A TRANISITIONING MAINE DAIRY INDUSTRY: FARMER PERSPECTIVES ON CHANGE, CHALLENGE, AND CHOICES FOR A SUSTAINABLE FUTURE

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ABSTRACT

The dairy industry is an integral part of Maine's social and economic history. Today dairy has a total impact of $2.71 billion in Maine, directly and indirectly, employing 14,000 people in rural communities, and supporting other agricultural production. As economic and climate conditions have fluctuated, the Maine dairy industry has struggled. To prevent further decreases in dairy-farmer population in the state, dairy farmers must be supported with programming tailored to meet their unique needs. This paper covers sustainability challenges and solutions for farmers and identifies available and necessary supports as they adapt. Business mentors, marketing help, sustainability consultants, and financial incentives will push the industry toward environmental sustainability and longevity. Listening to farmers ask for policy changes surrounding milk pricing, immigration, and financial incentives is important at federal and state levels. Dairy farming has the potential to reduce GHGs and sequester carbon while producing a nutrient-dense product necessary for regional nutrition.

BIOGRAPHICAL SKETCH

Kristin is passionate about farmer protection, namely through education and empowerment. Growing up in a Maine dairy family that made conservation of their land and forests a priority. Kristin discovered early on that life can be hard on farmers. She often found herself experiencing tension between the environmentalist movement and the farming community. Having spent time in Mexico and Guatemala, she watched as farmers struggled to deal with the consequences of poor agricultural methods. Kristin believes that education alone is not enough to help farmers make changes — they must also be empowered and protected to take the social and economic risks of making change. After getting a degree in Environmental Science, working with Cooperative Extension, and managing a small vegetable farm using regenerative methods, Kristin decided to go back to school. She hopes to better identify the optimal approaches for empowering rural communities to shift to more sustainable farming methods. Her hope is that through farmer-centered education, producers everywhere can eliminate pollution and sickness caused by unsustainable farming methods, improve farm productivity, and ultimately improve the livelihood of farmers and their communities.

For the Bensons.

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Thank you

to my professors and friends in Ithaca who gave me grace and took care of me,

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

BMP:	Best Management Practice
DIF:	Dairy Improvement Fund
DMC:	Dairy Margin Coverage program
EPA:	Environmental Protection Fund
FARM:	Farmers Assuring Responsible Management program
GHG:	Greenhouse gas
PFAS:	Polyfluoroalkyl Substrates
UN:	Unite Nations
USDA:	United States Department of Agriculture
WWF:	World Wildlife Fund

The History and Evolution of the Maine Dairy Industry

History of Dairy Farming in Maine

When the sheep industry became unprofitable in the state of Maine in the 1840s, many of Maine's farmers looked to the dairy industry as a suitable new business (Boardsman, 1867). The industry took off, with the population of dairy cows in the state of Maine increasing by 13,000 in the ten years between 1850 and 1860 (Bidwell, 1941). Dairy products were produced and sold within the state, becoming a steady source of revenue. Then in the mid-19th century, with the creation of refrigerated box cars, a new outlet for Maine's rapidly growing dairy industry was created. In 1881, the Boston-Maine railroad connected Maine-produced butter, cheese, cream, and liquid milk to the rapidly increasing Boston market (Day, 1963). Until the early 20th century, the Maine dairy industry was able to stay competitive in Boston, outcompeting larger dairies from the Midwest because of their proximity to the city.

Over time milk became easier to find and cheaper to buy. Farmers began investing in more animals and producing more milk as a means of livelihood survival. Starting early in the 20th century, smaller dairies facing high costs for entering the commercial milk market began to be bought up by larger farms. These larger farms experienced stability and protection from volatile milk prices for a while, but soon increasing production costs and decreasing milk prices had them participating the same unending race. Farmers continued to invest time and money into new technologies allowing them to produce more, only to create an influx of milk on the market. As the supply of milk climbed, prices dropped; forcing farmers to push harder to produce more milk to keep their farms afloat (Love, 2012).

Milk Prices and their Volatility

For a while, Maine farmers were able to produce, process, and sell their own milk

products, but as production expanded they began to rely on other businesses for processing and selling milk. Maine's first creamery was built in 1878 and was quickly replicated in other towns. Within a decade 16 other creameries had been constructed (Love, 2012). As milk processors grew and milk became more available, the money distributed to farmers for their products began to decrease. Milk processors, dealers, and distributors kept a larger percentage of milk revenue for themselves in order to pay for labor and processing costs. As smaller revenue returned to the farmer for their milk, the government stepped in and established a classified pricing approach to the milk market (Wagner, 2020).

Federal Milk Pricing: Government's First Involvement

Federal government milk price regulation began in the early 20th century. Under their first system, established in the 1930s, milk was classified and priced based on the intended use of the purchased milk. Established categories such as fluid milk, cheese, or butter production were assigned a price that reflected the market. Seeking better assurance of a dependable market and fair prices, farmers established milk cooperatives. These cooperatives pooled money from all milk sales and distributed it among their members based on volume of milk deliveries, regardless of milk classification (Wagner, 2020).

During the Great Depression, the federal government stepped in to regulate the market again. The Agricultural Adjustment Act was introduced to regulate the price of agricultural produce in an effort to ensure fair prices for both farmers and consumers. In the ninety years since the Great Depression, government dairy policy has featured a diverse set of approaches. They have included government purchase of surplus milk to maintain profitability for farmers, various support price programs, programs to cover milk production margins, and whole herd buyout programs where farmers were incentivized to exit the dairy industry. While helpful at

times, uncertainty associated with changing milk market conditions and these frequently changing government policy responses created financial risk for farmers. Increasingly, dairy farmers struggled to cover production costs, let alone to cover fixed costs and earn returns on the expanding capital investments. The number of dairy farms has seen a steady decline for many decades (Nepveux, 2021).

Today's Dairy Farmers Face Many Challenges

In addition to weak milk pricing, today's dairy farmers have been hit with rising costs, more challenging regulations, and increasing market and policy uncertainties. While production costs have risen across all sectors over the past 5 years, for the US dairy industry the cost of feed production, fuel, equipment, and labor have increased significantly. Greater financial burdens and other challenges have forced many farmers out of the industry. Since former Secretary of Agriculture Earl Butz made his infamous 1973 statement that farmers should "get big or get out", dairy farming has experienced high attrition rates both in Maine and nationally. According to USDA data from 2023, more than half of the dairy farms in the US disappeared between 1997 and 2017. Meanwhile, the average herd size on farms increased by 139%. This consolidation of farms has kept yearly milk production at about the same level (Lakhani, 2023). Amid large fluctuations in cost and profit farmers are also facing labor shortages, environmental regulations that can be challenging to comply with, public concerns over animal welfare, shifting consumer preferences, and challenges with farm succession planning.

