STATE OF THE SCIENCE

REDUCING METHANE FROM ANIMAL AGRICULTURE

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UCDAVIS CLEAR Center

UCDAVIS COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

SPARK CLIMATE SOLUTIONS

The State of the Science Summit: Reducing Methane from Animal Agriculture

Methane is the second-most plentiful of our greenhouse gases, and an area of concern for the health of the planet and the future of animal agriculture. More potent than carbon dioxide in the short term, methane is responsible for 30% or .5°C of the net warming we feel today.

Animal agriculture is not the only industry responsible for methane emissions, but it is arguably the one we think of first. That's likely due to enteric fermentation, part of the digestive process of ruminant animals, which naturally produces methane as a byproduct.

In fact, enteric methane accounts for 30% of global anthropogenic methane emissions — the largest individual source of anthropogenic methane emissions globally (UNEP & CCAC., 2021).

California has called for an unprecedented 40% reduction in statewide methane emissions by the end of the decade. Daunting as it is, California farmers and ranchers are well on their way to meeting and possibly surpassing the world's most ambitious goal for cutting methane emissions. What's more, they're doing it through a toolbox of solutions, many of which are being incentivized by the state.

Kudos to California policymakers for taking a novel approach to the challenge of methane emissions in animal agriculture. Working with producers is leading to exceptional results, as it builds trust and cooperation among many stakeholders.

The State of the Science Summit was born in 2023 of that spirit of collaboration. True to form, we invited experts from academia, industry, government and NGOs to share their knowledge, their research, their successes and occasionally even their frustrations. We knew instantly we were on to something and that it must continue.

Our 2024 edition built on the first year's success, but it didn't stop there. We broadened our reach, expanded our slate of speakers and had more news to share. Once again, we were energized and invigorated by the experience of sharing approaches to meet the oft-competing goals of mitigating global warming and feeding a rapidly growing global population.

It's a concept whose time has come. While many nations and regions recognize that enteric methane is a crux of the methane matter, few are dedicating enough resources to studying it and solving it. Our ambition must be greater, and our approach must be intentional, strategic and collaborative.

We're working to turn the tide, due in large part to the fact we understand how crucial agriculture is to the future of our world. At the same time, we realize no informed approach to the mitigation of greenhouse gasses can ignore enteric methane. While enteric methane is a significant challenge, and is a major source of global warming, it also presents a major opportunity to reduce warming in the near term.

We're proud to present the written summary of our 2024 summit and pleased with the changes we've seen in just a year's time. Thank you for your interest in our work. We look forward to welcoming more stakeholders to the table as we meet the challenge of reducing enteric methane. We hope you will join the conversation

Sincerely,

The steering committee for The State of the Science Summit – Reducing Enteric Methane











Dean Helene Dillard
College of Agricultural and Envrionmental Sciences, Univeristy of California, Davis

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It was a privilege for us to hold our State of the Science Summit once again on the ancestral land of the Patwin people. They have diligently protected and cared for it, with elders instructing the young people for generations.

Thoughtful stewardship has guided us in the planning and execution of this year's summit. Our goal has been to continue laying down a path to reducing the industry's greenhouse gas emissions while feeding a worldwide population expected to reach 10 billion in just a few decades' time.

This year's summit stayed true to that goal, even as it had an expanded scope. We welcomed an international audience that underscored the global nature of the challenges we face. As part of a consortium of world-ranked agricultural universities, our college is dedicated to educating the next generation of global leaders for sustainable food systems.

We are focused on developing and training in Southeast Asia and Central America, drawing on initiatives such as Feed the Future Innovation Labs, our Plant Breeding Academy in Africa, and the UC Davis program of International Community Nutrition.

We pride ourselves on collaboration. Indeed, it is only by working together across organizations and borders that we can effectively address complex challenges like climate change and the need to reduce enteric methane.

The research conducted at UC Davis, ranging from pioneering work on feed additives to the exploration of CRISPR technology for modifying ruminant gut microbes, demonstrates our continuous dedication to finding innovative, science-based solutions. I am particularly proud of our college's leadership in enteric methane, which traces back to Dr. Ermias

Kebreab's early work on seaweed to reduce methane emissions in dairy cows.

Dr. Frank Mitloehner has also been a trailblazer in his efforts to identify and test solutions to the challenge of livestock methane. Of equal importance is his commitment to communicate science-based data to the public at large, educating all of us about the impact animal agriculture has on greenhouse gas emissions, what we can do about it and why we must take up the charge.

As we move forward, the importance of interdisciplinary research and cooperation can't be overstated. The College of Agricultural and Environmental Sciences is unique in that it brings together agriculture, environment and social sciences under one roof, creating extraordinary opportunities for collaborative, multidisciplinary work. For instance, agricultural scientists are partnering with Cooperative Extension specialists in food science to find solutions for managing grape pomace, a byproduct of winemaking, while simultaneously helping the dairy industry meet California's emission goals.

Breakthroughs and progress occur regularly at our university. However, make no mistake — the path to reducing enteric methane emissions is complex. And yet, with our combined efforts, the dedication of our brilliant scientists and meaningful partnerships, we are making significant strides toward a more sustainable future for agriculture and our planet.

The State of the Science Summit exemplifies the spirit of partnership and collaboration that we strive for at UC Davis. It has been a privilege for me to serve as dean and to lead an innovative community of scientists and students that is applying interdisciplinary study and creativity to tackle some of our most significant global challenges. Our collaborative spirit gives us a special ability to create solutions that enhance the food we eat, the air we breathe, the animals we nurture, the communities we engage and the planet we steward.

I applaud those who envisioned this summit and have worked tirelessly to build on the success of last year's event. I thank our wonderful colleagues and partners who presented their information so eloquently and clearly. And most of all, thank you to our audience for blocking off time to be with us and to carry forth the spirit of this summit. This gathering and meaningful lasting change is possible because of you.

"Our college is unique in that agriculture, environment, and human and social needs are all housed under the same roof, creating opportunities for collaboration across disciplines that wouldn't necessarily happen if our faculty were spread across several different institutions."

Secretary Karen Ross
California Department of Food and Agriculture

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This year, our State of the Science Summit (SOTS) reached another important milestone in our efforts to reduce methane emissions from livestock. Addressing the climate crisis requires a united effort, and this year's summit was a testament to our collective dedication and collaboration.

I greatly appreciate the California Air Resources Board's renowned science and its collaboration with the private sector to generate the necessary data for creating the right policy signals in the marketplace. Indeed, the cap-and-trade model has been instrumental in generating economic returns to reinvest in our transition to neutrality. This is especially beneficial for California agriculture, where nearly $1 billion has been invested in climate-smart agricultural practices and programs. In addition, active participation from the private sector has been essential for driving progress, since voluntary incentive-based approaches can establish a strong business case for environmental solutions.

Research and technical assistance have been equally important. Our academic partners provide objective, evidence-based science that aids us in developing sound policies.

Indeed, their eagerness to work with us is proving invaluable in our fight for sustainable agriculture and practical, effective climate policies.

Simply put, these partnerships create value for stakeholders and beneficiaries. Similarly, those who provide technical assistance, such as cooperative extension and resource conservation districts, are critical in ensuring information

reaches as many farmers and consumers as possible.

As a resident of California, I'm proud of the leadership our state has shown and how we are serving as a model for other states, our nation and international partners. To date, we have allocated $227 million to the Dairy Digester Program, which has funded 140 projects. In addition, we have leveraged nearly $500 million in matching funds since the current program began in 2016. Over 10 years, this has resulted in approximately 25 million metric tons of CO2 equivalent savings.

At the same time, our Alternative Manure Management Program has provided funding of $20 million to 170 projects, reducing 1.44 million metric tons of CO2 equivalent over five years. These efforts serve as excellent examples of how a successful circular economy benefits the environment while simultaneously investing in local economies.

Although challenging, the ongoing groundbreaking research on enteric methane and adjustments to federal legislation could streamline the regulatory process for new products and strategies to mitigate emissions.* To continue making progress, we must keep engaging consumers while prioritizing the health of our animals and the safety of our products.

I can't stress enough that our work goes beyond meeting climate goals; it is urgent and all-encompassing. Through our efforts, we will demonstrate that agriculture can significantly contribute to finding solutions and securing a future for our food system.

If we fail to effectively address short-lived climate pollutants — the fastest way to slow global warming — we will have missed an opportunity to take action at a time when resources are available. This is an excellent opportunity for our industry to show leadership in climate action and to build resilience for the future.

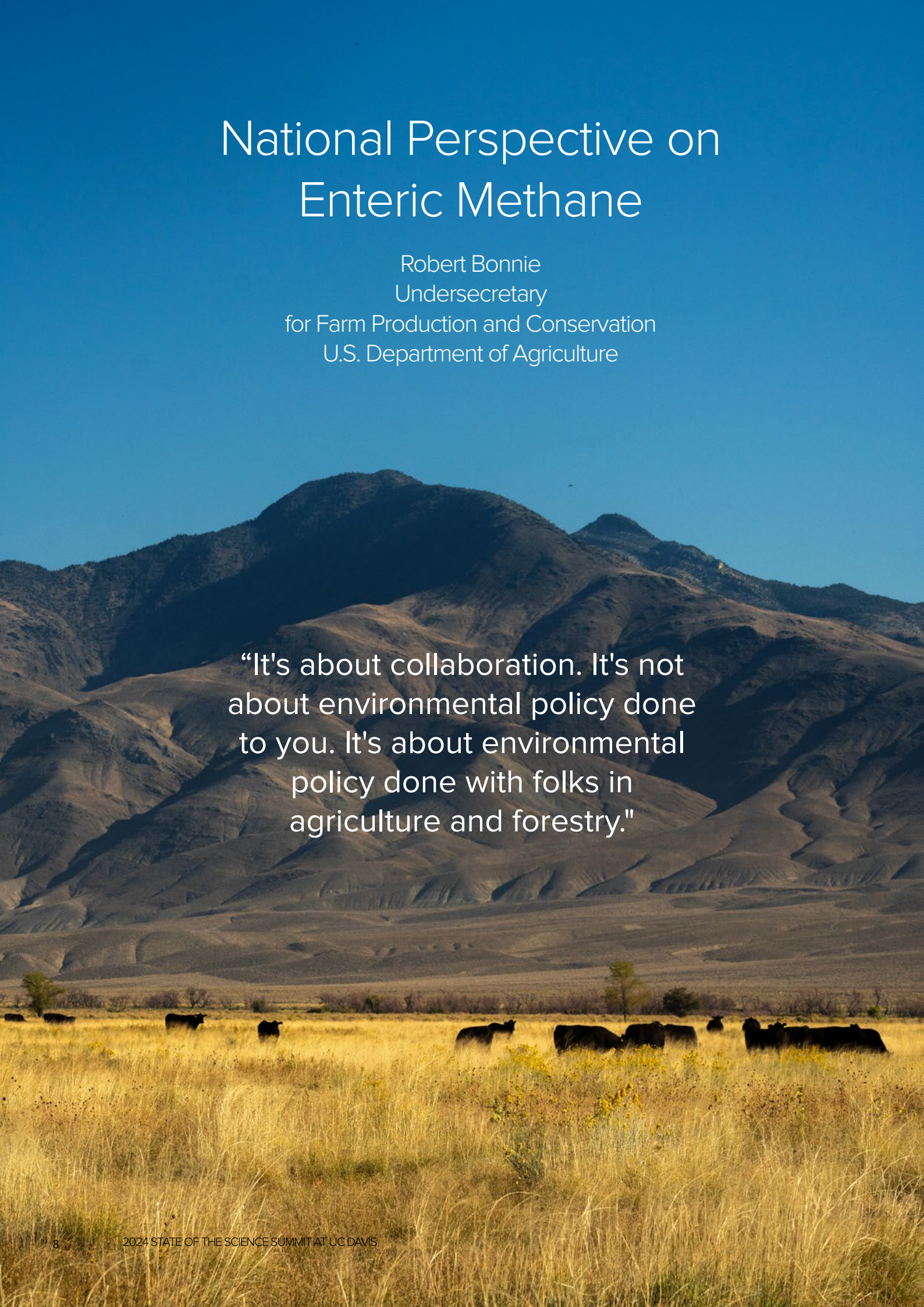
On behalf of the CDFA, thank you to everyone involved. I look forward to the great work we will accomplish together.

