2023

SOLUTIONS TO MEET THE NEED FOR FEED

SOLUTIONS

- RESPONSIBLE SOURCING
- REGENERATIVE AGRICULTURE
- CIRCULAR INGREDIENTS
- FEEDING INNOVATIONS

WWF

FOREWORD

In early 2022, the Institute for Feed Education and Research (IFEEDER) partnered with WWF to convene feed industry leaders for a Feed Systems Sustainability Summit to advance a vision for feed sustainability, catalyze action on critical impacts and elevate learnings and best practices. This year, IFEEDER set forth its priorities and objectives in the feed industry Sustainability Road Map and began bridging from research to implementation by launching the Animal Food Industry Sustainability Toolkit to support industry development of sustainability programs.

Throughout our partnership with WWF, we focused on four themes, which are further explained in this paper: Responsible Sourcing, Regenerative Agriculture, Circular Ingredients, and Feeding Innovations. These solutions give the whole animal protein supply chain a clear starting point for putting priorities into action and reinforces the need for partnerships and business models that send strong market signals to all involved in feed and protein production.

This paper is relevant, timely and extremely useful as it demonstrates the need for investments into an enabling environment that strengthens the ability to take clear actions around the four solutions.

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COVER PHOTOGRAPH

Overhead view of bags with feed ingredients.

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EXECUTIVE SUMMARY

Terrestrial animal-sourced foods (livestock and poultry), have been a valuable part of the global agricultural landscape for millennia. Global meat production has quadrupled over the past fifty years;[2] growth in production and consumption of animal products and feed calls for increased attention to the impacts of these intertwined systems and processes. As a component of the food system's footprint, animal-sourced foods currently account for 11% of global greenhouse gas emissions,[3] 12% of global freshwater consumption[4] and have been responsible for 65% of global land use change from 1961-2011.[5] The US and Canada produce 13% of the world's terrestrial animal protein and 8% of livestock's greenhouse gas emissions.[3] Over much of the global landscape, a small number of feedstuffs comprise primary ingredients in livestock rations and represent most of the embedded environmental impact and opportunity. Feed production (including feed crops and pasture) is a common source of embedded impacts across livestock species, and represents 41% of livestock's global greenhouse gas emissions (28% in US and Canada),[6] 98% of livestock's freshwater use,[7] and major impacts to biodiversity and habitat change. The major contributors to the greenhouse gas footprint of feed are energy use embedded in inputs, production and processing; nitrogen inputs; and land-use change from cropland expansion.

While substantial progress has been achieved to date, continued improvements across the entire supply chain are needed to stay within the planet's ecological boundaries and achieve a 1.5°C future. Animal feed is a particularly challenging sustainability issue to address due to a fragmented supply chain targeting multiple species. Complex feed systems provide diverse nutrient sources for livestock and poultry including raw ingredients, processed materials, co- or by-products and leftovers. Risks to feed production due to increased extreme weather events and water constraints may further impact the efficiency, consistency, and quality of feed production. Depending on the species, feed accounts for 20 to 60% of total emissions in US production systems yet demand signals for more sustainable feed ingredients and rations are not reaching all actors in the supply chain.

Nonetheless, collective action across the feed value chain can deliver positive impacts to climate, biodiversity, water use, and protection of critical landscapes. Supply and demand market signals need to be addressed both upstream and downstream of the feed sector to develop and scale partnerships, creating and enabling a culture of increased feed ingredient transparency and traceability, and supporting cross-sector progress to share data, best practices and lessons learned along the way.

Solutions that address Responsible Sourcing, Regenerative Agriculture, Circular Ingredients, and Feeding Innovations support aligned efforts to meet corporate and national climate commitments while building climate resilience for feed systems.

Organizations considering feed solutions should:

- **ELEVATE FEED'S FOOTPRINT** to highlight that feed underpins sustainability of all other livestock commodities: advance better data, transparency, and awareness of the role of feed sourcing and sustainability solutions
- **STRENGTHEN SUPPLY CHAIN ACTIONS AND MARKET SIGNALS** to promote sustainability, transparency, collaboration, and collective efforts
- **DRIVE INNOVATIONS** including new technologies, tools and frameworks that create meaningful outcomes for nature, animal health and productivity through economically sustainable models
- **CREATE AN ENABLING ENVIRONMENT** built on sound policy that favors sustainable feed production, quality data management systems and aligned standards/ expectations with a clear value proposition
- **SHARE PRE-COMPETITIVE LEARNINGS AND BEST PRACTICES** to accelerate implementation and scaling across the sector

WHAT IS THE NEED FOR FEED?

