epistatic (Swan, 1992). Crossbreeding enables increased genetic diversity at the allelic level. Crossbreeding also increases the total alleles available, by introducing new alleles from an unrelated breed. For those reasons there could be potential to eliminate inbreeding depression (VanRaden et al, 2001). This would also increase allelic heterozygosity, reducing the occurrence of negative homozygous recessive traits. This increase in total allele provides more genotypic capacity to overcome and adapt to environmental hindrances. For instance, the traits for disease resistance and stress may be present. Modern Holsteins do not have the genome capacity to adapt, so they struggle in less than perfect circumstances.Adaptations must be created by producer intervention, hence the use of fans and sprinklers (Mukherjee et al, 2012). A study projected that losses caused by heat stress due to climate change for dairy farms could range from 100 to 168 Kg of milk annually (Mukherjee et al, 2012).

There are a multitude of benefits associated with crossbreeding. Economic increases vary, depending on the cross that is made and the conditions the crossbred generations are exposed to. These conditions can be weather, climatic factors. And include how the animals are managed in all aspects of their lifetime. Reproductive gains of certain crossbred cattle can be large. For instance,compared to pure Holsteins, Scandinavian Red had less calving difficulty, reduced amount of dead on arrivals (DOA), less days open (DO), and increased productive life (PL) (Heins et al, 2006a).Jersey and Holstein cross F_1 generations had greater body condition scores at first calving (Heins et al, 2008). This would enable a smoother transition and decrease the severity of negative energy balance. Jersey crosses also had 23 fewer days open in comparison to their Holstein counterparts, and by 150 DIM 59 percent of Holsteins were pregnant compared to75 percent of Jerseys (Heins et al, 2008).

Advantages in terms of production can be seen by looking at components in milk. Crosses never had higher milk production then pure Holsteins. Granted no data was found for comparing crosses and Holsteins placed in environments exceeding 28 degrees Celsius simultaneously. Such a study would aid in comparing the heat stress induced differences in the lactation curve of both. The market a dairy producer sells to should be considered. If a producer is selling to a milk plant, volume would be of greater value. If a producer was selling to a cheese plant, or other processing plant, components would have a higher value. Heins and his associates found that Jersey crosses had similar fat (274 Kg) to pure Holsteins (277 Kg) (Heins et al, 2008). Making Holstein-Jersey crosses valuable to cheese processing plants. In addition, when comparing the lactation curve of a pure Holstein to a Scandinavian red there was very little difference at peak milk, approximately 2 Kgs, and the difference in fat was small, 6 Kg (Heins et al, 2006b). In the studyMontbeliarde crosses came in second, to Scandinavian red crosses. Montbeliarde crosses had 12 Kg fewer fat and 13 Kg less protein than a purebred Holstein (Heins et al, 2006b). Reproductive gains for crossbreds are of great benefit to producers. In addition, if the market value were to shift from volume to components utilizing Jersey crosses could be an advantage. Crossbreeding for economic merit has not taken off in the U.S., but the impending climate change may change that.

Perceptions of crossbred animals have influenced their appearance in the U.S. dairy industry, or lack thereof. There is a great loyalty to the Holstein breed, they have made producers great gains and economically kept dairies afloat while meeting population demand. Armfelt recognized that small producers would struggle to be successful in today's dairy industry (Armfelt, 2013). Due to high productive values (typically from Holstein dominated herds) and high cattle numbers per operation.

There is a reduction in heterosis after the first mating of crossbred animals. And a reduction in the reliability of traits that will be expressed in further generations. The maximum amount of hybrid vigor is achieved in the F_1generation, subsequent generations will vary (NMSU, 2014). This reason alone contributes a great deal to the resistance in moving from a very reliable and consistent structure to a less predictable program. Consistent utilization of high genetic merit sires of different breeds is important to continue regardless of breeding strategy (crossbred or purebred) (Heins et al, 2008). Boettcher proposed a system strategizedat maintaining heterosis by rotational crossbreeding a few breeds (Boettcher, 2001).An availability ofgenetically superior sires in breeds besides Holstein or Jersey ishard to come by. There would be a necessity to increase the number of other-breed sires of high genetic meritfor distribution by semen companies. This would take time, due to the necessity for testing and calculating animal genetic merit.