"There's no one single entity, one single person, one single organization that can do what needs to be done for the climate crisis. Understanding the importance of reducing methane emissions is yet another way for our farmers, our ranchers and all their partners to show leadership on climate."

*On May 24, 2024, just days after the State of the Science Summit concluded, the FDA announced Bovaer® had been approved for use in commercial settings in the United States..

National Perspective on Enteric Methane

Robert Bonnie
Undersecretary
for Farm Production and Conservation
U.S. Department of Agriculture



“It's about collaboration. It's not about environmental policy done to you. It's about environmental policy done with folks in agriculture and forestry."

Robert Bonnie concedes addressing environmental policies is a challenging prospect, especially since the climate debate is often polarized and met with skepticism. Indeed, producers and others in the agricultural sector often fear being sidelined in climate policy discussions and are concerned about top-down mandates that fail to be cost-effective or integrate adequately into their on-farm practices.

Yet, in his position as undersecretary for farm production and conservation for the U.S. Department of Agriculture (USDA), he isn't dissuaded. Instead, he is asking all the right questions.

"... How do we get the policies and incentives right at the federal level that create the incentives to allow for innovation, to do it in a way that creates economic incentives for our farmers, the supply chain and everybody to address climate change," he said.

He went on to assure the group that the USDA recognizes the complexities and is working to establish federal policies that create effective incentives for producers and other participants in the supply chain. The primary focus is on voluntary, incentive-based strategies that reward farmers for their stewardship and add commercial value to commodities produced with sustainable practices. If California is any indication — and many believe it is a shining example of policy done well — it's more effective to encourage producers to embrace change on their own versus issuing mandates.

According to Bonnie, climate-smart agriculture and forestry are well aligned with climate benefits, and that's rarely seen in connection with other environmental issues. For instance, by improving soil health, we can increase carbon sequestration while enhancing land productivity. Likewise, by utilizing digesters, we can reduce livestock methane emissions as we convert waste into a viable energy source. Continuing to invest in sustainable and cost-effective agricultural programs that leverage such alignment is therefore paramount for building trust and incentivizing stakeholders into climate action.

Recognizing the importance of the effort, the USDA is investing $19.5 billion derived from the Inflation Reduction Act to expand current efforts and programs, and to encourage further investment and resources from the private sector.

An additional $3.1 billion is being invested through the Partnerships for Climate Smart Commodities program to 1) scale up climate-smart practices, 2) ensure inclusivity, 3) invest in measurement, monitoring, reporting, and verification (MMRV), and 4) create market value for climate-smart commodities. As of May 2024, nearly 3,000 producers had enrolled, covering over 2 million acres.

True to the spirit of the State of the Science Summit, driving the implementation of climate-smart programs and production practices requires streamlining processes and developing robust partnerships with universities, producers and other government agencies.

"We need to spend these dollars in a way that invites additional resources, additional interest from the private sector," Bonnie said.

The USDA intends to support producers with technical and financial assistance while assisting the Food and Drug Administration (FDA) in simplifying its approval processes. This will ensure the timely delivery of innovative solutions that are safe and efficacious toward enteric mitigation while simultaneously accelerating their on-farm adoption.

A collaborative effort and dismantling the skepticism toward climate policy are essential to implementing feasible strategies that substantially reduce greenhouse gas emissions and maintain productivity. Building consensus is more than nice to have. Instead, it's central to U.S. agriculture's ability to play a critical role in addressing climate change.

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Fireside Chat with CDFA Secretary Karen Ross and USDA Undersecretary Robert Bonnie

Moderated by UC Davis CA&ES Dean Helene Dillard

If you can't measure it, you can't manage it — an adage that certainly holds true for the agricultural sector and its efforts to reduce enteric methane. In addition to operating as a commodity-type business with tight profit margins, crafting effective policies and incentives remains a complex challenge.

A major barrier is the lack of harmonized and consistent data collection and reporting. The $300 million investment in measurement, monitoring, reporting and verification (MMRV) by the U.S. Department of Agriculture* aims to address this issue and establish stronger credibility and trust among stakeholders.

"The challenge here, both on the farmers'/ranchers' side, as well as for some of the skeptics on the environmental side, is proving that this stuff can actually work, and having the data and science to back it up," said Robert Bonnie, who serves as the USDA's undersecretary for farm production and conservation.

Robust and reliable data can help universities and other institutions generate the scientific evidence required to demonstrate that climate-smart, sustainable practices are achievable and economically feasible for livestock operations. It does something else as well, said Karen Ross. It helps build trust, "the most precious commodity we all deal in."

"... This is not about competition," she said. "This is about saving the planet and improving the outlook for people and health. So ... what I would hope is that we could bring the whole family of the supply chain together."

As secretary of the California Department of Food and Agriculture, Ross keeps a watchful eye on her state's climate goals — and more to the point — its progress toward them. California has reached the halfway mark of its ambitious methane reduction targets. That alone is impressive,

Source: whitehouse.gov/wp-content/uploads/2023/11/NationalGHGMMISStrategy-2023.pdf.

"We're not going to do this unless agriculture and forestry comes along with us. And I think there are a lot of countries around the world that actually spent a lot of time working with California, and now they're looking at the US and some of the investments we're making." - Robert Bonnie

"Measurement really matters. Measurement helps everybody improve their own operations, it makes sure we're focused on the right things. And my biggest concern about this and other things that make claims about climate is that if we don't have the data, and I will say, a harmonized or consistent way of measuring, then I fear that that will do nothing to establish the trust that is the most precious commodity we all deal in." - Karen Ross

and it bodes well for the future. That is, there is a way to keep the momentum going and meet the remaining targets.

It will take a multipronged approach involving investments in and incentives for dairy digesters and alternative manure management practices, and advancements in and adoption of enteric fermentation solutions: feed additives, genetic selection for low methane-emitting cattle, nutritional strategies and others.

Even more, our best chance for success lies in getting myriad stakeholders around the proverbial table, collaborating to build an actionable portfolio of solutions.

"If the government does this alone, it's not going to have as much impact as if we do it together," Bonnie said. "And so, the partnerships with folks outside the government … are really, really important."

Bolstering collaboration and new technology are initiatives like tax credits for hydrogen and sustainable aviation fuel derived from livestock methane. Exchanging information and models with other countries is yet another approach. For example, effective strategies in countries such as the Netherlands and Denmark might make sense for smaller-scale solutions and programs in the United States.

At the end of the day, these efforts require a holistic approach that extends beyond farmers and ranchers to include the entire supply chain. Ultimately, driving meaningful progress toward our methane reduction goals requires full transparency in sharing both successes and failures across the entire sector.

"I think this is an important time, and I think the investments we make in demonstrating that this can work — this voluntary, incentive-based, collaborative market-based approach can work — and then we've got the data to prove it. I think this is a critical time, essentially, to prove our theory," Bonnie said.

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Pathways to Meeting Global Climate Goals

Aimable Uwizeye
Livestock Policy Officer
Food and Agriculture Organization of the United Nations

“We need investment. Investments not only in projects that we conduct, but also investment that goes to the farmer. We want farmers to be supported to get the direct incentives so that they can adopt the right best practices that are climate smart.”

Aimable Uwizeye has a pointed message for anyone who thinks the solution to enteric methane is as simple as shrinking the global herd: Animal agriculture is projected to grow by 20% by 2050,* and there are compelling reasons for it.

As a livestock policy officer for the Food and Agriculture Organization (FAO) of the United Nations, Uwizeye is well versed in the rapid population growth in Africa and Asia, and the associated higher demand for animal-sourced food. It’s change that presents challenges and opportunities in the form of all manner of societal issues, not the least of which are food security, nutrition and climate change.

“We need to produce more foods to feed the people,” he said. “So, livestock [is] here to provide livelihoods, food security and nutrition to different communities around the world.”

To be clear, the demand for animal-sourced foods is hardly coming from a place of conspicuous consumption. Meat and dairy are highly efficient ways of getting people the nutrients they need to thrive.

“… More than 800 million people … are hungry, are going to bed hungry. So, if we want to reduce the prevalence of malnutrition … we need more animal proteins,” Uwizeye said.

But increasing the supply of meat and dairy comes at a price, and national commitments are insufficient to meet global climate goals. Instead, he stated, we need to emphasize the need for raised ambitions in the next cycle of Nationally Determined Contributions (NDCs) in 2025.

Methane has emerged as a critical focus in his work with the FAO, and with good reason. The second-most plentiful greenhouse gas — methane — represents 54% of global livestock greenhouse gas emissions, with enteric methane accounting for 85% of that share. In addition, the FAO has reported 81% of livestock emissions occur in low- and middle-income countries. Given that the majority of the anticipated growth will be in these regions, the need for targeted interventions and international cooperation has never been more urgent.

"... What we're doing here is to find a solution on how to feed people to provide high-quality proteins to the people with low environmental and socioeconomic costs," Uwizeye said.

He outlined several pathways for emission reduction, including on-farm measures, consumer-based solutions and technological innovations.* These strategies could potentially reduce emissions by 5 to 20%, contributing significantly to the Global Methane Pledge target of a 30% reduction.

Yet, investment in methane mitigation is sorely lacking, with only 5% of global climate finance directed toward livestock-related initiatives.** The need for increased funding, particularly from the private sector, is crucial for implementing effective mitigation strategies.

Improved measurement, reporting and verification (MRV) systems are likewise critical, with 67% of countries still using basic Tier 1 approaches for emissions reporting, rather than the more detailed and accurate Tier 2 and Tier 3 methodologies that can better account for country-specific factors and complex emissions processes. In this regard, Uwizeye shares the belief of many other presenters at the State of the Science Summit. That is, enhancing the capacity for more advanced reporting methods is essential for effective mitigation planning and implementation.

By emphasizing the need for realistic, implementable pathways at the country level, guided by science and supported by appropriate policies and investments, the FAO's commitment to supporting countries in integrating enteric methane reduction into their climate strategies underscores the global nature of this challenge and the importance of collaborative efforts in addressing it.

"We want farmers to be supported to get the direct incentives so that they can adopt the right best practices that are climate smart to reduce emissions but also increase productivity as well as their income and life results," Uwizeye said.