Sustainable feed enables livestock systems to deliver on their role in achieving climate ambitions and goals. Leadership is needed to deliver strong market signals (both supply and demand) that would deliver solutions at the pace and scale needed. Action is also needed to advance the understanding and ability of efforts that halt land conversion, enhance carbon sequestration, and reduce production-stage emissions of methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) to be leading solutions to our climate crisis.

FOUR SOLUTIONS

Responsible Sourcing can halt land conversion in supply chains, thereby protecting valuable carbon stores in critical ecosystems and normalize the integration of environmental impact evaluation into feed formulation decision making.

Regenerative Agriculture interventions lead to multiple environmental benefits (e.g., interventions lead to multiple environmental benefits (e.g., biodiversity, water use, soil health) and support local producers and communities. They are key in both carbon sequestration and emissions mitigation because of the linkage to cropping system's nutrient needs (e.g., carbon, nitrogen, phosphorus, water).

Circular Ingredients reduce pressure on both landfills and land for crop production by utilizing already available "niche", novel, and alternative ingredients with important nutritional and/or functional health attributes. Leadership and action are needed to further quantify the impact and scale of available ingredients in an economically feasible way while maintaining quality and safety standards.

Feeding Innovations reduce the footprint of animal production through improved efficiency and health, and/or by lowering emissions from manure and enteric fermentation. Innovation is needed in ration formulation, ingredient development, equipment, and manufacturing and even business models that provide unique incentives for changing practices.

INTRODUCTION

Livestock are an important source of nutrition and cultural identity for many across the globe. Livestock and feed production also provides livelihoods for more than 1.3 billion people worldwide, including 2.6 million farm operators (with an additional estimated 2.5 million essential farm workers) in the US.[1] Terrestrial animal-sourced foods, historically based in grazing systems, have been a valuable part of the global agricultural landscape for millennia. Global meat production has quadrupled over the past fifty years;[2] growth in production and consumption of animal products and feed calls for increased attention to the impacts of these intertwined systems and processes.

Global livestock production currently contributes 6.2 GtCO_2e (approximately 11% of global greenhouse gas emissions (GHG)),[3] 12% of global freshwater use[4] and 65% of global land use change from 1961-2011.[5] The US and Canada produce 13% of the world's animal protein and 8% of livestock's global GHG emissions (0.5 Gt CO_2e of 6.2 Gt CO_2e in 2015).[3] In parallel, animal feeds contribute significantly to these impacts, where 41% of livestock's GHG emissions are embedded (28% in US and Canada),[6] and over 90% of livestock's water use is for growing primary feedstuff crops.[7] In the US, irrigation of cattle feed crops accounts for 23% of all water consumption nationally—the largest consumptive user.[8] Although environmental impacts vary across systems and ingredients, feed is a major contributor to the underlying footprint across all livestock species, and thus has the opportunity to meet challenges to climate and nature.

The US livestock and feed sectors have achieved significant improvements in their environmental footprint through innovations such as improved genetics, yields, animal productivity and management strategies; continued **improvements are needed to stay within the planet's ecological boundaries**. Feed systems are also impacted by the environment and a changing climate (e.g., extreme weather events, grain availability, grain quality and increased threat of disease) making it imperative that systems adapt to create sustainable feed products in a warming world. Addressing these interdependent threats and impacts can lead to opportunities for leadership and creating shared value across the supply chain while delivering nature-positive solutions for agriculture.

This report outlines four solutions to meet the need for feed: Responsible Sourcing, Regenerative Agriculture, Circular Ingredients, and Feeding Innovations. While these solutions are needed to limit global warming to 1.5°C by 2050, the capital investment necessary to change practices can be significant. Demand signals for more sustainable feed ingredients and rations are also not reaching the actors that have the power to make change. These dilemmas are important to acknowledge because no solution can be sustainable without the appropriate economic and market conditions to support it. While this paper does not solve these issues, it does elevate the need for new market opportunities to be created that address the issue specific to supply and demand of sustainable feed.

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> AS LIVESTOCK AND FEED PRODUCTION AND CONSUMPTION GROW AND INTENSIFY, CONTINUED IMPROVEMENTS ARE NEEDED TO STAY WITHIN PLANETARY BOUNDARIES.