Financial Instability

As farmers struggle to keep their farms afloat, volatile on-farm revenue continues to be an obstacle. The cost of milk production outweighed dairy farmer revenue every year from 2015-2020. Today the price of milk has come up to an all-time high but is still not adequate to cover total production costs for many farmers. The most recent average national milk price is up 7.2% from a year ago. However, the cost of milk production has increased by 19% in the past year. Fuel and fertilizer costs have come up significantly (50% increase), feed costs have risen (17% increase), and interest rates have spiked (41% increase) making this increase in milk cost seem

insignificant (Overton, 2023).

The fluid milk market is uniquely irregular because of milk's high perishability, the seasonality of production in some places, and fluctuations in export markets. The current margin program: the Dairy Margin Coverage Program (DMC), was created in 2018 to stabilize farmer income and minimize risk via the Farm Bill and can play a role in reducing farmer losses. In order to benefit from the program farmers must sign up during the four-month enrollment period and purchase the amount of coverage that they feel is appropriate for their farm. When the average national price of milk falls below the coverage level selected and paid for by the farmer, the DMC will begin to make payments to farmers.

The USDA Economic Research Service predicts that net farmer income across all sectors in 2023 will decrease by $30.5 billion, an 18.2% decrease from last year. They also estimate that farmer income from milk production will decrease by $8.4 billion, a 14.6% decrease from last year. This reduction in dairy farmer income will likely mean a large payout from the DMC, which is predicted to distribute $285 million to farmers this year (a 122% increase from previous years). Other programs that financially support farmers are scaling back their support including the government-funded Emergency Relief Program and Emergency Livestock Program, which are both expected to reduce support available to farmers beginning this year. This reduction in government support coupled with reduced milk prices will likely mean that dairy farmers will see the greatest reduction in net farm income of all animal-based farm businesses (Lyubomirova, 2023).

Labor

Workforce shortages are not unique to agriculture, but in rural towns it is exceptionally challenging to find affordable labor for vegetable and livestock-based production. Many farmers

are pushing for immigration reform as a means of increasing labor availability (Leach, 2022). According to data from the U.S. Chamber of Commerce there are 3.6 million more available jobs than there are unemployed people in the US (Dubay, 2023). When coupled with competitive pay in other sectors, dairy farmers face a serious disadvantage. Costs associated with training, increasing costs for higher skilled labor, and an aging workforce make it challenging for farmers to find and keep the skilled workers their farms require. Becki Benson, a long-time dairy farmer who transitioned to a compost business in 2015, expressed frustration about finding workers in the past. She and her husband would often hire high school students to work on their farm, but after the two years it took for them to be fully trained and efficient at their job, they were often looking for a higher-paying one. Additionally, training young workers comes at a cost. Broken equipment, careless mistakes, and slow working speed can make the training process expensive. Another farmer described similar challenges, "There are no high school students interested in working on farms today. They all have soccer practice at three, dance at five, and plenty of homework to do. They might be free from six-thirty to quarter-of-seven, but that's about it."

Farmers are looking into changing their on-farm infrastructure to compensate for the lack of available labor. Robotic milkers and robotic feeders are huge technological investments but can reduce labor costs. Steve Obert, a fifth-generation dairy farmer from Indiana echoed the sentiments of the farmers interviewed in Maine. "Anything that can cut down labor costs is a good investment for the future because all I can tell you is that labor costs are just going to keep going up," he said. Alongside investment in technology, some farmers are pushing for immigration reform. "Working with dairy animals takes knowledge, skill, and awareness which is hard to teach with high-turnover rates" Obert finished. He and many other farmers are supporters of immigration reform legislation that would open the H-2A program to people in

both the dairy and livestock sectors (Ali, 2022).

Environmental Regulations

While many dairy farmers feel a personal responsibility to steward the land they farm, they are also required to meet a number of environmental regulations limiting nutrient losses and greenhouse gas emissions from their farms. These regulations vary based on the region and proximity to water or residential areas. Regulations targeting nutrient run-off and manure emissions require farmers to invest significant amounts of money into new infrastructure to reduce their impact on the surrounding land, water, and air. While many farmers expressed their personal convictions to take care of the land that surrounds their farm, many also highlighted the financial and time costs of complying along with the lack of flexibility to meet the requirements of a specific local environmental context. Some farmers noted their frustration with other sectors having different and far fewer regulations. "We live in a 100-year flood plain. The development down the road is putting up buildings way closer to the river than we are allowed to."

Dairy farming is reducing its environmental impact - from 2007 to 2017 the dairy industry reduced the amount of land used to farm by 21%, its water use by 30.5%, the amount of fuel used by 20%, and is using 17% less feed to make the same amount of milk (NMPF, 2023). To further reduce their environmental and carbon impact, some farmers need support. Grants and funding programs are available to farmers as a means of financially supporting their infrastructure changes, but expecting farmers to have the free time to research and apply for these grants may be misinformed. With significant labor shortages outlined earlier, dairy farmers have very little available time to research resources and apply for grants.

Shifting Consumer Preference

Over the past couple of years consumers have begun to give greater attention to proactive

health and are beginning consider food as a form of medicine. Consumers have begun to think critically about the foods they put into their bodies and the impact of those foods on their health. Similarly, since the pandemic many consumers prefer sustainable food options. Years of campaigns painting the dairy industry as an inhumane food production system coupled with consumers' distance from the food system have led some consumers to believe that purchasing dairy products is irresponsible. Frequent conversations about sustainability and greenhouse gas emissions have further encouraged consumers to stay away from the product, as mismanaged manure on farms can release excessive methane, a potent greenhouse gas.

Finally, as inflation continues, the changes in pricing can impact dairy sales. The prices of dairy products consumed at home have risen by about 12.3% over the past year according to Madlyn Daley with Consumer and Market Insights at Dairy Management Inc.. In combination with other inflation-fueled rises in cost, consumers may be choosing to step back from purchasing dairy. As these market shifts continue, the amount of dairy produced and the amount consumed is imbalanced. The focus of the dairy industry has shifted toward targeting the right products to increase consumers purchasing and consumption of more dairy per person. Social media and health-related messaging have helped to present dairy as a healthful product, high in protein and healthy fats, and low in sugar. While this messaging is beginning to take off, these shifts in market consistency have had a concerning impact on dairy farmers' revenue.