**Source: openknowledge.fao.org/server/api/core/bitstreams/a06a30d3-6e9d-4e9c-b4b7-29a6cc307208/content.*

***Additional information: climatepolicyinitiative.org/publication/landscape-of-methane-abatement-finance-2023/.*

Emissions Tiers

Tier 1: Basic emissions

- Default values based on general factors
- Least detailed, uses broad averages
- Example: Estimating cattle methane based on national herd size

Tier 2: Intermediate emissions

- Country-specific data and enhanced detail
- More accurate than Tier 1, uses local information
- Example: Calculating emissions using regional cattle feed and climate data

Tier 3: Advanced emissions

- Highly specific, uses complex models and direct measurements
- Most accurate, accounts for detailed farm-level factors
- Example: Measuring actual methane output from individual animals or herds

Ref: https://agledx.ccafs.cgiar.org/estimating-emissions/unfccc-guidance/

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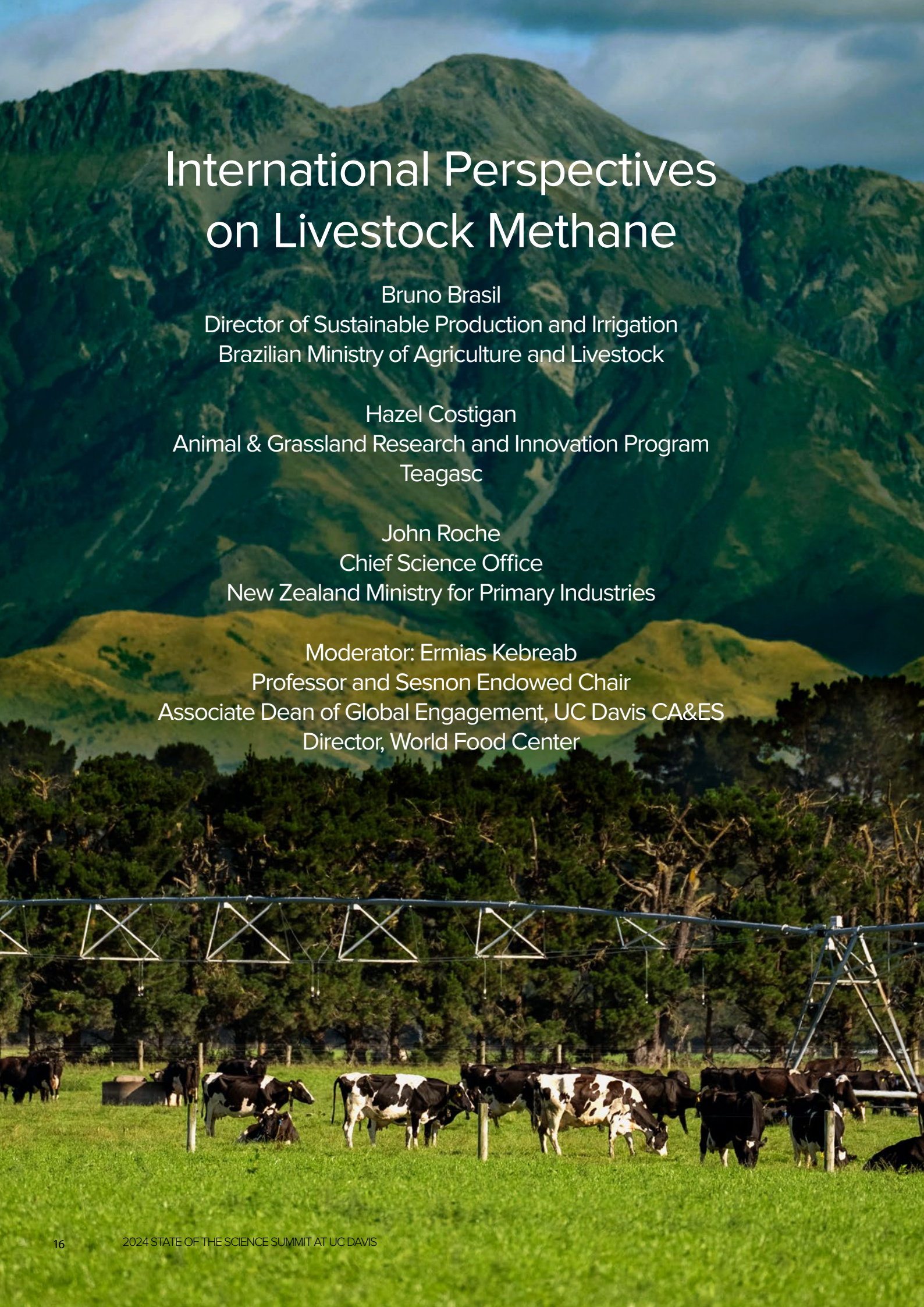
International Perspectives on Livestock Methane

Bruno Brasil
Director of Sustainable Production and Irrigation
Brazilian Ministry of Agriculture and Livestock

Hazel Costigan
Animal & Grassland Research and Innovation Program
Teagasc

John Roche
Chief Science Office
New Zealand Ministry for Primary Industries

Moderator: Ermias Kebreab
Professor and Sesnon Endowed Chair
Associate Dean of Global Engagement, UC Davis CA&ES
Director, World Food Center



Offering decidedly international perspectives, representatives of Brazil, Ireland and New Zealand explained their respective national strategies and research efforts to reduce methane emissions from livestock.

According to Bruno Brasil, the Brazilian government introduced the ABC (low-carbon agriculture) Plan in 2010 to address climate change in livestock production. Since then, Brazil has successfully promoted and implemented sustainable and cost-effective practices on 54 million hectares, resulting in the mitigation of around 200 million tons of carbon dioxide equivalent. In addition, the number of well-managed pastures increased from 25 to 37%, while severely degraded pastures decreased from 34 to 22%. The country also expanded integrated crop-livestock forestry systems from 3 million hectares to nearly 17 million in 2020. By diligently implementing the ABC Plan, Brazil was able to decrease methane emissions per animal by approximately 10% by 2016.

"... We are providing science-based solutions that are sustainable practices and technologies for the producers," Brasil said. "How do we do that? By providing government financial incentives. Incentives like rural credit — we are talking about loans, not subsidies. That keeps the activity competitive, and we are not trying to reduce that."

John Roche

Brasil went on to explain the success also has been achieved by addressing farmers' needs with practices that reduce costs, increase productivity and/or add value in the marketplace. All of these will prove important as Brazil follows through with the second phase of the ABC Plan, which aims to target a more ambitious goal. That is, mitigating 1.1 gigatons of carbon dioxide equivalent. To reach the next level, additional strategies and technologies, such as manure management, animal breeding and feed additives, must come into play.

And lest we forget, in addition to stewardship of the land and our environment in general, farmers are the linchpin in our ability to feed people, something that's not negotiable.

"So I'm here representing Brazil, a developing country quite representative of the Global South, and we are not trying to solve

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“We are providing science-based solutions that are sustainable practices and technologies for the producers. How do we do that? By providing government financial incentives.” - Bruno Brasil

the climate crisis with a social or economical crisis. That’s not a tradeoff for us,” Brasil said. “We still have a lot of food insecurity in the country, considerable food insecurity, and we are trying to see that intersection, that safe path … make the connection with all the stakeholders to align … and run that path.”

Turning to Ireland, Hazel Costigan explained her country’s approach. To achieve climate neutrality by 2050, Ireland plans to reduce greenhouse gas emissions by 51%, including a 25% reduction in the agricultural sector. The initial phase of its roadmap involves implementing technologies already available for producers, such as reducing the age at which cattle are processed for beef and decreasing the output of artificial fertilizer. The second phase focuses on almost-ready technologies, such as leveraging feed additives during the winter housing period. Finally, the third phase introduces early-stage technologies like the use of feed additives in grazing animals and breeding cattle that emit lower quantities of methane.

Hazel Costigan

“In terms of our emissions share, methane accounts for a huge proportion of our agricultural greenhouse gas emissions,” Costigan said. “So, 74% in total, but 65% of that being from enteric fermentation. So, as you can see, reducing our entire methane emissions will have a huge role

to play in whether or not we can achieve the emissions reductions targets set out for us."

To help ensure that it does, Teagasc's climate action strategy consists of three main pillars: a virtual climate center to coordinate climate action and research; a digital sustainability platform (AgNav) to provide farmers with a baseline calculation of their emissions; and the Signpost Advisory Program, a large cohort of farmers across Ireland serveing as the flagship for climate action initiatives.

Teagasc also developed a marginal abatement cost curve (MACC) that ranks measures based on their cost per ton of carbon dioxide equivalent abated to help policymakers and industry stakeholders identify the most cost-effective pathway to reduce emissions.

Providing an altogether different case study, John Roche explained New Zealand has a unique set of attributes that make addressing methane emissions quite distinct from other nations.

Livestock production is the main driver of the economy, with 25 million sheep and 10 million cattle in a country with only 5 million inhabitants. Consequently, more than 50% of greenhouse gas emissions come from agriculture, and 75% of those come from enteric methane. For this reason, farmers and ranchers have been pioneers in improving their sustainable practices since the 1980s, making New Zealand a leader for small countries and those whose livestock is on pasture.

"[We] see ourselves as holding a leadership role for some of the smaller nations around the world," he said. "And when I say we're unique … our animals are outside 365 days a year 24/7, apart from the short period when they're brought in to be milked."

New Zealand exports 95% of its agricultural output, primarily as raw food ingredients processed by large commercial entities that integrate these into the global food supply chain. Given its substantial economic dependence on agriculture, the country primarily relies on market-driven incentives rather than governmental interventions to motivate sustainable practices within the sector. Its grazing production system echoes that of Ireland, thus sharing similar methane mitigation strategies, such as breeding for cattle that emit less methane, the use of rumen modifiers for early-life interventions and the development of vaccines.

Breeding and Genetics

Troy Rowan
Assistant Professor, Beef Cattle Genomics
University of Tennessee

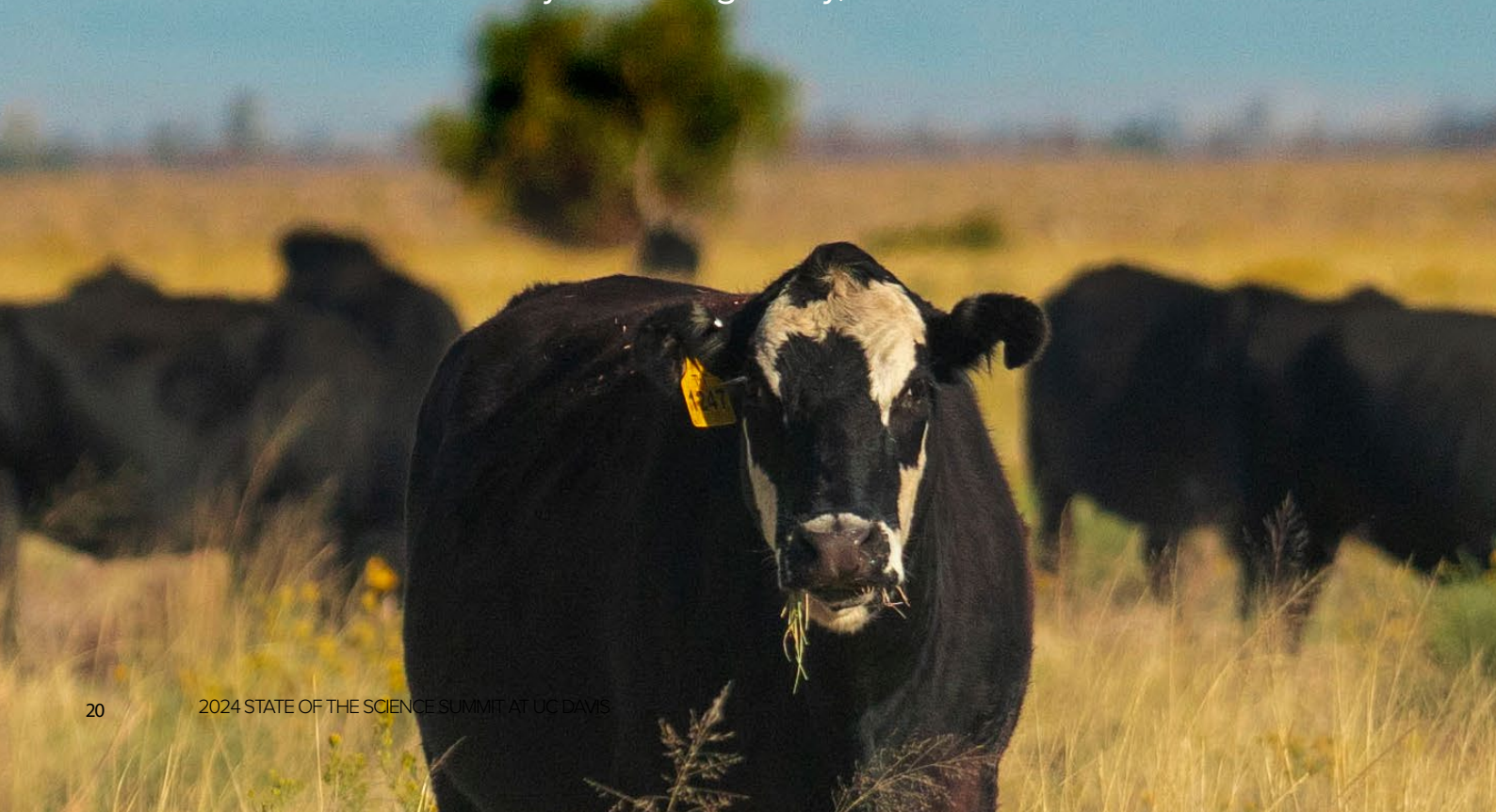
Ann Staiger
Assistant Professor, Genetics
Texas A&M University, Kingsville

Francisco Peñagaricano
Assistant Professor, Quantitative Genomics
University of Wisconsin-Madison

Paul J. Kononoff
Professor and Dairy Extension Specialist
University of Nebraska-Lincoln

Alex Hristov
Distinguished Professor, Department of Animal Science
The Pennsylvania State University

Moderator: Hayden Montgomery, Global Methane Hub



Advancements in genetic approaches to reduce methane emissions from cattle have shown significant promise, but they also have revealed persistent challenges in data collection and implementation.