Defining Feed Systems

Feed systems deliver diverse and nutritious inputs for animal agriculture. These inputs include raw commodity ingredients (e.g., corn, soy, wheat), processed materials (e.g., extracted/crushed oilseeds, fermented residues, heat or mechanically altered forages and grains), and by-products or leftovers of other processes (e.g., distillers grains from ethanol production, bone meal from slaughterhouse waste). Across regions and throughout time, livestock have been opportunistic consumers of a wide array of easily available feeds. Feed and livestock systems continue to evolve to make use of innovative sources of energy and nutrition, including food waste, invasive flora and fauna, and insects, among others. In all cases, input crops and ingredients are formulated and fed appropriately to support animal health and productivity.

The actors and processes that provide these inputs comprise complex feed systems and are subject to the demand influences from both the animal protein and food value chains. As illustrated in **Figure 1**, these systems are complex, fragmented, and often built on interdependencies that limit the ability of any one actor to have direct control or influence over supply chain shifts. Collaborative partnerships, support, and collective action are key to delivering successful market signals and implementing action.

What Does Meat Eat?

In 2019, the US livestock sector (not including aquaculture and pets) consumed approximately 250 million metric tons of manufactured feed; cattle utilized an additional 264 million metric tons of hays and/or crop residues (**Figure 2**).[9] This feed was produced from approximately 303 million acres of planted cropland (**Figure 3**), with primary crops including:

- 90 million acres corn (~40% of harvest used as animal feed)
- 76 million acres soybeans (~75% of harvest used as animal feed)
- 52 million acres cultivated forage
- 46 million acres wheat
- 40 million acres other row crops[10]

Additionally, ruminants grazed on approximately 600 million acres of US rangeland.[11,12] While volumes differ, proportional usage of various ingredients in livestock diets follows similar patterns nationally or globally. Over 70% of livestock feed is not edible by humans; less than 30% of total livestock feed, primarily cereal grains, is also used for human consumption.

> COMPLEX FEED SYSTEMS PROVIDE DIVERSE NUTRITION SOURCES FOR LIVESTOCK, INCLUDING RAW INGREDIENTS, PROCESSED MATERIALS, AND BY-PRODUCTS AND LEFTOVERS.

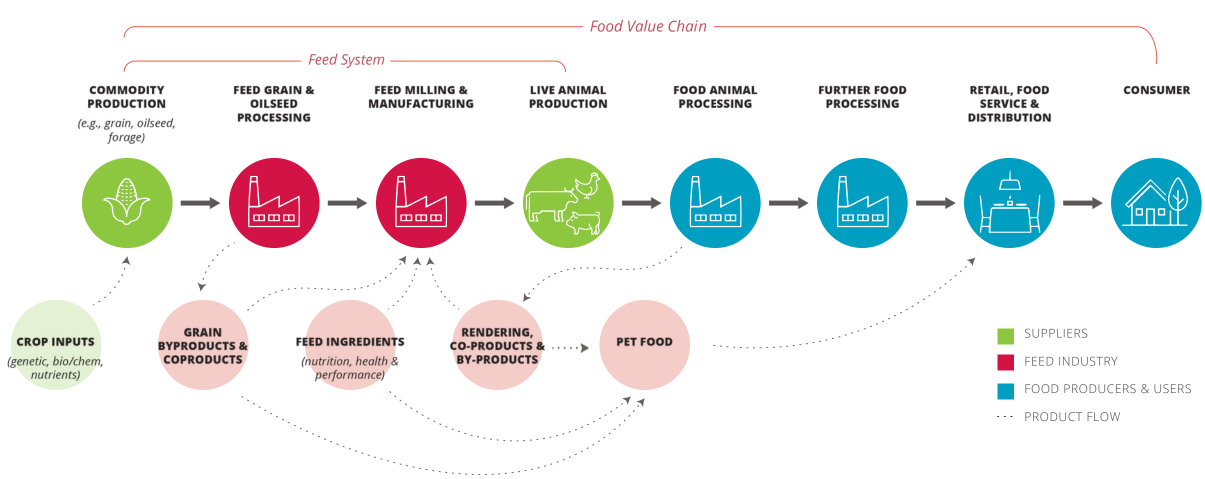


FIGURE 1. Illustration of multiple levels and integrative nature of feed and food chain industry sectors.