The Future of Dairy in Maine is Unsure

Current challenges to the dairy industry from the perspective of dairy farmers and experts.		
Theme	**# of farmers that brought up theme**	**Example Quote**
Lack of Infrastructure	6	“Farmers have only 4 options for where to sell their milk commercially. There are only four places to buy feed. Limited Ag Lenders and large animal vets too. There is only one Balance Plant (oversupply processing plant) in New England that can make powdered milk."
Poor Pricing System	8	"You're not competing against the neighbor farm to do better. Farms have to scale up to make money, but for a lot of farms they can't."
PFAS	4	“PFAS prevents us from expanding to the land around us, you always have to have your guard up about new land. You need to test it before you move anything."
Rising Costs/Inflation	6	"The cost of everything has gone up." "Farms have no way to regain that loss."
Labor	6	"You can't get anyone who is willing to do this work for the level of pay we can afford." "It's hard to find people with the skill-set we are looking for."
Changing Weather	5	"More unpredictability [in weather patterns] especially the past few years makes it hard to plan." "Last year we had a beautiful month of June and then no rain until October when it dumped and we had floods. This year, we have had maybe nine days that it hasn't rained."
Succession Planning/ Development Pressure	2	"Farmers love to think that their family will carry on, but they might also think that it's been a struggle and they don't want to pass that on." "It's complicated with many generations involved... needed a mediator."
Environmental/ Sustainability Scrutiny	2	You try [your best] ... but sometimes there is no give! [...] We all try to be better. There are other challenges that don't make it easier to do the things you'd like to do."
Animal Rights Scrutiny	2	"Agri-Mark sends out letters letting us know what is going on in New York, activists giving farmers a hard time. Pineland got a nasty letter recently.. something about cows in poor conditions. We all know those cows have the most resources [in southern Maine]."

Table 1. Key qualitative themes are presented with the total number of farmers discussing each theme (out of 8 interviews) and a quote to illustrate the meaning of the theme.

Challenges Unique to Maine

Maine’s dairy farms are disappearing at a slower rate than other states because of support systems put in place by Maine legislation. However, the attrition rate does continue to be concerning. Maine’s dairy industry acts as a backbone for agriculture around the state. Bringing revenue to rural communities, and supporting needed vets, tractor repairmen, and feed

transportation companies. Between 2021-2023 Maine lost 25% of its remaining dairy farms, leaving only 161 farms remaining today (Overton, 2023). Many of these remaining farmers are struggling to make ends meet. Changing climate conditions, polluted soils, aging farmers, and increasing costs of production have left many Maine farms unsure of their future in the industry.

Lack of Dairy Infrastructure

Dave Marcinkowski, a recently retired Dairy Specialist and long-time professor with Maine Cooperative Extension and the University of Maine, highlighted Maine's lack of dairy-related infrastructure as the greatest challenge to farmers in Maine. "There are four milk processors in the state, four grain distributors, and a handful of large animal vets," he said. Most farmers in Maine sell their milk commercially to Agri-Mark, Oakhurst (owned by Dairy Farmers of America), H.P. Hood, or Organic Valley. Alternatively, some farmers may process their milk on their own or at a small local creamery in tandem with a few other farms. Others sell their milk raw after receiving the appropriate license. Farmers who wish to leave behind the set-price system currently in place with commercial processors must leave the industry or blaze their own trail to get their milk processed.

There are only two commercial milk processing plants located in the state of Maine, Oakhurst Dairy and H.P. Hood, both located in downtown Portland. Two smaller processors, Smiling Hill Farm and Houlton Farms both process a small amount of milk from a couple of local farms. Even more unsettling, there is only one processor in New England capable of producing powdered milk. With just one processor with these capabilities, excess milk produced in the region is worth very little.

Dairy farms in Maine are sprinkled throughout the state, making milk transportation a challenge for farms in more remote rural areas as well as processors. Danone, who owned

Horizon Organic, recently pulled out of the region because of challenges associated with transportation costs. Throughout the northeast, eighty-nine organic farms were left to find a new way to sell their organic milk. The state worked hard to get left-behind farmers' milk picked up by Organic Valley, an organic milk processor headquartered in Wisconsin. Farmers in the region worry that distributors may one day pull out of the region all together, leaving farmers stranded. "The industry has changed dramatically, it's scary to think about what it would be like in the next five to ten years," Jeanie Lewis said as she discussed the quota system Agri-mark uses. Jeanie is a lifelong dairy farmer and co-owner of Maple Down Farm in Auburn, Maine which she runs with her husband. Farmers like Jeanie feel that they are at the mercy of the processor-distributor. "We are limited on the amount of milk we can produce. We're penalized if we go over our base, and if you don't maintain the base you lose it for the future." She said, "The whole country is not playing by the same rules" as she explained that midwestern farmers are not experiencing the same level of uncertainty when it comes to the future.

Little Support for Farmers

Additionally, there are only a few extension agents in the state. Recently hired Dr. Glenda Pieria is the only Dairy Specialist. Farmers rely heavily on their vets, nutritionists, and friends to find solutions to new rising challenges and to hear about new innovations in the industry. "When challenges come, hopefully you have a good relationship with your vet or someone at extension," said NA Martin of Martin Place Farms and director of operations at Pineland Farms. "It used to be people helping people. Now, I think people just google it," Julie Martin, co-owner of Martin Place Farms, added. They described how helpful other farmers in the area, the milk truck driver, and other industry people used to be. Today many farmers feel that they must solve their problems on their own. "We have gotten very good at figuring things out

ourselves," Jake Harris of Harris Farms in Dayton, ME said. Natalie Sneller of Conant Acres had a similar sentiment " Cooperative extension historically had been the connector of farmers to resources, but today extension doesn't know as much about what we are trying to do." The Conants, like more and more Maine farms, have set themselves apart by diversifying their farm. In addition to selling their milk commercially, the Conants sell vegetables, raw milk, beef, and cheeses at a small store on their farm.

Consistent themes mentioned by farmers as they discussed the future of the industry were innovation and pivoting. "Everyone needs to be making changes or they won't survive," said Connie Wood, a long-time dairy farmer and 4-H leader of the Cumberland County Dairy Club. Others added, "The farms that survive will be the ones who are proactive, not stuck in their ways." Pivoting for some Maine dairy farms will involve diversifying their farm enterprises is , but there is far more to diversifying successfully than just producing something new. In order to be successful, farmers must have strong business sense and marketing skills, and the time to learn and build capacity. When asked about who helped the Harris farm develop a marketing strategy and business plan, Jake Harris said, "we figured it out entirely on our own." Dairy farmers in Maine may need a new kind of extension service, one that is prepared to help farmers diversify and build a business less subject to the risks related to commercial milk pricing.

Climate Change

Over the past century, the average temperature in Maine has increased by 3° F. Dr. Sean Birkel, a climatologist for the University of Maine, predicts that the state will continue to become hotter and have more yearly precipitation. Wet periods and dry spells have been common occurrences throughout Maine's history, but today we are seeing these occurrences at greater extremes (Molmud, 2022). In the past eight years, Maine has had serious droughts occur

four times, in 2016, 2020, 2021, and 2022 (Drought, 2023). These changes in climate conditions have meant a reduction in both harvested feed crop quality and quantity. Farmers are forced to purchase supplemental feed, namely soy, putting a heavy strain on farmers' input costs and increasing their environmental footprint (Mulmod, 2022).

Maine farmers perspective on climate change from the perspective of farmers and experts.