A key finding is the confirmation of methane emissions' heritability in cattle, which is comparable to other important economic traits, such as weaning weight. This discovery suggests ample genetic variation exists for selection to drive genetic trends toward lower methane emissions. However, capturing phenotypes in extensive grazing environments remains a significant obstacle, particularly for the beef industry, where animal interactions are limited, particularly in extensive grazing systems.

"As any good quantitative geneticist would tell you, you can't make selection on a trait that isn't passed down genetically," said Troy Rowan, assistant professor of beef cattle genomics at the University of Tennessee.

"Methane appears to be — at least in grazing beef cattle and beef cattle that are in feedlots — somewhere in the neighborhood of 0.2 to 0.3 heritability. ...That tells us that there's ample genetic variation for which we can make selection on and drive the genetic trend of this trait of methane emission forward."

Several projects are exploring novel approaches to phenotype collection. Per Rowan, the University of Tennessee is investigating the use of precision livestock technologies and molecular phenotypes as proxies for methane emissions. This includes integrating wearable monitoring devices and exploring buccal swabbing as a cost-effective method to simultaneously collect DNA for genotyping and assess the rumen microbiome.

Meanwhile, Ann Staiger, assistant professor of genetics at Texas A&M University in Kingsville, reported a USDA Climate Smart Commodities grant project in South Texas is tackling the issue by providing incentives to producers. The project covers costs for genotyping, environmental testing and phenotyping for feed intake, methane emissions and weight gain for up to 11,000 animals, focusing on tropically adapted cattle. This approach aims to overcome the financial barriers that often prevent widespread data collection in commercial settings.

Ann Staiger

"Genetic selection is a very powerful tool to achieve lasting gains in dairy cattle performance. The changes we can achieve through genetic selection are cumulative, permanent and incremental, making it a potent approach to mitigate methane emissions from our dairy cattle." - Francisco Peñagaricano

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On the dairy side, a multi-institutional effort funded by the Greener Cattle Initiative is combining selective breeding, milk spectra data analysis and rumen microbiome manipulations to reduce enteric methane emissions. With nearly 1,000 cows already phenotyped, the team plans to implement a national genetic evaluation for methane emission traits and develop predictive tools based on milk spectra data for on-farm management. “Reducing methane emissions from dairy cattle has multiple advantages,” said Francisco Peñagaricano, an assistant professor of quantitative genomics at the University of Wisconsin’s flagship campus. “Not only reducing the environmental impact of dairy farming, but also improving production efficiency … think of methane as an energy sink, a loss of energy between 6 to 12% of gross energy that otherwise could be used for growth or for production.”

Paul J. Kononoff

These efforts are echoed by an international breeding coordination program being led by Wageningen University and supported by the Global Methane Hub and Bezos Earth Fund, to establish standard approaches and strategies for a concerted global effort to breed next-generation low-methane cattle.

Researchers noted that changes achieved through genetic selection are cumulative, permanent and incremental, making it a potent approach to mitigate emissions while maintaining or improving productivity.

It’s a promising field that’s opening doors to a number of additional opportunities, including:

- Developing cost-effective and scalable phenotyping methods for widespread implementation across diverse production systems.
- Integrating data from various sources, including precision livestock technologies, molecular phenotypes and traditional measurements.
- Exploring the interplay between host genetics and the rumen microbiome to better understand and manipulate methane production.
- Creating predictive tools based on easily obtainable data (e.g., milk spectra) for on-farm management of methane emissions.

The speakers underscored the need for continued collaboration between geneticists, nutritionists and microbiologists to address the complex challenge of reducing enteric methane emissions.
As research evolves, there’s a continued emphasis on developing solutions that are not only effective but also practical and economically viable for producers.

Troy Rowan

Alex Hristov

Anti-Methane Vaccines

Paul Wood
Global Methane Hub – Enteric Fermentation Accelerator

The path to reducing enteric methane is neither straight nor narrow; thanks to ongoing research, producers may have various options to consider, including one that might seem too good to be true.

And yet, vaccines that can reduce enteric methane emissions in ruminants are a promising strategy. Furthermore, it's an approach that offers broad applicability across all ruminant species and production systems, making it particularly attractive for global implementation.

"[Vaccination is] probably one of the most routine processes done on animals," said Paul Wood, whose current connection is to the Global Methane Hub and Enteric Fermentation Accelerator. "We know that we could implement it quite easily if we have an effective vaccine."

The potential for a methane-reducing vaccine that's easily integrated into existing practices is sparking interest and investment. A product profile came as a result of a 2023 meeting in Dubai that was funded by the Gates Foundation. The profile outlines key characteristics, such as the use of inactivated antigens, a target of 30% methane reduction and a development timeline of three to seven years for full registration.

"It's not going to be a simple vaccine to develop," Wood admitted, adding, "In the U.S., it's probably going to be registered by the FDA because … it's not a disease."

The scientific basis for a methane-reducing vaccine lies in the potential for antibodies in saliva to interfere with methanogens in the rumen. Encouraging in vitro results have shown that polyclonal antibodies against methanogens can reduce their growth and methane production. The relative stability of antibodies in rumen fluid and the cross-reactivity of antibodies across different methanogenic species would suggest the potential for a broadly effective vaccine.

However, there are challenges, including understanding the co-evolution of the rumen and the immune system, characterizing antibody responses to methanogens at the single-cell level and identifying effective antigens in vivo. The complexity of the rumen ecosystem and the need for a persistent immune response also present significant hurdles.

Despite these challenges, research initiatives are sprouting up around the world. Funding from organizations such as the Bezos Earth Fund and the Enteric Methane R&D Accelerator are helping researchers identify and address the knowledge gaps. In addition, projects are underway to study the interaction between the rumen and the immune system, as well as to characterize antibody responses at a molecular level.

As futuristic as it all sounds, Woods is seeing new players enter the field, like ArkeaBio, a private company. Plus, increased collaboration among researchers worldwide is driving innovation in this area. Nevertheless, there are naysayers everywhere.

"When you're a scientist, people always tell you why it won't work. You know, I managed to crack a problem down from about 100 years by being young enough and naive enough not to listen to people," he said. "So again, you know, the answer is we're not naive. We know how challenging this is. But this is worth having a go at."

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CRISPR and Rumen Microbiome Engineering

Matthias Hess
Associate Professor, Department of Animal Science
College of Agriculture and Environmental Sciences
University of California, Davis

Not only are microbes a prolific and diverse bunch, they are essential in numerous biological processes, from nitrogen fixation in soil to oxygen production in oceans.

They make plants grow, and they keep humans healthy — or not. In ruminants, microbes play a central role in breaking down complex plant materials through enteric fermentation. This process results in volatile fatty acids (VFAs) that are a major energy source for the animals. However, it also gives rise to methane, a potent greenhouse gas.

That's where Matthias Hess comes in. An associate professor in the University of California, Davis Department of Animal Science, he believes understanding the balance and efficiency of these microbial processes is essential to understanding life in its many forms and enhancing it as well. Where the summit is concerned, that includes improving ruminant health and minimizing the environmental impact of livestock.

"... Microbes are really, really essential in many different environments .... If you think about yourself as a human being, I have to disappoint you. You're actually more microbial than human," Hess said.

Traditional methods of studying microbes involved culturing them in a lab, which limited the scope of questions that could be addressed. The advent of DNA sequencing and metagenomics has revolutionized the field, allowing researchers like Hess to analyze the genomes of uncultivated microbes directly from environmental samples. It's an approach that's uncovered a vast diversity of microbial life previously inaccessible, providing insights into their functions and interactions. And there are plenty of both.

"No microbe really lives alone," Hess said. "They hang out in groups, just like any other animal. They are depending on each other. They basically communicate with each other. And what's really important is that these microbes really function as a group. And the function of that group is basically then also dictating the function of that environment they are living in."

Indeed, microbial communities exist and proliferate as interconnected systems. "And so, only if you understand them — how they interact with each other — only then can you successfully direct rumen function into the way you want to have it," Hess said. In other words, by manipulating the microbiome a certain way, you could potentially steer rumen function toward reduced methane emissions and improved animal productivity.

Several tools, including antibiotics and chemical inhibitors, are available to affect microbiomes. However, these methods have limitations such as nonspecificity, potential resistance development, and the need for repeated application. To overcome these challenges, Hess and his team are exploring the development of targeted, permanent and scalable solutions using advanced technologies like CRISPR (clustered regularly interspaced short palindromic repeats), which allows precise editing of microbial genomes to target specific genes and pathways in the rumen microbiome.

By integrating metagenomics and metatranscriptomics, researchers can identify active genes and their functions under different conditions. Leveraging genomics tools in combination with interventions, such as the red seaweed Asparagopsis taxiformis that is linked to significant reductions of enteric methane, can help us understand how the microbial community reacts to interventions and may also help identify new intervention pathways and targets.

While still in its early stages, the effort to address the dual challenge of reducing methane emissions and enhancing livestock productivity via genomics-informed, microbiome-based interventions holds great potential. In fact, by redirecting metabolic pathways in the rumen, these strategies could significantly benefit the sustainability of livestock operations worldwide.

"By understanding microbial communities and their interactions, we can manipulate rumen function to reduce methane emissions and improve feed efficiency."
- Matthias Hess

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Feed Additives

Peter Lund
Professor of Animal and Veterinary Sciences
Aarhus University

Sara Place
Associate Professor of Feedlot Systems
Colorado State University, AgNext

Joe McFadden
Associate Professor of Dairy Cattle Biology
Northeast Agribusiness and Feed Alliance Sesquicentennial Faculty Fellow
Department of Animal Science
Cornell University

Alex Hristov
Distinguished Professor
Department of Animal Science
The Pennsylvania State University

Moderator: Charles Brooke – Spark Climate Solutions

The Danish government recently announced a plan to tax livestock emissions starting in 2030, with a proposed rate of $100 per cow per ton of carbon dioxide equivalent.

According to Peter Lund, professor of animal and veterinary sciences at Denmark's Aarhus University, it's a significant move. In fact, it's so unprecedented, news of the planned tax was broadcast on national television, which typically doesn't cover taxation.