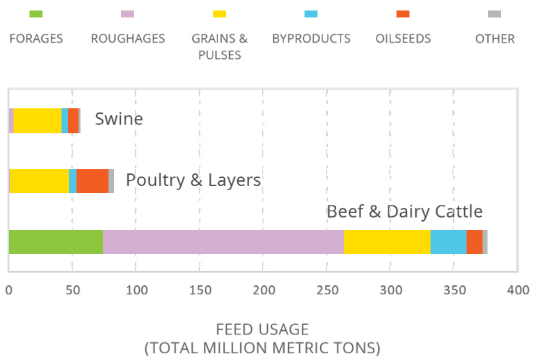


FIGURE 2. Estimated feed usage (dry matter) by livestock in the US, 2019.[9]

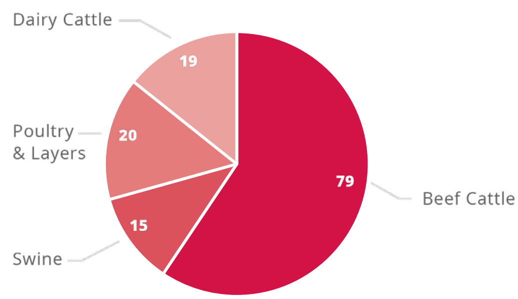


FIGURE 3. US land-use for forage and feed production by livestock group (million acres). Adapted from Eshel et al.[13]

The Feed System's Impact, Challenges and Opportunity

> THE FOOTPRINT OF FEED IS A SIGNIFICANT COMPONENT OF THE FOOTPRINT OF LIVESTOCK, ACROSS ALL LIVESTOCK COMMODITIES. THE FOOTPRINT INCLUDES IMPACTS TO CLIMATE, BIODIVERSITY, FRESHWATER USE, AND LAND-USE CHANGE.

Feed is produced through a complex, fragmented system that is a source of environmental impacts and faces unique challenges from environmental degradation and climate change. Actions taken by one segment or sector influence the rest of the system; however, current market signals are not strong enough to penetrate the complex and fragmented value chain, leaving those who can implement changes financially unincentivized to make them. Market opportunities to address the embedded environmental footprint of feed are not yet sufficient to drive all sustainable feed solutions. Nevertheless, the entire system will be more resilient to shocks and stresses (e.g., extreme drought, rain, and flooding) through improvements made to reduce feed's environmental impacts. For these reasons, all actors in the animal protein supply chain need to collaboratively build flexible, holistic solutions that create shared value.

FEED'S IMPACT ON THE ENVIRONMENT

In the US and Canada, approximately twenty percent of livestock's carbon footprint (over 100 MtCO_2e/year)[3] is associated with the production and manufacturing of feeds (**Figure 4**). This includes:

- CO_2: emissions of carbon dioxide associated with the production of synthetic fertilizers and pesticides, energy consumption for tillage, crop management, harvest, and storage and, in the case of some feed materials such as by-products, with ingredient processing. For some crops, emissions include the transport and the energy used in blending and pelleting.[14]
- N_2O: nitrous oxide emissions derive from nitrogen inputs, such as fertilizer application, manure application and deposition, nitrogen from crop residues, biological fixation, and natural deposition, in the form of direct and indirect emissions, through volatilization and leaching.[14]

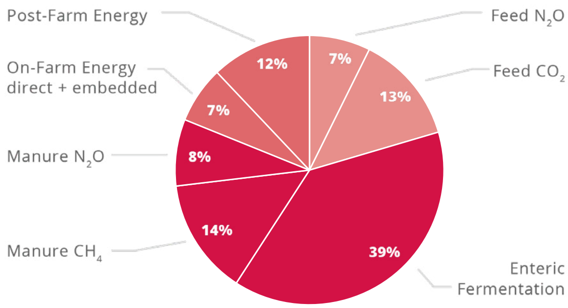
Land-use change from cropland expansion is responsible for additional CO_2 emissions, ranging from roughly 18% (fed beef cattle) to 44% (chicken) of total feed-related emissions for US-based livestock production systems.[15]

The relative contribution of feed-associated emissions varies by species, with the largest impact in monogastric systems (60% and 35% of cradle-to-processing emissions in chicken and pork production, respectively) (**Figure 5**).

> FEED ACCOUNTS FOR ROUGHLY 20-60% OF TOTAL EMISSIONS FOR US LIVESTOCK PRODUCTION SYSTEMS, DEPENDING ON THE SPECIES.