Theme	# of farmers that brought up theme	Example Quote
Not talking about it as a global trend	2	"The average farmer doesn't think very seriously about it." "[They're] not talking about it, they're too short-sighted, more interested in changes right now."
The Evidence is Here	3	"You'd get a majority saying there is something to it. Even five years ago there wasn't the data or experience. I think enough has changed at this point"
Extreme Weather	8	"The biggest change has been the extremes. Extreme colds...floods.... dry summers.
Perspective has changed in the past ~5 years	5	"My perception has changed over the past ten years. There comes a critical mass where you can't ignore it."
The Blame on Dairy is Misplaced	4	"I believe there is climate change. I find it hard to believe that it's all the dairy cow that is doing it." "I have a greater carbon footprint from my everyday life than I have from my dairy occupation."

Table 2. Key qualitative themes are presented with the total number of farmers discussing each theme (out of 8 interviews) and a quote to illustrate the meaning of the theme.

Unlike previous summers, this summer the rain hasn't stopped. "We've had maybe nine days that weren't raining this summer… This hasn't happened since 1969," Julie Martin said. "This year has been miserable, some fields we won't cut at all," Jeanie added. This has a significant impact on farmers' ability to feed their herds. It has also impacted farmers' perspective on climate change as a whole. While many interviewed farmers perceive many Maine farmers as skeptical, each of them explained that their personal perspectives had changed over the years. "The seasons have changed, I don't know. Everything's different," said one farmer. "[Now] a majority say there is something to it, I think at this point enough has changed." While it seems that there has been a shift in dairy farmer perspective, there is still significant hesitancy to say that their industry has much to do with it. "I believe in climate change," said NA Martin, "I find it hard to believe that it's all the dairy cow that's doing it." NA is on to something. Only 2% of

US greenhouse gas emissions come from the dairy industry and 4% come from livestock as a whole (UC Davis, 2019). Dairy farming has the potential to play an important role in eliminating greenhouse gases from the atmosphere. When farmers begin to feel discouraged after hearing conversations about their sector being a significant contributor to GHG emissions Sarah Littlefield, the Executive Director of the Maine Dairy and Nutrition Council, likes to remind them, "You're already a part of the solution!"

Even with the skepticism and defensiveness surrounding the concept that the dairy industry is significantly contributing to climate change, there is interest in improving manure handling to reduce GHG emissions. "It's too bad there isn't more of a program that helps [farmers] to catch and convert manure," NA said. He then mentioned injection for manure applications as fertilizer, bedding separators that remove the liquid portion of manure (allowing farmers to reuse dry material as bedding), and anaerobic digesters that allow farmers to sell the natural gas emitted by the manure - which can be used to make electricity. Other adaptations may be interesting to farmers in the future. "If it's profitable then you can afford to do things right. If it is not profitable, you're stuck," says Jake Harris.

Polyfluoroalkyl Substances (PFAS)

In 2020, Polyfluoroalkyl Substances (PFAS) took center stage in Maine agriculture. The application of wastewater sludge was once encouraged by the state government as a way to reduce landfill space. PFAS also known as "forever chemicals" found in the wastewater sludge leached into groundwater and agricultural soils around the state. These chemicals have a strong potential to be harmful to humans and animals and have been linked to a number of cancers and health challenges. PFAS are taken up by crops grown on polluted soils, and seep into water sources. Once made bioavailable in their feed and water, dairy cow milk and meat become

contaminated with PFAS and are unfit to sell if at high enough levels.

A history of wastewater sludge application on a plot of farmland has caused many Maine farms to have to shut down, dump milk, eliminate hay production, and replace dairy herds around the state (Leigh, 2022). “PFAS prevents us from expanding to land around us. You always have to have your guard up and get land tested before moving to new land,” Jake Harris said. NA and Julie Martin highlighted the challenges with scaling up your farm as well. They noted that so much farmland around the state has been polluted, there might not be much arable land in a farmer’s area for them to be able to lease or buy. Another PFAS-related challenge highlighted by farmers is that its regulation is brand new. The state of Maine set a limit on PFAS in milk to 210 parts per million. One farmer expressed frustration that the limit is only on farms in Maine. Farmers in other parts of the nation do not have regulations on their PFAS levels. Recognizing that farmers are under such pressure from established challenges already, it is understandable why farmers would be frustrated with the lack of regulatory consistency around the country and the added pressure put on Maine farmers.

Increasing Costs:

Interviewed farmers and experts consistently made comments about rising costs and crippling inflation. “Rising cost is something we have seen in everything, the availability of the products and equipment we use has been a challenge,” said Jeanie Lewis. Interest rates and inflation have risen consistently across the nation. Being heavily reliant on loans as working capital for start-of-season costs each year, this increase has been a hurdle for farmers; making it challenging to invest in on-farm improvements. This increase has also reduced overall profit margins for dairies around the state. “Every challenge always comes back to being a financial challenge,” says NA Martin. “Farmers need to have strong relationships with their lenders.” As

mentioned previously, there are only a few agricultural lenders available to farmers in the state. With such limited options, farmers are not able to escape should the regional lenders collectively raise their prices.

With prices rising on every input for milk, farmers struggle to find ways to make that money back. In a keynote speech for the Maine Dairy Summit, Madlyn Daley - Consumer and Market Insights at Dairy Management Inc. - explained that the dairy industry saw milk prices rise 2-3 months after inflation began affecting other food prices. Natalie Sneller highlighted this imbalance saying that managing margins was one of the greatest current challenges on their farm. Because of these challenges, some farmers have left the commercial industry behind and are able to process and sell their own milk. “We set our own milk price,” says Jake Harris, who has his milk processed at one of Maine’s two small local processors. “Prices of every input have gone through the roof, it makes it so hard to plan,” he adds. Even with the ability to set their own milk prices, Jake still needs to get his consumers on board with higher prices. “We still have to respond to consumer demands, [...] but our clients are loyal.”

As challenges to the dairy industry have risen, so have the cost of land and pressure from developers to sell. Many farmers must consider whether or not it is better to stay in this heritage industry or to sell everything and get out (Griswold, 2020). Additionally, in 2018 the average Maine dairy farmer was 54 years old (Sabina, 2018). The industry is slowly aging out of this occupation, and many farms do not have succession plans. One farmer highlighted the challenges with succession, “Being family owned with multiple generations involved, succession planning is complicated.” When asked about resources supporting farmers in succession planning she said, “Support is all over the place, pinning down the grandparent generation to utilize the support is

the challenge." In addition to the complexities of building a succession plan, some farmers may be wondering if they want to pass the occupation on to their children.

Being a legacy industry, most of the farmers today are standing on work done by the generations of their family who came before them. "We can't talk about the farm without talking about our family," said Becki Benson. She and her husband sold their dairy business in 2015, recognizing that the industry and the challenges associated with it are not something they want to pass on. "Farmers love to think that they're family will carry on, but they might also think that it's been a struggle and they don't want to pass that on," Connie Wood said. "What kind of future is it?" she asks after watching many dairy families struggle and then leave the industry. When the struggle is coupled with strong pressures to sell to developers, Maine dairy farmers have a major incentive to leave the industry.