Some common concerns with crossbreeding are not necessarily (or accurately) scientifically supported. One being that crossbreeding would require an operation to revert back to utilizing bulls for natural conception and stop AI The other is that only dairy's with low levels of management will see a benefit in heterosis of crossbred animals. In a crossbreeding system, AI is highly recommended, giving a producer access to more bulls (Heins et al, 2008). In the case of heterosis and management systems, the idea that low management systems only saw gains was discredited by (Kargo et al, 2012). Who found that heterosis was highest in the intermediate management groups, and recommended that it should be considered for higher management groups as well.

Discussion:

The changing climate system may aid in steps to take producer's attention away from genetic merit and refocus it on the idea of economic merit. Since genetic merit can be suppressed by environmental factors such as high heat, it should not be the main consideration when evaluating breeding programs. Notter emphasized the importance of implementation of a clear and specific breeding program for every herd in order to reduce inbreeding (Notter, 1999). He also recommends having a mass sampling of all breeds nationally and internationally to determine their genetic potential and any breed discovered to contribute to dairy gains should be implemented immediately (Notter, 1999). This idea could reduce the amount of inbreeding in a herd, and possibly make inbreeding depression obsolete. Crossbreeding is a challenging product to sell, an innovative solution was proposed by Boettcher (1999). Boettcher described utilizing a rotational cross system to maintain heterosis in allgenerations of crossbred herds (Boettcher 1999). He recommended that pure registered Holstein (or Jersey) herds continue to breed their select stock. Some producers would be crossbred while others would be purebred. This compromise would enable the coexistence of both breeding systems. This system allows for a presence of genetically diverse stock while not forcing producers with high loyalty to purebredsto compromise their own values. Having crossbred operations placed in regions of the U.S. which commonly experience extended heat has potential. Having high producing pure bred herds in the more ideal regions where they would meet their genetic potential. There would be two markets stimulated with this system, production and seed stock(Boettcher, 2001).

Capper and her associates work in the reduction of GHG and the dairy carbon footprint would not necessarily be lost to crossbred herds. Although they will not produce the gains that high genetic merit animals have potential to deliver, so gain per animal may be technically less. Focus must be placed on the difference in gains between the cross bred and the pure bred animals in a specific environment or climate. In the presence of high heat, production does not equate to what genetic merit predicts it would be for the pure bred cattle. The crossbred herds could theoretically be the most efficient because production loss may not be as devastating and their other traits such as reproductive ability and productive life provide producers more economic gain.

The utilization of rbST is another method that should not be lost to crossbred herds. Economic worth would rise while also aiding in reduction of dairy industry GHG emission and this combination makes rbST a powerful tool.

There is not much information available that displays how production of a pure Holstein and the production of crosses in the same heat stress inducing environment compare. Utilizing animals which are already in existence, such as the cattle from the experiment's performed by Heins and his colleagues would be a valuable resource. A study examining the lactation curves of Holsteins and the curves of the crossbred individuals would be insightful. This could display the true value, or decreased value, of crossbred animals in industrial dairy settings.

Conclusion:

Regionalized cross breeding systems may be the most realistic step towards implementing cross bred herds into the U.S. dairy industry. Crossbred animals have great economic potential due to their reproductive gains and potential lifetime in a herd. However, their genetic potential in milk production never equates to a pure Holstein. The Capper data displays the value of few-animal high production systemson GHG emission. Theoretically, it would require more crossbred animals to meet production demands of the population. More animals would equate to higher GHG emissions. The value of a crossbred animal is found in its potential to provide a producer with greater economic profit and increased genetic diversity. Yet, it would be at the expense of GHG emissions. More research is necessary to determine which breeds and a breeding strategy of most value for the dairy industry. A U.S. based research project aimed at comparing lactation values of both Holstein and crosses in heat stress inducing environments is needed. This would aid in deciphering the actual value of crossbred animals. The project would also help determine which regions a crossbred dairy farm may be applicable. Overall, the shift of the U.S. dairy industry towards crossbred herds and how adaptations to global climate change commence will be driven by consumers, government interaction, and economic viability.

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