Enteric methane emissions from livestock contribute ~39% of livestock's carbon footprint[3] and while enteric methane emissions are not attributed to feed systems, parameters such as livestock diet composition, feed efficiency, genetics, health, and management practices heavily influence the amount of GHG emissions produced through enteric fermentation.[16,17]

Soy production is a major driver of deforestation and land conversion in the Brazilian Cerrado biome;[18] however, **the conversion of natural landscapes to cropland is not confined to South America.**



*Land-use change from cropland expansion not included

FIGURE 4. Contribution of GHG emissions by source for livestock production (cradle-to-processing) in Northern America in 2015, not including CO_2 emissions associated with land-use change from cropland expansion (GLEAM v3.0).[3] Total footprint = 502.4 $MtCO_2e$. NOTE: livestock feed is also a significant driver of **cropland expansion and land-use change** in the US and Canada, although not included in the GLEAM calculations shown here. US cropland expansion in 2017 was responsible for approximately 93 $MtCO_2e$ of GHG emissions in 2017.[15]

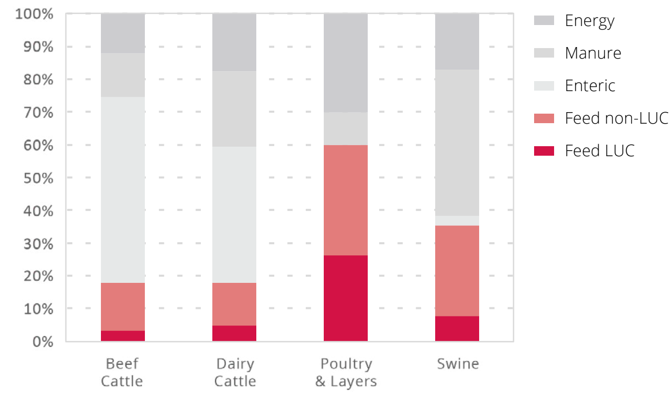


FIGURE 5. Proportion of cradle-to-processing greenhouse gas footprint attributed to feed, enteric emissions, manure, and energy (on-farm and post-farm) for livestock commodities in US production systems. Feed includes emissions from land-use change associated with cropland expansion for each supply chain as well as feed production emissions of N_2O and CO_2. Data from GLEAM v3.0[3] with LUC calculations based on Pelton et al.[15]

THE MAJOR CONTRIBUTORS TO THE FOOTPRINT OF FEED ARE ENERGY USE EMBEDDED IN INPUTS, PRODUCTION, AND PROCESSING; NITROGEN INPUTS; AND LAND-USE CHANGE FROM CROPLAND EXPANSION.

Today, savannas in Africa and prairies in North America are being converted as well. The loss of grassland to cropland expansion is driven by many factors including policy, economics, climate change, and shifting land uses. For example, over a 15-year period from 2001-2016, 4.4 million acres of cropland was displaced by urban buildup.[19] By comparison, over a 5-year period from 2016-2020, 9.5 million acres of grassland across the US and Canadian Great Plains was converted to cropland for increased production of wheat, corn and soy.[20] Land-use change is a significant driver of greenhouse gas emissions, and other types of development can present direct challenges to adequate land for agricultural production. Nonetheless, US cropland expansion for corn, soy, and wheat in 2017 was responsible for release of approximately 93 $MtCO_2e$.[15] Deforestation and land conversion also lead to substantial changes in hydrological flows which disturb natural ecosystem services and, depending on the local context, can alter precipitation patterns, groundwater levels and sediment runoff.[21]

Livestock's water usage is primarily used to produce feed crops. Global animal production requires about 335 billion m^3 water per year,[4] with a staggering 98% of the water used in the production of animal feed, with drinking water, service water and feed mixing water accounting for only 1.1%, 0.8% and 0.03%, respectively.[7] Water availability throughout feed systems is an increasing priority, with primary production regions in the US already under stress for differing reasons: the Northeast and Midwest face water quality issues from agricultural sediment/nutrient losses and subsurface drainage, respectively, whereas the Southeast, Southwest, Great Plains and Western regions are experiencing volume declines due to increased drought and demand for crop irrigation.[22] Irrigation of cattle-feed crops (including alfalfa and grass hay and haylage, corn silage and sorghum silage) is the single largest consumptive user of freshwater in the US at both regional and national scales, accounting for 23% of all water consumption nationally, 32% in the western US and 55% in the Colorado River basin.[8]