Support and Programming for the Dairy Industry

There are a number of ways dairy farmers have been supported in the state of Maine. Some impact nearly all dairy farmers, while others are little-known or hyper-specific programs. As farms continue to disappear, it will be important for these methods of supporting state dairy farmers to adapt, grow, and become more available to farmers.

Available supports for Maine dairy farmers from the perspective of farmers and experts.

Theme	# of farmers that brought up theme	Example Quote
Figure it out on your own	2	"We've gotten good at figuring things out ourselves"
Google/Internet Resources	2	"It used to be people helping people, now I think people google it." "Listening to podcasts, watching youtube. [I am] Always trying to absorb, sometimes information is hard to find.
Cooperative Extension	3	"[With Cooperative Extension] Recently there have been a lot of great opportunities for workshops and networking."
Not Cooperative Extension	2	"I think many farmers think that Cooperative Extension doesn't have any common sense. They're just college people."
Applying to Grants	3	"It's a lot of paperwork." "We worked with Windham Butcher Shop to apply for a grant."
Talking to more experienced farmers	4	"Usually [farmers] talk to people [farmers] who are successful and have had the same issue."
Soil Conservation Service	2	"We go to Soil Conservation for challenges with manure. They're helpful."
Vets, Nutritionists, Producers, industry Leaders	2	"When challenges come up, hopefully you have a strong relationship with your vet or lender."

Table 3. Key qualitative themes are presented with the total number of farmers discussing each theme (out of 8 interviews) and a quote to illustrate the meaning of the theme.

Support for Maine Dairy Farmers via Legislation

Maine State Milk Pricing

The Maine people and legislature recognize the importance of the dairy industry in Maine. "Mainers understand that farmers are responsible for maintaining the open land that makes Maine beautiful," NA Martin said. The industry's effect on the state is both aesthetic and economic. In 2022, Maine produced 554 million pounds of milk from 26,000 cows, a 3.1% decrease from the previous year. Revenue from Maine milk production, directly and indirectly,

employs 14,700 people. Today dairy is still a large industry in the state, with a total impact of $2.71 billion (Overton, 2023). Governor Janet Mills, in a 2023 speech said, “Dairy farmers are a cornerstone of Maine’s agricultural industry, of our rural communities, and of our economy as a whole (Morin, 2023).” In 2002-2003, failed federal milk-pricing policies left prices volatile and farmers vulnerable. To provide economic support to dairy farmers in the state, Maine established the Maine Dairy Relief Program in 2004. Also known as the Tier Program, dairy farmers are assisted with funds if milk production costs outweigh their milk sale income (Drake, 2011).

The Maine Dairy Relief Program classifies farms into one of four tiers. Farms enter each tier based on the amount of milk they produce. All farmers enter Tier 1 at the beginning of the year. Farms that surpass 16,790 cwt move into Tier 2, farms that surpass 49,079 cwt move into Tier 3, and farms that surpass 76,800 cwt move into Tier 4. Each tier is then given a particular support price. These prices are based on assessments establishing the baseline cost of milk production at each production level. When the market price drops below a farm's established tier price, the Maine government will subsidize the rest of the respective price. To keep up with the volatility of milk prices, milk production costs are assessed every three years to prevent large margins. Since the implementation of this program in 2004, Maine has been losing dairy farms at a slower rate than other states in the nation (Chen et al., 2018).

The Dairy Improvement Loan Fund (DIF) offers financial assistance to ag-businesses in the state to improve their production. DIF offers loans at a fixed interest rate of 1% and allows farmers to take out as much as $250,000. Funds can be used “to enhance the viability and vitality of the farm, and improve the manufacturing, marketability, and production of their products (DACF, 2023).” Farmers often use the funds to build or improve their parlors, barns, silos, feed infrastructure, equipment, or land (FAME, 2023). In addition to legislation helping farmers to

improve their production, some tax credits are available to farmers, enabling them to reduce their production costs.

Farmer-Centered Research and Extension Services in the Public and Private Sector

UMaine Dairy Specialist and researcher Dr. Glenda Pereira is working to develop precision technology that can be used on Maine's small dairy farms. Wearable devices in the form of ear tags allow small low-input farms to track cow behavior (standing, lying, and movement) in hopes that farmers might be able to care better for their animals, and therefore improve their milk production. As Dr. Pereira spoke about the program, she highlighted the cohort of five farmers who are testing out this product in Maine. Jake Harris is a member of the cohort and feels that he has already greatly benefited by joining the program. "As part of the cohort we are going on tours of each farm that is participating, [...] It's been a great opportunity to network with other farmers," he said. This opportunity to network and engage with the dairy community was part of Dr. Pereira's design. When describing the most successful aspect of the cohort she said, "For a lot of farmers — specifically dairy farmers because of their schedules and having to milk — it's tough to get off the farm and socialize. I can sit here and lecture them about feeding management all day, but when they're learning from people who are in their same shoes they can really take that home with them and say, 'Hey this works at this farm. I think I can try it (Schipani, 2023).'"

Improving on-farm systems and trying new things is a must for the future of the dairy industry. Many farmers mentioned that the Farm Bureau and the Soil Conservation Service have been helpful resources for their businesses. The Soil Conservation Service makes sure that farmers are in compliance with their manure management plans. Both Jeanie Lewis and the Martins recognized the Soil Conservation Service as being beneficial to farms, "The Soil

Conservation Service and Farm Services Agency, if you belong to them, there is some government money that they'll pay a certain amount toward [on-farm sustainability improvements]. That's how some farms did their manure storage," the Martins said. NA quickly added, "You have to show a need, show a plan. It's lots of paperwork."

The paperwork comment made by NA is an important one - farmers are extremely short on time. The labor shortage highlighted earlier has meant that many farmers are working longer hours to keep their production up, leaving even less time available for researching and applying for resources. To get around the limited time, some farmers and businesses are applying for grants together. "We applied for a grant with Windham Butcher Shop, in return they gave us access to resource groups that offer small-business support," Natalie Sneller said. "There is support all over the place [...] it just depends if you know about the resources or not." In order to benefit from the resources available to farmers today, farmers need help connecting to the resources.

Agriculture consultants were also referenced as a helpful tool, "There is a man named Ron Boone [who helps us]. If you have problems in a field he'll come out and tell you what you should plant," said Jeanie Lewis. Ron Boone belongs to Northeast Ag Sales. He has been someone Jeanie has relied on. However, his company was recently purchased as part of a corporate consolidation. "All the companies are getting bought out. You don't know them, they don't know you, they don't know what you're doing [on your farm]," Jeanie said. She then added, "You're willing to pay a little bit more money if you're getting what you want. You'll be loyal. It's all becoming so limited, you really don't have the option to go somewhere else." When asked how programming could better support farmers, many said they wanted information to come from people who truly understand what it's like to be a dairy farmer. "Spend some time

on the farm to understand it. It's one thing for someone to tell you what to do, but it's another [when they] have experienced it," Jeanie said.