"... That just shows how important it is in Denmark. And it of course creates a lot of concern in the farmers," he said.

To avoid being taxed, Danish farmers can consider three main commercially available options: fat supplementation, nitrate supplementation and 3-NOP (sold under the brand name Bovaer). Initially, researchers expected these solutions to have additive effects due to their distinct modes of action. However, recent trials with animals revealed that combining all three additives does not reduce methane emissions more effectively than using 3-NOP alone. The results temper some of the urgency Danish regulators were feeling to approve the options for use on farms.

In addition, side effects arising from the proposed solutions will generally slow the path to regulatory approval, Lund said. And then there's the issue of targets, results and data, all of which can differ from region to region and even from animal to animal.

"So again, we can talk about additives, and we should think about how will those additives, ... potentially have different actions in these different animals that have distinctly different rumen microbiomes," said Sara Place, associate professor of feedlot systems at Colorado State University's AgNext.

Peter Lund and Joe McFadden

The challenge of adopting solutions becomes even more complex if feed additives lack productivity benefits, since farmers worldwide often work with thin profit margins. Considering this scenario is relevant because even with a low cost per head, the carbon price required for farmers to break even may well be higher than current voluntary carbon prices, which could discourage adoption on farms. Adding to the complexity, the effectiveness of

Sara Place

"We need to have those technical solutions, we need to think about all those points that have been raised: the safety, the welfare of the animal, all those components, the efficacy. We also have to think about how practically will this be fed and how will it make economic sense for producers to adopt."

- Sara Place, Colorado State University

feed additives in reducing methane can vary by up to 70% between animals on similar diets, making it all the more important to have a holistic perspective.In other words, we have to meticulously balance the technical efficacy of feed additives with their practical application and economic viability.

Joe McFadden, associate professor of dairy cattle biology at Cornell University, has helped to form a team of people who are all researching enteric methane. And something else that is fueling success. “You need infrastructure, you can’t really just do these things with just cows and a couple of pens,” he said.

This all-encompassing approach is particularly relevant for regions like the global south, which is the primary source of enteric methane emissions and offers the strongest lever to pull for advancing our climate goals. For instance, Cornell has initiated a program to help smallholder farmers in India reduce emission outputs and improve milk production efficiency. This initiative involves building a national feed library, establishing baseline methane inventories for indigenous breeds and examining the scalability of methane mitigators.

The future of feed additives will, therefore, be defined by our collaborative global efforts to build organizational and research capacities, leverage strategic teams, implement robust on-farm documentation practices, optimize data sharing and develop transparent academic-industry partnerships across the board.

Future steps should include conducting long-term studies to mechanistically assess the safety and stability of these products, exploring delivery mechanisms for pasture-based systems, and assessing their combination with other mitigation strategies to ensure comprehensive and effective solutions.

“... We have to be very careful with these feed additives,” said Alex Hristov, a distinguished professor from The Pennsylvania State University. “I mean, we cannot just throw them at the cows and expect miracles. We have to understand how they work, what are the mechanisms, what are the potential side effects and how they interact with other feed components.”

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Enteric Research and Adoption Opportunities

Juan Tricarico
Senior Vice President for Environmental Research
Dairy Management Inc., Greener Cattle Initiative

Hayden Montgomery
Program Director of Agriculture
Global Methane Hub

Roberta Franco
Supervisor for Methane Reduction Programs
California Department of Food and Agriculture

Wayne McNee
Chief Executive
AgriZeroNZ

Moderator: Charles Brooke – Spark Climate Solutions

When it comes to solving the problem of enteric methane emissions, we need options.

Perhaps that should go without saying, but according to Juan Tricarico, senior vice president for environmental research at Dairy Management and the Greener Cattle Initiative, it begs to be underscored — often.

In fact, that's the mindset that led to the Foundation for Food and Agricultural Research (FFAR) and the Dairy Research Institute (DRI) jointly developing the Greener Cattle Initiative, a pre-competitive program aimed at supporting collaborative research on enteric methane mitigation from dairy and beef cattle. In its initial phase, the initiative developed a strategic framework via a first round of requests for proposals, funding three projects focused on dairy and beef genetics, hydrogen production and utilization, and methanogenesis inhibitors. The initiative has now moved to the second round of requests, with a much narrower call that focuses on the delivery mechanisms of mitigation technologies, the impact of early-life interventions, the effect of combined mitigation strategies and the evaluation of their long-term effects.

An example of collaboration with a world view is the Enteric Fermentation R&D Accelerator, initially announced at COP28 in Dubai and orchestrated by the Global Methane Hub. It's the largest globally coordinated public-good investment in breakthrough research tackling livestock methane emissions.

Per Hayden Montgomery, who serves as program director of agriculture at the Global Methane Hub, erasing borders is the only way to proceed. "So, we can't focus on one system type and one or two geographies and expect to solve this problem globally. So, the vision we're taking is global. And that means all of the systems and wonderful diversity that brings with it."

Roberta Franco

This initiative is transformational not only in its scale but also in the unencumbered nature of its funds. This financial flexibility allows for more adaptive and responsive funding criteria regardless of geographic location or production system. The Accelerator unites funders, guided by its Science Oversight Committee, to invest in a globally coordinated plan designed to identify knowledge gaps and bottlenecks, assess the current research landscape and infrastructure, identify research outputs, and design an effective research strategy. The Accelerator has already funded projects in microbiome characterization, low-methane genetics, low-cost measurement for grazing livestock, anti-methanogenic forage, and immunological research for vaccine development.

Representing the state of California, which is often looked to for its forward environmental thinking, was Roberta Franco, supervisor for methane reduction programs at the California Department of Food and Agriculture (CDFA).

Agriculture and Forestry represent about 8% of the state's total emissions, corresponding to 30.5 metric tons of CO2 equivalent. Of these, 70% come from enteric fermentation and manure management. The CDFA has made considerable progress in reducing these emissions without implementing regulations. The answer lies in incentivizing farmers to adopt voluntary measures instead of imposing mandates.

Hayden Montgomery

It's more than a nicety. It's downright effective. Indeed, the combined efforts of the Dairy Digester Research and Development Program (DDRDP), the Alternative Manure Management Practices (AMMP) and the Dairy Plus Program (DPP) are expected to mitigate 2.86 million metric tons of CO2 equivalent per year. And yet, despite this progress in the mitigation of manure methane, advancements in enteric fermentation are still required to meet reduction goals.

The CDFA has two main research programs dedicated to supporting progress on this front: the California Livestock Methane Measurement and Thriving Environments Research Program (CLIM3ATE-RP), which has awarded $3.1 million to projects addressing enteric methane, and the Livestock Enteric Methane Emission Reduction Research Program (LEMER-RP), which has awarded $9.2 million. Additionally, the CDFA holds a $2 million budget to develop a framework for a future program that encourages the voluntary adoption of products or strategies on farms. The CFDA intends to continue pursuing opportunities to build upon these efforts.

"We are very close [to] meeting the targets that we have at least for California in terms of methane reduction, but without enteric methane solutions, we are not going to be able to get there. And so we need to do something about it," Franco said.

Wayne McNee

Juan Tricarico

"We can't focus on one system type or geography and expect to solve this problem globally. So, the vision we're adopting is global, encompassing all systems and the wonderful diversity they bring with it." - Hayden Montgomery

Representing a high-potential program from the Southern Hemisphere was Wayne McNee, chief executive of AgriZeroNZ.

AgriZero is an initiative that was created as a public-private partnership between the New Zealand government and major agribusiness companies to ensure all farmers have equitable access to affordable, practical solutions to reduce biogenic methane and nitrous oxide emissions.

AgriZero aims to undertake targeted investments and actions to accelerate the development and adoption of solutions that drive down methane and nitrous oxide emissions by 2040. More specifically, the commitment includes delivering systemwide funding and unblocking constraints, investing capital and capability to enable local and global ventures to be successful in New Zealand, building international partnerships and providing input into local research strategy and government regulatory settings. AgriZero is currently executing its initial phase, consisting of ramping up investments and scouting for potential solutions while streamlining the country's regulatory framework.

"We're a tiny, tiny little proportion of a global problem. But we need to be part of the solution as well. If everybody says they're a small proportion, nobody does anything.... And we bet we do have some farming groups in New Zealand, some fairly large farming groups, that are very keen on having access to tools and trialing them out and their farming systems," McNee said.

Future steps will involve supporting regulatory approvals for identified solutions, large-scale manufacturing and commercialization, and widespread adoption by 2030.

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Reducing Emissions in the Beef Sector

Frank Mitloehner
Professor
University of California, Davis
Director of the CLEAR Center at UC Davis

Reducing the methane emissions of livestock is no easy task. And yet, some emissions scenarios pale in comparison to the challenge of improving the footprint of grazing cattle. According to Frank Mitloehner, an expert in animal agriculture and air quality, and an international authority on livestock emissions, that's among the most daunting of tasks.

He began his talk at the 2024 State of the Science Summit by laying his cards on the table.

"Methane mitigation for dairies and on feedlots is relatively easy compared to animals on pasture," he said. "But that's really where the lion's share of emissions come from."

Mitloehner spoke to a diverse audience of approximately 400 stakeholders who came to Davis, California, or attended the summit virtually. He presented research that aims to answer the question of whether the beef sector has a fighting chance of achieving the 40% methane reduction goal called for by California's SB 1383, by far the most ambitious methane-mitigation legislation in the world.

"It's tricky because how do you reduce emissions from animals that you get your hands on maybe two times a year?" he said. "That's tough."

By the end of the current decade, California's beef sector must dial back its methane emissions by 1.3 MMTCO2e in order to be in sync with SB 1383. Using simple math, that calls for a reduction of .26 MMTCO2e each year from 2026 through 2030. Further complicating the call is the fact there are no accepted quantification methods or protocols, and any emerging technology requiring government approval simply won't be ready in time.

But Mitloehner is nevertheless bullish that a plan can be formulated to do the job, especially since California's farmers are rising to the formidable challenge of the 40% goal. Even more amazing is they're doing so willingly, with a host of incentives designed to sweeten the deal.

"By all accounts, no single tool is a practical solution; the necessary rate of implementation is simply too high. But through a combination of all three options, the goal is in reach."
- Frank Mitloehner

"It's a recipe for success," he said. "California is advancing toward its goal without force, rules, regs, fines or taxes. We're almost halfway to 40% [of a reduction of 7.2 MMTCO2e] on the dairy side."

Despite some very real challenges, history gives us reason to be optimistic on the beef side as well. From 2010 to 2019, beef production in California swelled by roughly 41%, but direct greenhouse gas emissions increased by only 17%. Furthermore, from 2015 on, direct greenhouse gas intensity declined at roughly the same pace as beef production increased.

It has a lot to do with genetic engineering, Mitloehner asserted, and it also goes to the perseverance of producers. Still, options are limited for on-pasture cattle, which accounted for 77% of enteric emissions from 2010 to 2019.

Presently, he noted that there are three approaches worth considering:

- Methane-reducing feed additives could be an option for part of the supply chain, but not so much for grazing animals unless we could get them into drinking water or salt licks, which are frequented often by livestock.
- Managed grazing, whereby cattle are strategically moved, has some potential.
- And finally, genetic selection, whereby cattle are bred to be less prone to produce and emit methane, is another option for grazing animals.

By all accounts, no single tool is a practical solution; the necessary rate of implementation is simply too high. But through a combination of all three options, the goal is in reach, Mitloehner said.

"Because we are so limited with what we can do with grazing animals, we have to be realistic. But we can get there," he said.