RISKS TO FEED PRODUCTION

Risks to the feed system are becoming more prevalent each year—increased frequency of extreme events such as flooding, water shortages, drought and wildfire are all impacting efficiency and effectiveness of feedstuff production. These interconnected risks also lead to disease and pest threats, water quality and management concerns, and many other complex issues—linked through physical, economic, and political systems that can result in markedly different potential futures for livestock production.[23]

Feed manufacturers and livestock producers also must consider feedstuff quality risks, which are critical to managing livestock heat stress associated with a warming climate. Reduced feed consumption that accompanies heat stress means that higher nutrient density and more digestible diets are needed to maintain productivity in the livestock, most efficiently achieved through higher energy from fats rather than proteins or carbohydrates. Increased electrolyte and other minerals, along with antioxidant nutrients, phytochemical and other additives also prove supportive. Thus, not only feed amounts, but also composition remain in flux.

Beyond these risks, it is difficult to enact system level change because market demand signals for more sustainable feed ingredients and rations are often not reaching commodity crop or live animal production where change can be implemented. System changes will require all actors in the food value chain to collaboratively build incentives and market signals that can catalyze the changes needed. Until broader market signals are sent, supply of products and strategies contributing to lower impact feeds remain insufficient, and scale remains out of reach.

> INCREASED EXTREME WEATHER EVENTS AND WATER CONSTRAINTS WILL IMPACT THE EFFICIENCY, CONSISTENCY, AND QUALITY OF FEED PRODUCTION.

FEED SYSTEM'S OPPORTUNITY

The opportunity for feed systems to make substantial contributions toward a 1.5°C target[24] and address impacts to biodiversity exist within three major categories of GHG emissions (**Figure 6**):

- halting conversion of carbon-rich ecosystems (forests, grasslands, wetlands, peatlands)
- enhancing carbon sequestration by land used to grow crops and livestock
- further reducing methane and nitrous oxide emissions of feed ingredients[16,24]

As discussed throughout this paper, the feed system needs the support and resources of the full value chain to deliver these actions in a way that is effective, scaled and economically feasible. While implementation needs and market signals will vary based on supply chain structure, **now is the time for collective action that identifies critical needs across systems and aligns both priorities and investments across all three categories of GHG emissions, creating a proliferation of standard solutions that increase feed systems sustainability, effectively raising all boats and greatly increasing the likelihood of successful implementation**. Prioritizing climate action also creates opportunities for important co-benefits to be achieved across impacts such as water use and water quality, biodiversity, and land use efficiency.

> COLLECTIVE ACTION ACROSS THE FEED VALUE CHAIN CAN MAKE MEANINGFUL PROGRESS TOWARD REACHING A 1.5°C FUTURE AND DELIVERING POSITIVE IMPACTS TO BIODIVERSITY, WATER USE, AND PROTECTION OF CRITICAL LANDSCAPES.

All solutions require investment in a strong enabling environment built on sound policy, strong market signals, quality data management systems, aligned standards, and clear value propositions. Solutions should be anchored on the following considerations:

- **BE CLEAR ON WHY FEED SUSTAINABILITY MATTERS—** Organizations within the feed value chain can clarify to their leadership teams, employees, customers, and suppliers on why nature-based solutions matter, their role in delivering those solutions, and what they will prioritize to achieve it. This clarity of purpose and focus will strengthen alignment of value chain efforts
- **SOLVE FOR NECESSARY DATA NEEDS—**Collective action on feed systems can close the gap on relevant needs for data systems and work to solve priorities such as:
  - Feedstuff composition data, animal response variables, and regional, national, and global commodity LCA improvements
  - Promote standardizing the quantification of environmental impacts to strengthen the business case for a value chain and company to implement feed sustainability solutions
  - Further engagement and education of the interconnected issues, risks, and opportunities of feed system sustainability
  - Normalize data transparency and traceability at all levels of the value chain
- **SEEK OUT NEW PARTNERSHIPS AT SCALE—**New partnerships that stretch beyond the feed system, anchor on sound science, are clear on the value proposition, leverage the best of existing efforts, and transparently communicate progress, failures, and learnings.
- **MAKE PROGRESS OVER SEEKING PERFECTION—**The size, scale and speed of action and partnership needed can make many uncomfortable and unwilling to act. Stakeholders that prioritize progress and are willing to be uncomfortable with what's ahead of them can elevate and inspire others to pursue their own progress instead of waiting for a perfect solution. Better data and action must occur simultaneously.