As farmers diversify, they are relying on people who are not tied to the dairy industry to help them boost their on-farm revenue. Becki Benson expressed that throughout their time in the dairy industry, she and her husband didn't often connect with cooperative extension agents outside of 4-H. But, "We spoke all the time with the compost guy," Becki remarked. "It was all brand new, we needed the help to know what we were doing." Like the Benson's, many other farmers are interested in bringing new ideas to their farms, and they need thought leaders to give them the information they need. Jake Harris and Natalie, both described challenges in designing marketing strategies and business plans on their own as their farms diversified and separated from the commercial setting. NA Martin expressed interest in small anaerobic digesters, draglines that spread manure more efficiently, and tiling fields for better drainage. The Martins lease a large portion of their land to a solar company and are therefore able to rely on income generated from the lease to support their lifestyle. "I am interested in the dairy industry's role in future green or clean energies," NA proposed. To survive, farmers may be looking to step away from supports that help them inch into higher production levels and instead be looking for programs that give them access to complementary revenue opportunities that may be entirely new to them.

Perspective on environmental stewardship from the perspective of farmers and experts		
Theme	**# of farmers that brought up theme**	**Example Quote**
Personal Responsibility	4	"We all have a responsibility to [steward the land]. You're hoping you're leaving it well."
Legislative Responsibility	2	"It's a combination of personal and legislative responsibility, we're in a 100-year flood plain."
Challenging to meet environmental expectations	2	"We have people on the farm all the time for the market. We will be scrutinized heavily because of high traffic and being in a regulated area."
Very Important	3	"How important is it? Very." "It's something that is always on your mind."
Stewarding for the Future	5	"If it is profitable, then you can afford to do it right. If it is not profitable, you're stuck - you're not going to have a lot of fun. Doesn't leave room for the next generation."

Table 4. Key qualitative themes are presented with the total number of farmers discussing each theme (out of 8 interviews) and a quote to illustrate the meaning of the theme.

While the dairy industry has struggled over the course of the past 50 years, the business is not dying out. Experts predict that the demand for dairy products will increase over the next 50 years because of the essential nutrients they provide (Capper and Bauman, 2013). Animal products are highlighted by the UN's Food and Agriculture Organization as being able to "improve the nutritional status of low-income households." These products: milk, meat, and eggs are able to provide appropriate amounts of protein, vitamins, minerals, and micronutrients including calcium, vitamin D, and potassium to malnourished communities (Capper and Bauman, 2013). At the same time, the production of dairy products remains a prominent emitter of greenhouse gasses and ammonia and a contributor to nutrient run-off-related environmental issues (Gerber et al., 2010).

Dairy production requires less land to produce higher amounts of protein than any other livestock products. As the global population grows and diets continue to shift toward being

higher in protein, the dairy industry will need to become more productive and more sustainable. The industry has become significantly more efficient over the past ~20 years, reducing their carbon footprint by 19% since 2007 (Capper, 2019). As mentioned earlier, approximately 2% of US GHG emissions are generated by the dairy industry. However, as climate change continues it will change the microbiological and chemical soil reactions, increasing nitrogen and methane emissions from farms (Van der Stelt et al., 2007). More frequent high-precipitation events will also increase the risk of nutrient run-off involving nitrogen and phosphorus (Motew et al., 2018). A changing climate not only negatively impacts the dairy industry's environmental footprint, but also its productivity.

Environmental and Climate Challenges Associated with Dairy

Reducing the carbon footprint of dairy farms is in the best interest of the industry. Approximately 72-75% of the greenhouse gas emissions produced by the dairy industry happen on-farm (Clay, 2023). The greatest emitter is enteric fermentation, a process taking place in cows' digestive systems which produces methane, a potent greenhouse gas. Manure management is the second greatest contributor. When manure begins to break down methane is released. Methane is 25 times more potent than carbon dioxide, trapping significantly more heat energy in the atmosphere. In anaerobic conditions, urinary nitrogen can volatilize and enter the atmosphere as nitrous oxide. Nitrous oxide is even more potent, roughly 273 times more than carbon dioxide. The application of nitrogen on fields as fertilizer can emit nitrous oxide when excessively spread. Land-use-change (the conversion from forest or grassland to commercial feed crops) releases significant GHGs into the atmosphere as well. Finally, on-farm energy use as both fuel and electricity also contributes to dairy farmers' total carbon footprint.

Improper land use and application of fertilizers can have detrimental effects on the communities and watersheds surrounding farms. Erosion and excess fertilizer applied to fields have historically impacted water bodies around the United States. Legislators and agricultural experts in the nation have worked to limit the amount of excess fertilizer and loose soil washing from agricultural fields and manure pits into bodies of water.

Improving the Sustainability of the Dairy Sector

The dairy industry has come a long way in its journey to reducing the environmental impact of milk production. Today, the industry has pledged to reduce its carbon footprint, reaching net zero by 2050 via greenhouse gas removal and carbon sequestration. The focus of the improvement targets enhancements in on-farm efficiency, as a way to limit waste and find ways to reuse waste products. Already the industry has significantly reduced the amount of water used, carbon released, and manure generated. Between 1944 and 2007 milk production processes reduced water use by 65%, carbon emissions by 63%, and manure amounts by 76% per unit of milk (Capper, 2009). As efficiency builds on farms, more milk is being produced using fewer resources and generating less waste. In addition, many farms are relying on by-products and waste as feed and usable resources. In the words of Jeanie Lewis: “Everything is recycled on the farm.” Utilizing circular economy concepts: to design waste out of systems, to keep products circulating, and to regenerate nature creates context-relevant opportunities for farmers to reduce their impact on climate change.

Four areas being targeted are enhancing feed production practices, boosting care and feed-to-milk efficiency for cows on farms, advancing manure handling and nutrient management practices, and increasing renewable energy use while improving on-farm energy efficiency. 35% of a dairy farm's greenhouse gas emissions are related to enteric fermentation during the

digestion process in a cow's rumen, and releasing methane in the form of belches (Clay, 2023). The first compartment of the cow's stomach, the rumen, is home to microbes that generate methane during the digestion process. The methane, along with carbon dioxide and hydrogen gas also generated in the rumen, is then released by the animal into the atmosphere.

Enteric fermentation is not preventable, but it is reducible. Feed type plays a significant role in the amount of methane produced during digestion. High forage diets provided during times in pasture are not easily digestible. Feeds with high free-sugar content and starches are easier for cows to digest, spending less time in the rumen and releasing less methane (Gaviria-Uribe, 2020). Grinding and pelleting forages can also shorten the amount of time the food spends in the rumen (Kohlman, 2023). Typical sources of these easy-to-digest feeds are corn and non-human edible byproducts like brewers' grain. Feed additives have also been recommended as a means of reducing enteric fermentation. Agolin Ruminant, an effective feed additive that improves feed efficiency and reduces enteric emissions, is one of the few feed additives currently on the market, and others are still in the research and development stage (Carrazco, 2021). A final strategy for reducing enteric emissions from farms is through genetic selection as a means of improving production efficiency in cows. As cow feed-efficiency advances over time, less feed will be required to produce more milk, reducing the methane emissions released per unit of milk (Clay, 2023).