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Adoption in Beef Production Systems

Troy Rowan
Assistant Professor, Beef Cattle Genomics
University of Tennessee

Jenna Sarich
Technical Consultant and Analyst
Canadian Roundtable for Sustainable Beef

Tom Sturgess
Founder
Lone Star Farms

Nicole Jenkins
U.S. Beef Sector Lead
Environmental Defense Fund

Jonathon Beckett
Beef Nutritionist

Moderator: Samantha Werth - National Cattlemen's Beef Association and U.S. Roundtable for Sustainable Beef

Despite an increased population of humans, the cattle herd in the United States is at its lowest level in more than 60 years. And yet, output hasn't dipped. In fact, the opposite is true.

"... These animals, even though we have less of them than we've had since 1960, are as productive as ever," said Troy Rowan, assistant professor of beef cattle genomics at the University of Tennessee.

The substantial increase in beef cattle productivity over the last decade, despite a declining inventory, is largely explained by advances in selection tools and genomics that have catalyzed genetic progress on growth productivity traits, contributing to a notable reduction in emissions intensity within the U.S. beef sector.

Given the complexities of measuring emissions on pasture-based systems, genetic evaluations for low-methane-emitting cattle tend to begin at the seedstock level before being deployed in commercial operations. Successful adoption of these tools will also require proactive extension work to educate farmers about the benefits of their on-farm implementation. This is particularly relevant for the beef sector, as most operations are small multigenerational family businesses, where traditional incentives have often been insufficient to shift production practices.

It's not that farmers and ranchers are uncooperative. Rather, theirs is a tricky business that has taken decades to finely tune. Thus, while advancements in selection tools and feed additives offer promising potential for reducing emissions, it's important to demonstrate financial benefits as well.

Farmers are generally reluctant to incorporate new technologies in their production systems unless there is a strong return on investment, often a minimum of two-to-one, to justify their adoption. To truly drive motivation among farmers, it's imperative to conduct comprehensive, applied research studies that evaluate their impact on animal productivity and economic performance.

Jenna Sarich offered another viewpoint in her presentation

Jenna Sarich

on the Canadian Roundtable for Sustainable Beef (CRSB). According to Sarich, who is a technical consultant and analyst for CRSB, "We adopted the same sustainable beef definition as the Global Roundtable. So that's a socially responsible, environmentally sound and economically viable product that prioritizes the planet, people, animals and progress. So the mission statement of CRSB is to advance, measure and communicate continuous improvement in sustainability of the Canadian beef value chain," she said.

The CRSB's latest National Beef Sustainability Assessment (NBSA) shows that most emissions (83%) come from on-farm factors, with enteric methane as the main contributor (61%), followed by feed

"As we start to think about what methane mitigation looks like in the beef industry, the focus on the producer and their behaviors and their willingness to adopt these technologies is going to be so important." - Troy Rowan

production (21%), manure (17%) and transport (1%). Consistent improvements in cattle production efficiency have led to a 15% reduction in sector wide emissions since 2014, putting Canada on track to achieve its goal of a 33% reduction in greenhouse gas intensity by 2030. Moving forward, the CRSB plans to optimize knowledge transfer between researchers and producers to further encourage sustainable practices and reduce the environmental footprint of Canadian beef.

Tom Sturgess, the founder of Lone Star Farms, provided an altogether different viewpoint. A producer, investor, philanthropist and more, he talked in plain terms about the need to develop methane-mitigation solutions and — more important — to communicate how they work and why producers should consider them. The answer to the problem shouldn't come as a surprise.

"... Here's a secret about farmers. You guys ready for this? If you pay a farmer to do something, the farmer will do it, providing it's a good thing for the operation. In other words, if it has a three- or four-fold return on investment, and it doesn't negatively impact the animals' health, it's a go. So, let's pay the farmers to do the right thing," he said.

That very theory has driven nutritional progress, like the kind Jon Beckett, a beef nutritionist, delivers to his clients. As far as he's concerned, improving cattle's diet has led to remarkable increases in productivity. He also believes it can help us reduce enteric methane.

"... How are we going to reduce methane emissions? Well, we either reduce methanogenesis either through feed rations and so on, or through some type of feed additives," he said.

But at the end of the day, regardless of the size of the enterprise, corporate climate action is primarily driven by risk management, consumer and investor demand, long-term profitability, and, most importantly, the urgent need to build greater agricultural resilience.

Nicole Jenkins, U.S. beef sector lead at the Environmental Defense Fund (EDF), reported the EDF supports downstream food companies in elevating their climate ambition and identifying key priorities. A common misconception in the enteric space is that progress relies solely on implementing on-the-ground solutions. However, the EDF's recent report outlines near-term opportunities for addressing livestock methane, such as advocating for a more efficient regulatory approval process and government support to cost-share methane mitigation practices. These actions will pave the way for the rapid and more efficient adoption of newly developed solutions.

Jonathan Beckett

Samantha Werth

Tom Sturgess

Nicole Jenkins

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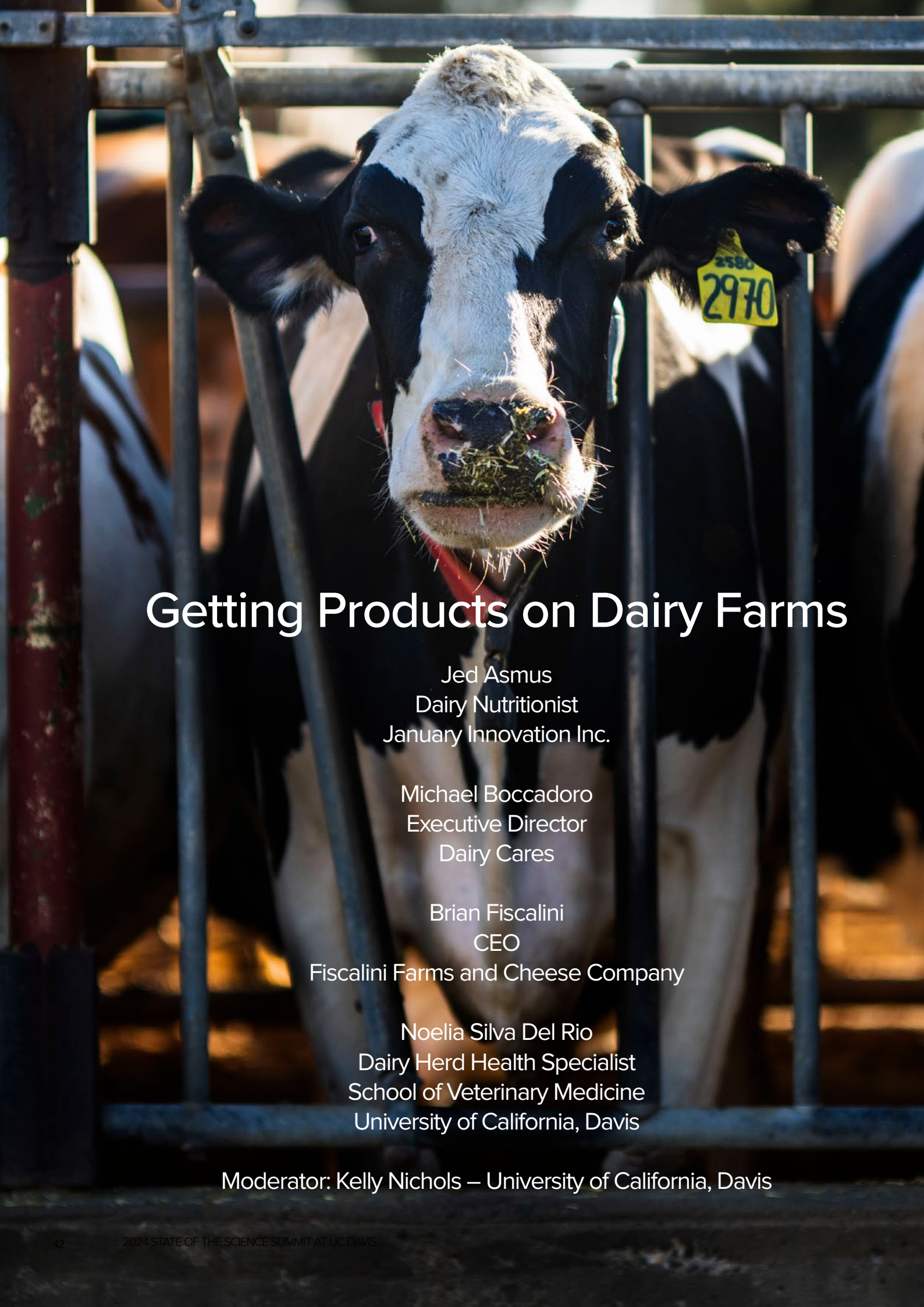

Getting Products on Dairy Farms

Jed Asmus
Dairy Nutritionist
January Innovation Inc.

Michael Boccadoro
Executive Director
Dairy Cares

Brian Fiscalini
CEO
Fiscalini Farms and Cheese Company

Noelia Silva Del Rio
Dairy Herd Health Specialist
School of Veterinary Medicine
University of California, Davis

Moderator: Kelly Nichols – University of California, Davis

"We cannot achieve the state's goals without finding reductions in enteric methane."
- Michael Boccadoro

Jed Asmus, a dairy nutritionist from January Innovation, compared being a farmer to going a few rounds with a prize fighter: It's fine to have a plan, but be ready for the left hook.

"When you feed cows every day on a practicing dairy, that's what it feels like. You don't know what's going to happen," he said, using the example of the effect of wildfires on cows' milk production. "And we did lose 10 to 15% of the milk just associated with the smoke inhalation of these cows. Why? That's what happens when the environment impacts the animal's decision to what she does. Because she gets a decision in this every activity we do."

Regardless of cows and beef cattle having choices, similar to the U.S. beef industry, the dairy sector in California has made notable strides in methane reduction through improved production efficiency, despite significant attrition in its inventory.

To be sure, producing more milk with fewer cows not only reduces methane emissions and their intensity, it also decreases water, land and fossil fuel consumption per gallon of milk produced. Additionally, California has a unique feeding system in which 40% of the

Michael Boccadoro

Jed Asmus

cow's diet comes from byproducts, such as almond hulls and citrus pulp, that would otherwise be sent to landfills.

But make no mistake. According to Michael Boccadoro, executive director of Dairy Cares, an all-out fight against enteric methane is critical.

"We cannot achieve the state's goals without finding reductions in enteric methane," he said.

Indeed, meeting California's reduction goals hinges on addressing enteric methane. The successful implementation of manure management practices serves as a valuable model for deploying enteric mitigation strategies on dairy farms. Progress on this front will necessitate developing a suite of programs tailored to different types of dairy operations, focusing on making these strategies convenient and beneficial for farmers, including potential additional revenue streams, which can be a significant catalyst for their adoption.

Kelly Nichols

Brian Fiscalini, CEO of Fiscalini Farms and Cheese Company, provided the important voice of the farmer.

"I just really want to drive home the message that dairy farmers are a part of the solution ... and we always have been. I think that that's really important for consumers, for all of us in this room, to remember that our dedication is to produce healthy food," he said, adding there is also a commitment to sustainability. And by sustainability, Fiscalini means environmental and economical.

Noelia Silva Del Rio

“Because, if our business has been around for four generations, and I want to see it go on for four more, we’ve got to make a little money doing it.”

The latter is perhaps the most compelling motivator for producers, and who can blame them? Thus, learning from early adopters is key for integrating mitigating strategies into dairy operations. Farmers want to see what is working. To this end, co-ops from the Netherlands and Denmark, FrieslandCampina and Arla Foods, respectively, have conducted large-scale pilot studies with products such as 3-NOP that have shown promising results. These co-ops also introduced an incentive framework based on a point-based system that rewards producers for climate and environmental sustainability practices.