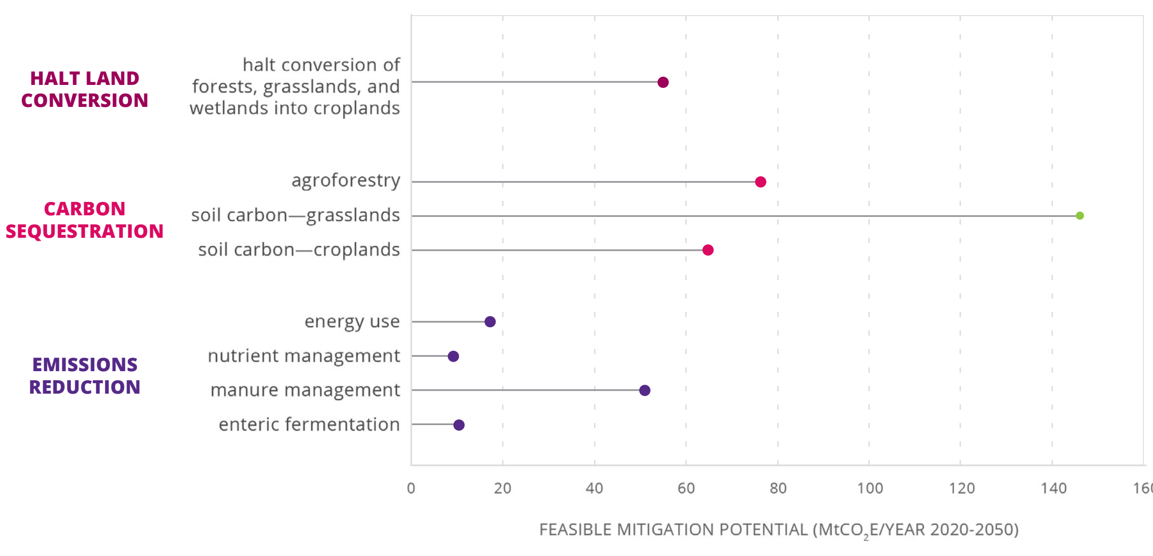


FIGURE 6. The potential for US food systems to mitigate climate change through halting land conversion, enhancing carbon sequestration, and reducing production-stage emissions of CH_4, N_2O, and CO_2. Carbon Sequestration and Emissions Reduction measures are cost-effective mitigation values (possible up to $\$100\ /tCO_2eq$) from Roe et al.[24] Halt Land Conversion value is the mitigation potential as calculated by Eagle et al.[25] at a price of $\$10/tCO_2eq$.

SOLUTIONS TO MEET THE NEED FOR FEED

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The four solutions outlined below can be used as a guide for collective action that creates a stronger enabling environment and scalable implementation, and while no single solution will work for all stakeholders across the value chain, no one alone can accomplish the food system mitigation potential (outlined in **Figure 6**).

Responsible Sourcing of feedstuffs contributes to halting land conversion impacts embedded in food products,[15] thereby protecting valuable carbon stores in critical ecosystems. Actions may also focus on minimizing negative impacts on biodiversity, water use, excess nitrogen application and/or GHG emissions.[15] Transparency and traceability create foundational components of sustainable feed systems by delivering the mechanism for credible emissions reductions (direct and embedded). Responsible sourcing implementation can be aided by leveraging existing and new technologies to further sector-led cooperation and coordination to integrate evaluation of environmental impacts with feed formulation decision making.

Regenerative Agriculture is a holistic and place-based approach that Indigenous People have developed, evolved, and advanced as part of food systems that improve planetary, human, and economic health. This holistic and place-based approach increases biodiversity, protects water ecosystems, builds soil health, mitigates climate impacts, and adapts to climate change, supporting producers and communities to thrive, while also producing nutritious food. Feed systems should focus on understanding the value proposition for adopting practice change while implementing with an eye towards achieving multiple outcomes.

Circular Ingredients including regionally "niche," novel, and alternative ingredients are feeding strategies with important nutritional and/or functional health attributes that display potential for broader and sustainable use in the feed industry. These circular systems reduce greenhouse gas emissions during feed and animal production, displaying the critical role that livestock feed can play in capturing the value (or underutilized by-products) from other systems' waste streams. These systems use crop residues, by- and co-products of the feed/food industries, as well as significant quantities of available streams of human food surplus, providing sustainable and safe alternative ingredients in a closed system that are nutritionally relevant and economically viable.