Establishing regenerative agriculture practices for dairy feed production will limit fertilizer use, increase carbon sequestration, and require less water. Precision agriculture practices, as well as no-till, rotating crops, and leveraging manure as a productive fertilizer, are means of building the soil and increasing yields, limiting the inputs necessary for feed production. These methods also help to establish soils that have healthier populations of

microorganisms. Established fields with healthy soils can reduce both erosion and nutrient run-off risks, protecting nearby bodies of water from excess nutrients. Utilizing manure as a productive fertilizer also limits the need for synthetic fertilizers generated via fossil fuels, minimizing a farm's carbon footprint. Disturbing the soil during manure application can increase biological activity in microbes that release carbon dioxide and nitrous oxide. Instead, the precise application of manure using injectors improves soil fertility without excess disturbance.

On-farm liquid manure, when it ferments, releases methane and nitrous oxide. New technologies are being developed to separate the dry and liquid aspects of manure into useful products. Some manure systems remove the liquid aspects to be used as liquid fertilizer and reuse the dry matter as clean bedding. The use of these manure solids as bedding can reduce economic strain on farmers by limiting bedding costs, without negatively impacting the overall health of the herd (Schwarz and Bonhotal, 2010). Other alternatives are to use the manure to make dried pellets which could be used as fertilizer or to make energy.

Proposals are common for the utilization of dairy farm-generated waste products or marginal land to be used to generate renewable energy. Both biogas and electricity can be generated using manure. Anaerobic digesters, enclosed structures that house manure as it ferments and produces biogas, are a frequent conversation for on-farm GHG reduction. Biogas created inside the structure can then be captured and used to create energy. However, the construction of on-farm anaerobic digesters can be expensive. The US EPA approximates that a unit typically costs $1.2 million, a high price for most farmers (UMissouri Extension, 2014). Digesters work best at large-scale farms because of the amount of available substrate. For smaller farms, a cooperative model has been proposed - farms could collectively contribute their

waste products to a regional digester. This model has successfully been taken up in various regions of Europe (Cornell Small Farms, 2014).

Today, it is more appealing to produce biogas than electricity on farms because of incentive systems. Current incentive systems for generating electricity with manure are priced based on the energy potential of various substrates used in production. Manure has a much higher potential than other substrates and is therefore most cost-effective as a solo-substrate, rather than when it is mixed with other waste products. WWF author Jason Clay pushes for incentive reallocation. He believes the farmers should be paid for the cellulosic gas they contribute to digesters, as well as compensated for acceptance of food waste and other substrate to their on-farm digester. This influx of revenue because of the digester makes investment in this important technology more appealing to farmers who have limited resources.

A few farmers brought up opportunities to improve on-farm sustainability but recognized that many of these improvements require more investment than is viable for farmers today. Jake and Becki both noted that sustainability improvements must be profitable for the farmers implementing them. NA described large farms in New York that are able to collect their manure from their six farm operations, run an anaerobic generator, and sell the energy generated as an additional source of income. For smaller operations, Julie and NA suggested small digesters that might be able to generate on-farm electricity to run a hot water tank or another energy-consuming on-farm necessity. Other farmers brought up wanting to manage manure well but finding it to be challenging on their own.

Conversations about policy and incentive shifts are at the forefront of the sustainability push in the dairy industry. Technologies and innovative practices are available and under development, but the transition to net-zero practices for farmers will require government support.

The economic feasibility of new practices and infrastructure on Maine farms is not quite in sight, but action is necessary today. There are a few producers in Maine that have been able to raise appropriate funds and withstand delayed economic returns for infrastructure changes, but most farms would need assistance in order to act soon. Over time farmers will likely make back the money they invest into sustainability infrastructure, but in the meantime, state and government incentives and market support are needed to maintain on-farm sustainability development.

Sustainability Support for Farmers

PUBLIC SUPPORT

Maine State Cooperative Extension Services:

There is currently one dairy extension agent in the state.

Glenda Pereira: Glenda's research and extension focus is on current industry needs. Most recently she has worked with wearable devices for precision dairy and PFAS solutions. Leading a cohort focused on small-farm efficiency, Glenda is working to connect farmers to other farmers in hopes that on-farm efficiency will improve as they learn from each other.

Extension Topics:

Maine Cooperative Extension releases frequent bulletins geared towards dairy and livestock producers. Most are publications related to risk management, livestock health, and farm business sustainability. These bulletins highlight common challenges farms face, best management practices (BMPs) to minimize risk, and science-based solutions to on-farm problems. Written by extension agents and reviewed by dairy science academics from the University of Maine, the bulletins are found on the dairy page of the extension website. Along with the bulletins, extension agents occasionally host events with local farms to look at pasture management, cow health management, and other production techniques (UMaine, 2023). It is likely that there are more programs available to dairy farmers through Cooperative extension, but they are not readily visible on their online platforms.

National Dairy FARM (Farmers Assuring Responsible Management) Program

In light of many consumers becoming more conscious of how their food is produced, the National Dairy FARM Program has created a way to assure that consumers can trust US dairy farmers to prioritize environmental, animal, worker, and consumer health. The program offers

farmers science-based tools, standards, and verification methods to increase BMP use on farms. Created by the National Milk Producers Federation, the program pulls together farmers, subject matter experts, dairy cooperatives, and processors to set standards and BMPs for the national dairy industry. The initiative's pillars are Antibiotic Stewardship (est. 1990), Animal Care (est. 2009), Environmental Stewardship (est. 2017), Workforce Development (est. 2018), and Biosecurity (est. 2021). The Environmental Stewardship Task Force is a cooperative, made up of dairy extension directors, corporate sustainability directors, and farmers. This team works together to advise the FARM program, giving recommendations and reviewing programming with the goal of helping farmers make environmentally conscious decisions that "make business sense" (FARM, 2023).

Climate Adaptation Fellowship:

A peer-to-peer learning program that helps farmers build climate resilience as it relates to their farms, forests, and communities. The program is funded by the USDA and runs in collaboration with the USDA Northeast Climate Hub and land-grant universities from the Northeast. The Climate Hub gathers appropriate data for particular sectors and feeds it to industry leaders like the Farm Bureau, who partner with them in distribution. Partners utilize the data to make fact sheets or social-media posts that relay the data most important to their audience and in a way that is relevant. Extension agents and program facilitators lead educational programming and act as a resource for participating farmers on a one to one basis. Sarah Keleman is the program lead for the Dairy Climate Adaptation Fellowship. She described the fellowship as being for farmers who want more information on climate change and its impact on farms. "We're not trying to convince everyone that climate change is happening. [This program] is for the farmer who is already thinking through their on-farm dynamics." Farmers who participate spend a year learning about

mitigation and adaptation with a cohort of other farmers. They then spend a second year implementing a "Farm Change Action Plan.' After adopting new sustainable methods, they will act as panel members and lead farmers, speaking on their experience and giving walk-through demonstrations of their farms and adaptations. Farmers are expected to perform a set number of hours of "outreach" and are paid hourly for their work. This outreach can range from giving demonstrations to the public or speaking with another farmer on the road (Climate, 2023).