To ensure the successful adoption of 3-NOP and other similar products in the United States, it is important to conduct comprehensive and large-scale studies that generate granular data on the long-term impacts of incorporating them on farms. This includes understanding their interaction with diverse diets, individual animal responses, product shelf life, implications of feeder errors, effects on digester efficacy and their collective impact on milk’s nutraceutical value, safety and consumer acceptance. Admittedly, it’s a lot, and not all advances are worth adopting.

“So, you can have a great technology, but you need to find the right application.... Keep the research up and make sure that we are doing the right thing, said Noelia Silva Del Rio, dairy herd specialist at the School of Veterinary Medicine at the University of California, Davis.

Once feed additives and other solutions are scientifically evaluated, farmers are likely to adopt them as long as the reported benefits are also quantifiable and reflected in their financial results.

The appropriate amount and where proper market signals should be applied need to be thoroughly evaluated to determine the best way to achieve rapid and durable adoption of these technologies.

Brian Fiscalini

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Managed Grazing

Logan Thompson
Assistant Professor
Kansas State University

Justin Derner
Supervisory Research Rangeland Management Specialist
USDA-ARS

Steve Wooten
President
Beatty Canyon Ranch

Matthew Wilson
Professor of Animal Sciences
West Virginia University

Moderator: Kim Stackhouse-Lawson, Colorado State University, AgNext

Grazing livestock presents a unique set of challenges.

One such chllenge is how to reduce enteric emissions, the primary source of livestock emissions worldwide. In part, the issue stems from the complexity of grazing ecosystems, which can vary significantly in forage quality and availability, management practices, mesoscale climates and socio-economic landscapes. And because a farmer or rancher might not have daily contact with the herd, emerging solutions such as feed additives are often impractical for these operations, adding to the complexity. As Steve Wooten pointed out, “The practicality of adoption is not just focused on the science of the cow, but also the science of people and those social structures.” And he should know. He oversees Beatty Canyon Ranch, a 500-head operation in Colorado.

The bottom line? We need a comprehensive systems approach.

Justin Derner, a supervisory research rangeland management specialist for USDA-ARS, is a strong believer that the only way to make that happen is to go right to the source.

“We bring the ranchers, we bring the groups to us, and we ask them, ‘How can we help service you?’” he said.

Kim Stackhouse-Lawson

A prerequisite to successfully addressing emissions in grazing systems is understanding how land management decisions affect plant-soil-animal interrelationships. Providing a suitable habitat that is synergistic with grazing practices is critical for guaranteeing a sustainable climate strategy. This calls for equipping land managers with the knowledge and decision tools they need to manage these lands effectively and responsibly.

Another challenge is the lack of standardized methods for measuring emissions, individual animal intake and biodiversity within grazing systems.

“Predictive algorithms and machine learning can significantly improve feed and water use efficiency in grazing systems,” said Matthew Wilson, a professor of animal sciences at West Virginia University.

In fact, progress on this front is critical for establishing baselines and designing effective roadmaps

“The practicality of adoption is not just focused on the science of the cow, but also the science of people and those social structures.” - Steve Wooten

to meet emission reduction goals.

Despite the challenges and complexities, ranchers can adopt readily available management practices to catalyze short-term progress — so-called low-hanging fruit. For starters, bigger isn't always better, said Logan Thompson, an assistant professor at Kansas State University.

"Smaller, more moderately framed cows produce calves that provide more returns and are an easy avenue to reduce emissions," he said.

Additionally, enhancing animal productivity by actively leveraging improved key performance indicators, such as weaning and pregnancy rates, provides another route for immediate climate action.

Forage and grazing management are also pivotal for maximizing returns, both environmentally and economically. Implementing innovative technologies such as virtual fencing and pasture management software can support more adaptive and climate-resilient land management by enabling more efficient grazing, control of invasive species, and smarter scheduling of pasture rests.

There is an urgent need for funding and multidisciplinary talent to advance grazing-based, applied research that fine-tunes solutions for various regions and diverse socio-economic contexts. Reducing emissions while safeguarding soil and animal health is key for sustaining multigenerational family operations facing a changing climate.

"We bring the ranchers, we bring the groups to us, and we ask them, 'How can we help service you?'" - Justin Derner

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Taking Action in the Supply Chain

Thomas Bauer
Principal Industry Specialist
IFC/World Bank

Meryl Richards
Program Director of Food and Forests
Ceres, Inc.

Jim Eckberg
Research Agronomist
General Mills

Hannah Stefenoni
Producer Relations and Dairy Sustainability
Clover Sonoma

Moderator: Vrashabh Kapate – Environmental Defense Fund

California has experienced 19 extreme weather events in the past decade alone, each costing over $1 billion in damages. These events not only severely impact farmers, who are on the front lines of climate change, they also affect companies via disrupted supply chains. However, the potential of methane mitigation presents a powerful lever for the food system to slow down near-term warming and avoid the worst impacts of climate change.

“The urgency to slow down warming has never been greater,” said Vrashabh Kapate, manager of dairy industry at the Environmental Defense Fund. “Methane is one of the most powerful levers that the food system can pull to slow near-term warming.”

The good news is food and agriculture companies have the scale to reach millions of farmers through their supply chains, the capital to support their transition to climate-smart agriculture, and the innovation engine to spark and rapidly deploy new mitigating products, offering a hopeful future for the industry.

Even better news, according to Jim Eckberg, a research agronomist at one of these major companies — General Mills — is a growing understanding that the best place to start is with producers.

“Working with farmers and learning from them is key to making meaningful progress,” he said.

A long-standing issue in addressing supply chain emissions has been the lack of disclosure regarding Scope 3 emissions — those indirectly caused throughout a company’s value chain. Meryl Richards, program director of food and forests at Ceres, reported on investor-led initiatives, such as Food Emissions 50 at Ceres. It’s an example of a program that’s addressing this gap by urging North America’s highest-emitting public food companies to disclose their greenhouse gas emissions, set ambitious reduction targets and implement climate transition plans aligned with the Paris Agreement.

Similarly, the Dairy Methane Action Alliance (DMAA), orchestrated by EDF and CERES, aims to accelerate

"Trust-based relationships with our farmers are essential for implementing sustainability initiatives. Their willingness to participate in trials... is invaluable."
– Hannah Stefenoni

Hannah Stefenoni and Meryl Richards

action and ensure accountability by encouraging companies to annually account for and publicly disclose methane emissions within their dairy supply chains and implement comprehensive action plans by the end of 2024.

But as so often is the case, it all comes down to trust. Without it, there is little chance for success.

“Trust-based relationships with our farmers are essential for implementing sustainability initiatives,” said Hannah Stefenoni, who works in producer relations and dairy sustainability for Clover Sonoma. In fact, she called farmers’ willingness to participate in trials “invaluable.”

Building trust-based relationships with farmers begins with a simple desire to understand the challenges they face. That needs to happen before deploying effective solutions and evaluating their downstream effects on commodity-level footprints.

As an example, General Mills has launched collaborative projects with Quebec farmers to introduce regenerative agriculture practices such as crop rotation diversification, perennialization and manure management. The company also emphasizes comprehensive farm-level MRV (measurement, reporting and verification) through Holos, a peer-reviewed model that estimates GHG emissions and changes in soil carbon in Canadian farming systems. Combining this thorough monitoring with continuous technical assistance can reduce methane emissions by up to 25%, while simultaneously boosting economic performance for producers.

Jim Eckberg

However, this is a global issue and thus, chipping away at methane

Thomas Bauer

emissions in emerging markets is also important, if not more so, according to Tom Bauer.

“Addressing methane emissions in emerging markets is critical, as these regions have a significant number of underproducing livestock contributing to the problem,” he said.

The International Finance Corporation (IFC), where Bauer is a principal industry specialist, is a member of the World Bank Group and the largest global institution dedicated to creating markets and opportunities in developing countries. In response to the negative impacts of climate change on smallholder farms in these countries, the IFC’s mission has recently evolved from poverty alleviation to ending poverty on a livable planet. The IFC has pledged investments to replace inefficient production practices and provide training and technical assistance to increase productive efficiency, ensure animal welfare and ultimately help farmers meet their nutritional needs while protecting the environment.

And yet, there is a growing concern over a decline in investments developed countries are making in emerging markets. This decline is primarily driven by protectionist trends, which may stagnate production and worsen global food security. Therefore, it’s essential for developed countries to renew their engagement and support emerging markets in order to effectively tackle methane emissions and productivity challenges. Adapting successful strategies and solutions from developed countries to the Global South can be effective in addressing their production inefficiencies, provided that these solutions are carefully tailored to their socioeconomic contexts.

"Food and agriculture companies have the scale needed to reach millions of farmers through their supply chains and the ability to deploy capital to support climate-smart agriculture." – Vrashabh Kapate

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Regulatory Barriers and Updates for Enteric Methane Mitigation

Deborah Roche
Head of Catalyst
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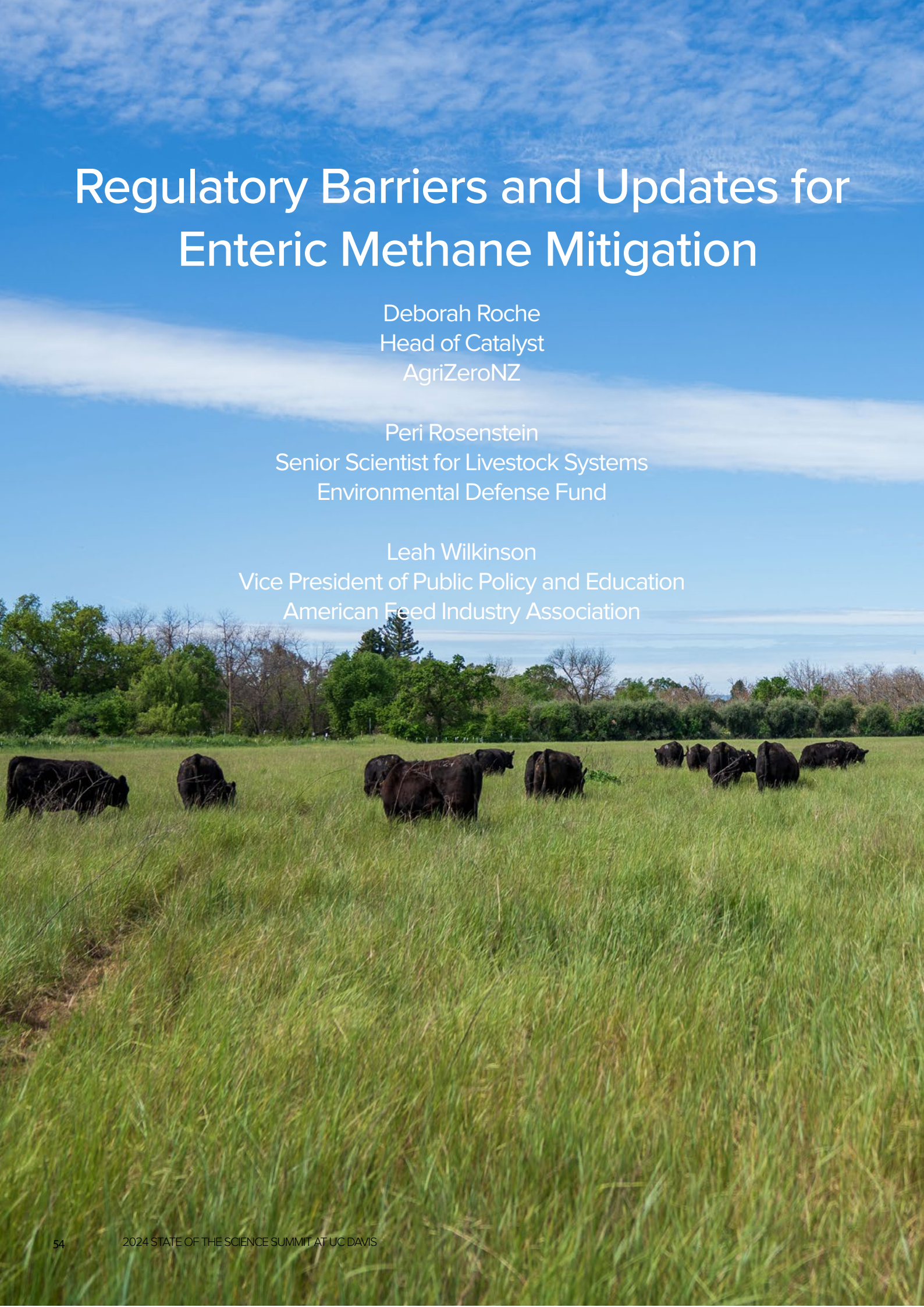
Peri Rosenstein
Senior Scientist for Livestock Systems
Environmental Defense Fund

Leah Wilkinson
Vice President of Public Policy and Education
American Feed Industry Association



Anyone who has shepherded a food additive through the regulatory process — not to mention those who are waiting for approval of new emissions-reducing ingredients —leaned in to hear panelists Deborah Roche, Peri Rosenstein and Leah Wilkinson.

Rosenstein and Wilkinson, especially, discussed what's required currently to gain approval for new feed additives in the United States. They outlined the progress the country is making in reviewing new products and how to get them to market sooner. Roche shared considerations for bromoform-rich asparagopsis seaweed as an inhibitor in New Zealand's grazing livestock systems.

Sharing good news from Washington, D.C.

Leah Wilkinson was a bearer of good news, sharing that just several days before, on May 20, 2024, the U.S. Food and Drug Administration's Center for Veterinary Medicine (CVM) officially withdrew Guide 1240.3605. The long-standing rule, which put food additives and ingredients for animals in the same category as medications, subjected them to an excessively long and highly rigorous approval process.

The American Feed Industry Association (AFIA) has been behind the movement to amend Guide 1240.3650. "It isn't 100% solved, but it's huge progress," Wilkinson said.

The AFIA, for which she serves as vice president of public policy and education, approached CVM in September 2020, asking for a policy modification whereby products that act in animals' digestive tracts be treated as food instead of drugs for purposes of regulatory review and approval.

The U.S. Congress stepped in the following year with the same ask. Bipartisan companion bills H.R. 6687 and S.1842 have yet to be signed into law, but that doesn't mean the United States can't begin to approve emissions-limiting additives under the new category of "zootechnical animal substances."

Whereas it used to be necessary for an additive to affect taste, nutrition or aroma to be considered food, there is now a non-nutritive category in play. It should make the approval process less cumbersome going forward. In addition, it's a shift that puts the United States more in line with the regulation of structure, function and health claims in other developed countries, Wilkinson added.


Peri Rosenstein

Proving there is no time to sit back and rest with so much at stake, the AFIA is already looking ahead to the next challenge: Once ingredients are approved, how do we get them into the hands of producers?


Leah Wilkinson

From the best science to regulatory approval

Peri Rosenstein offered the four qualities a methane-mitigation tool for animal agriculture must have:

It must be effective at reducing enteric methane without causing negative environmental tradeoffs.

- It must be safe for humans and animals.
- It must be widely adopted by the industry.
- It must be accepted by the industry.

"Pretty much the only way to do all this is to have quality, transparent, rigorous science and a federal regulatory approval process," Rosenstein said.

Knowing the challenges are formidable, the Global Research Alliance on Agricultural Greenhouse Gases brought together experts in this space to look at technical guidelines to develop feed additives to reduce enteric methane, focusing on the United States, Canada and the European Union.

As part of this endeavor, the Environmental Defense Fund conducted an expert workshop for scientists from academia, industry and regulatory agencies to demonstrate the effectiveness of products designed to inhibit enteric methane.

It's an important endeavor, especially in light of the FDA's Center for Veterinary Medicine's move to withdraw Guide 1240.3605 and ease up on the approval process for feed additives. In fact, the FDA has made a commitment to modernizing the process and pathway to allow for innovation, while at the same time keeping the public safe. Those seeking to navigate the regulatory process should know that establishing contact with the FDA early in the development timeline is likely to help the approval process go more smoothly.

Deborah Roche

Rosenstein's call to action comes from an informed, no-nonsense approach:

- Understand the requirements for regulatory approval.
- Conduct rigorous scientific studies that include key parameters for data collection and utilize validated methodologies for quantifying methane-emissions reductions.
- Follow best practices for scientific research.

A roundtable approach in New Zealand

Although representing a different continent and even a different hemisphere, Deborah Roche illustrated the importance of feed additives, highlighting an alternative endeavor underway in New Zealand.

Among many solutions to reduce enteric emissions, such as vaccines and genetics, she explained New Zealand is currently looking to asparagopsis, a type of seaweed that contains bromoform, to take a bite out of its methane emissions. Such a measure, as well as other methane-reducing solutions, would allow the nation to avoid reducing its herds to meet goals for greenhouse gas emissions, a move that simply isn't practical.

There is a myriad of reasons why the latter isn't an attractive option. For starters, animal agriculture plays an integral role in New Zealand's economy. Thirteen percent of employed New Zealanders work in the sector, which accounts for 10% of its gross domestic product. Furthermore, the country's food and fiber sector is responsible for $57.4 billion in export earnings each year.

At the same time, animal agriculture in New Zealand is very much the product of wide-scale changes over the past 40 years. In 1982, there

were 70 million sheep grazing New Zealand's lands. Today, that number has shrunk to 24.4 million. However, beef cattle and dairy cows have more than made up for it. Together, they amount to more than 9.5 million animals, all of which naturally emit methane.

"Our need for emissions reduction has never been greater," said Roche. Although New Zealand's methane emissions are roughly on par with those of California, that doesn't tell the whole story. "The big difference is that's 50% of our emissions," she said.

Seaweed is a promising solution being considered for wide-scale implementation in New Zealand, given bromoform's ability to keep ruminant livestock from producing so much methane in the first place — and that's a huge deal. Of course other solutions such as vaccines, in which New Zealand has pioneered for many years, are promising. For New Zealand to reach its Paris Agreement assignment, methane and nitrous oxide must be a major part of the plan, Roche said.

Showing an alternative approach, the New Zealand Agricultural Greenhouse Gas Research Center has set up a public-private initiative to address climate goals, at the same time keeping an eye on shoring up farmers' productivity and profitability. The group has identified key knowledge gaps and outlined priority areas for research and regulatory development. There is important collaboration taking place between regulators, scientists and industry stakeholders to address the gaps and support the commercialization of effective mitigation technologies.

"Our need for emissions reduction in New Zealand has never been greater. We must support farmers to remain profitable while reducing methane and nitrous oxide emissions." - Deborah Roche

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Closing Remarks

Christine Birdsong
Under Secretary
California Department of Food and Agriculture

Undersecretary Christine Birdsong closed the 2024 State of the Science Summit by amusing the audience with stories about her kids, as she did in 2023. At the same time, she talked about how even her teenagers have evolved in their understanding of the crucial role of agriculture and what members of the essential industry are doing to lessen their environmental impact.

It served as a metaphor for what happens at the annual summit: deepening understanding, appreciation for the work of others and a willingness — if not an eagerness — to share what's working and what is a stumbling block to this day. Maybe we should meet more than annually, she joked.

Indeed, the 2024 conference underscored the growing momentum and innovation in addressing methane emissions from dairy and livestock. Among the many highlights was California's leadership in agricultural research and innovation, particularly in the realm of dairy and livestock sustainability. This progress is largely attributed to strong partnerships between the California Department of Food and Agriculture (CDFA), academic institutions, and industry stakeholders, with such collaboration being central to the purpose of the summit.Another key theme was the importance of ensuring the safety of enteric methane reduction technologies for both humans and animals.

"Public confidence in the safety of enteric methane reduction technologies is crucial," Birdsong said. "We must ensure these technologies are safe for both people and animals to be accepted."

To that end, the CDFA has taken proactive steps by investing $15 million to enhance research on the efficacy, implementation and safety of emerging technologies. This investment is a testament to California's commitment to meeting its methane reduction targets, she said.

However, the national stage is even more important because of its reach. Federal regulatory approval is a critical factor for the success of products designed to reduce enteric methane. She urged companies to collaborate with the FDA — and to do so early — to secure necessary approvals, ensuring that new technologies meet safety standards, a must-have for consumer acceptance and market viability.

Stakeholders around the world are working on innovative solutions, such as genetic engineering, nutrition plans and grazing management, and they are all intended to get us to a better place. We need that kind of research and

ingenuity, Birdsong said, as no single course of action will get us to our reduction goal.

As far as our tool kit goes, dairy digesters are a shining example of what else can be done. They also serve as a model of a public-private partnership, with investments matching state funding by 215%.

And speaking of partnerships, isn't that what will change the course of history?

Kudos to public-private collaborations, like the Greener Cattle Initiative, for their potential to accelerate progress in the pre-competitive space. And hats off to anyone who picks up the phone or sends off an email to share ideas and breakthroughs. The diversity of livestock production systems globally necessitates a diversity of thought and collaboration to achieve meaningful reductions in methane emissions.

Simply put: We are all in this together.

The 2024 State of the Science Summit reinforced the optimism and momentum behind developing safe, cost-effective and practical solutions for enteric methane reduction.

We must have continued partnerships and innovation to meet climate goals while supporting the agricultural sector's role in feeding a growing global population. It's a moonshot goal, but it's one that's doable.

"The future is bright for safe, cost-effective, practical solutions for enteric methane reduction," she said. "The momentum shows we are forging ahead, and we are optimistic."

"The future is bright for safe, cost-effective, practical solutions for enteric methane reduction. The momentum shows we are forging ahead, and we are optimistic."– Christine Birdsong

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It started out as a good idea, albeit a bit of a dream.

What if we could pull stakeholders together from every corner of the industry? We would want government reps, NGOs, academia, for-profit corporations, media and most of all, farmers. Everyone would be welcome at a gathering designed to talk about what we know about enteric methane and — more to the point — what we can do to reduce it.

And thus, in 2023, the inaugural State of the Science Summit took place in Davis, California.

To our wonderment, despite the cross-section of people in a very large conference center, we all quickly became a cohesive group. There were honest discussions about what we are doing well and what we could and should do better. No blame, no finger pointing. Our scientists tipped their hands about breakthroughs on the horizon, and our policymakers were the first to say we have to think about simplifying the road to gaining regulatory approvals for emerging technology. All the while, the introductions and reunions in the hallways were every bit as important as the formal presentations and panel discussions.

We were a little amazed ... and a lot proud.

Having recently completed our second summit, we are so grateful to those visionaries who persevered through the “yeah, buts” and kept their eyes on the prize. Not only did they believe it could be done. They understood it must be done.

We have in front of us a two-pronged challenge, perhaps the most serious dilemma of our day. Our planet is heating up at an unprecedented rate that is threatening its very existence. At the same time, we are on a trajectory that will result in a worldwide population of 10 billion by 2050, all of whom will need to be nourished.

Animal agriculture plays a hand in both issues. Ruminants in particular play a unique role in the human food supply, giving us access to calories and nutrients that would be otherwise unavailable or wasted, and there is every indication that demand for these products will continue to rise globally. Yet methane in the atmosphere is rising at an unprecedented rate. Therefore, we must continue to find ways to reduce emissions, especially the major one to come from ruminant livestock: enteric methane.

The State of the Science Summit is helping us do that.

From all of us who worked to put this year’s program together, a sincere thank you for the support, the wisdom, the time and so much more that you gave. Because of you, our dream has become a reality, and our summit is sustainable!

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