Net Zero Initiative

The Net Zero Initiative is a cross-industry program aimed at reducing the dairy industry's carbon footprint and increasing on-farm income. The initiative is a part of the US Dairy Innovation Center. Paid for by six national dairy organizations and a few corporate sponsors, the initiative works to develop and scale sustainable solutions for dairy farms of all sizes to bring the whole US industry to Net Zero by 2050. Currently still in the pilot phase, the initiative is focusing first on larger mid-western-style dairies. Their goal is to empower farmers by offering programs and creating strong incentives for farmers to create a pathway for the entire US dairy industry toward sustainability (Clay, 2023).

PRIVATE SUPPORT

Wolfe's Neck Center for the Environment

Wolfe's Neck Center for the Environment is a 600-acre organic research farm and agri-tourism. An organic vegetable and organic dairy apprenticeship program is available through Wolfe's Neck. In 2022, the USDA invested $35 Million in Wolfe's Neck Center to establish a program to help farmers adopt climate-smart techniques and generate and sell climate-smart commodity markets. Wolfe's Neck has been working on carbon sequestration techniques and verification for

years. These funds will also help Wolfe's Neck train and assist with the creation of soil health management plans for agricultural service providers (Cebula, 2022).

Nutritionists

Sarah Littlefield and Dave Marcinkowski both recommended that farmers talk with nutritionists as a first step if they are looking for ways to improve on-farm sustainability. Being selective with what is being fed to your cows, and improving their health and comfort is a quick way to ensure that cows are at their peak production. Feed companies and cooperative extension agents should be able to connect farmers with nutritionists who can help them improve their herd health and productivity.

DISCUSSION

Dairy products are an important product for regional and global nutrition, requiring fewer inputs than meat to produce 1 gram of readily available protein. Additionally, it is important to keep the dairy industry active in the state of Maine because of its social, economic, cultural and land stewardship contributions to rural communities. Farmers in Maine have a lot on their plates. From challenging land conditions to fluctuating economic conditions, farmers are always working to keep their heads above water. To remain competitive many farmers are beginning to pivot and look for secondary ways to generate income alongside selling milk commercially. Jake Harris's comment, "If it's profitable, you can afford to do it right" brings home the fact that farmers need to be financially stable in order to afford to be environmentally sustainable. It is unreasonable to ask farmers to tackle their sustainability challenges without supporting them as they tackle their profitability challenges.

Many solutions have been proposed to lighten the burden on farmers across the state. Migration reform, marketing for new consumer trends, reworking the milk pricing system, and helping farmers diversify have all been highlighted as helpful tools. These solutions must also be considered important in the push for sustainability. While it is appealing to highlight renewable energy generation as a strong new solution to sustainability challenges because of its potential for profitability and emissions reduction, the longevity of the industry must be considered as well. Long-standing problems like a labor shortage will remain even if new revenue from renewable energy generation is introduced.

Some Maine farms have already taken significant steps to improve their sustainability. Many of these farms happen to be already relatively financially stable. Diversification and pivoting to additional business ventures have set some Maine farms up for success. Harris Farm

in Dayton sets its own milk price and has diversified, allowing them to take risks as they improve on-farm sustainability. Flood Brothers farms in Northern Maine are a highly successful large dairy. Milking 1700 cows, they have been able to invest in new infrastructure: a rotary milking parlor, robotic milkers, owning their own transportation business, and two methane digesters. For farms that are less financially stable, investing in sustainability-related infrastructure and practices beyond what is required by current regulations is a challenge.

Dave Marcinkowski, with 40+ years of experience in the dairy industry, highlighted efficiency as the path to sustainability, a thought found throughout the industry. While this approach will limit inputs and reduce the environmental impact of the industry, it is important to recognize that consolidation brings its own new challenges. Consolidation of farms may add technical and economic efficiencies to the milk production process, but manure handling becomes a true challenge.

In a pasture-based system, manure breaks down in fields - reducing GHG production. However, farmers have significantly less control over what animals are consuming, reducing the efficiency of the feed-to-milk process. Eliminating pasture from the system limits the amount of sequestration possible for farms to meet their Net Zero goal by 2050. Balancing efficiency and circularity is the tension for the future of a sustainable dairy industry, making the path complicated. A contentious but important debate remains concerning the structure of the dairy industry (number and size of farms). Transitioning the dairy sector toward increased environmental sustainability, climate resilience and financial viability, farmers of all sizes will need to be met where they are.

CONCLUSION

Maine dairy farms consistently prioritize stewardship of their land but need support to continue to make it a priority. While resources are available, farmers need connectors and practical ways to share ideas and concerns among themselves and with others. The creation of a list of resources as well as more innovative social media designed to enable and support dairy industry "communities of practice" can give farmers a strong voice in role in future support systems and "solution building". Solving sustainability challenges on Maine farms is a heavy lift. A holistic approach including help with diversification, business planning, financial advising, and technical experts working alongside farmers (without taking up too much of their time) is what is needed. As older farmers move out of the industry and younger generations take their place, there is a real opportunity for the development of a new and more sustainable industry. As farms try out new technologies, new products, and new ways of thinking about their farm, educating and enlisting the support of the Maine's rural communities, ancillary businesses "upstream and downstream" from the farm, and other stakeholders will be essential.

The Maine dairy industry is a significant contributor to the state of Maine and is worth fighting to protect. Over the course of Maine's history, dairy farming has changed significantly. Today, as farmers once again change their approach to farming, new methods of supporting farmers will be necessary. Sustainability cannot come to the industry without profitability. Business mentors, marketing help, sustainability consultants, and financial incentives for sustainable improvements will push the industry toward environmental sustainability and longevity. Listening to farmers as they ask for policy changes surrounding milk pricing, immigration policy, and financial incentives is happening at the federal and state level. But there

is concern that the change is happening too slowly to keep pace with farmers' needs. Dairy farming remains an important engine of economic vitality in many Maine communities. Going forward, it has the potential to reduce greenhouse gas emissions and sequester more carbon while producing necessary nutrient-dense foods. Supporting Maine farmers' efforts to enhance environmental sustainability and financial viability is vital to the regional and community vitality. Retaining a viable dairy industry in Maine will involve elevating farmers' voices in conversations about farm, rural development and environmental policy. Finally, the dairy farming community's capacity for innovation and problem solving has long been recognized. Finding practical ways to incentivize and support more fulsome and meaningful farmer involvement in the parts of the policy arena, value chain, and the agricultural research, education and innovation system is increasingly important as non-farm citizens (and decisionmakers) become increasingly disconnected from the food system.

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