Feeding Innovations in feed rations and ingredients can reduce the footprint of animal production through improved efficiency and health, and/or by lowering emissions from manure and enteric fermentation. There are opportunities to improve animal wellbeing and performance while also improving the efficient production and use of commodity feedstuffs to concurrently reduce pressure on the landscape. The use of some genetically modified seed technology in the US has been shown to increase crop yields. Technologies that increase crop productivity and intensification sustainably have the potential to reduce the need for land conversion, as well as to reduce tillage and fuel usage, contributing both environmental and economic benefits.[26] Precision feeding and ration formulation approaches can customize feed delivery to meet individual animal or group needs at a particular point in time; additives can alter animal performance and diet utilization. Thus innovation in feeds is not limited to specialized ingredients; new tools, systems and processes are needed to speed adoption of all feed sustainability solutions.

THROUGH A COLLABORATIVE PARTNERSHIP WITH THE INSTITUTE FOR FEED EDUCATION AND RESEARCH (IFEEDER) CULMINATING IN A FEED SUMMIT, WWF RECEIVED CASE STUDY EXAMPLES OF A VARIETY OF WAYS THAT THESE SOLUTIONS CAN BE ACTIVATED AND IMPLEMENTED. THANK YOU TO EVERYONE WHO SHARED THEIR INSIGHTS THROUGH A CASE STUDY! LOOK FOR THESE BLUE BOXES FOR DIRECT INSIGHTS FROM THESE EXAMPLES.

SOLUTIONS TO MEET THE NEED FOR FEED

RESPONSIBLE SOURCING

Responsible Sourcing occurs through supply chain transformation including commitments and meaningful action toward eliminating all deforestation and land conversion from the feed system and supply chain. The UN High-Level Expert Group on Net Zero[27] calls for a stop to all land conversion by 2025: ensuring that operations and supply chains don't contribute to deforestation, peatland loss and the destruction of remaining natural ecosystems. Companies can assess their current exposure to deforestation and conversion, considering all natural ecosystems that impact above- and below-ground carbon, and commit to time-bound targets and milestones that reflect the urgency of the issue.[28,29] **Credible implementation plans must include cut-off dates (a date after which no deforestation or conversion is permitted) and target dates (a date in the future by which the whole supply chain is free of deforestation and conversion).** Supply chain transformation will be driven by strong market signals and full traceability infrastructure to the farm level, support for direct and indirect suppliers to act across their operations, and mechanisms to verify implementation along with public disclosure of the plan, monitoring, and progress toward the goal. Commitments and real action to end deforestation and conversion are a critical part of ensuring credible corporate AND commodity production pathways to net zero.[30]

> RESPONSIBLE SOURCING INCLUDES COMMITMENTS AND ACTION TO END HABITAT CONVERSION; INTEGRATING SUSTAINABILITY METRICS INTO FEED FORMULATION; RESEARCH AND DEVELOPMENT OF INNOVATIVE AND RESILIENT CROP VARIETIES; AND EFFECTIVE PUBLIC POLICY.

Responsible sourcing implementation also leverages existing and new tools to integrate environmental impact analysis into feed formulation alongside historic least cost and nutrient formulation approaches. Since feed systems produce to meet customers' requests, increased use of such tools must originate within the livestock sector. Education is needed across the livestock sector to build awareness and competency of using these tools, which will support a better understanding of the value they create when a more holistic and integrated approach is taken, while also supporting industry efforts to further develop and improve data quantity, quality, and integration.

New varieties of commodity feed crops including annuals and perennials, with enhanced attributes to address the challenges of climate change and animal nutrition, are under development through either genetic modification or classical breeding technologies to promote feed efficiency. Feed systems can prioritize research to assess the characteristics and benefits of these new crops as feedstuffs, as such ingredients could become important dietary solutions in the future.[31] Existing facilities and infrastructure may need to be adapted to address logistical constraints as these solutions become more widely available, and care must be taken (by the upstream production side) to ensure that use of new feed ingredients does not lead to increased land conversion.

FEED SYSTEM INSIGHTS: RESPONSIBLE SOURCING

INTEGRATION OF ENVIRONMENTAL IMPACTS INTO FEED FORMULATION

Traditional least-cost formulations target productivity through optimized dietary nutrient balance but neglect important environmental sustainability considerations. Integrated cloud-based feed formulation and environmental analysis software enables companies to consider environmental impact benchmarking (using primary and secondary life cycle analysis (LCA) data, nutrient optimization, and systems transparency as part of the formulation process. During the Feed Summit, technical leaders from BASF shared their learnings to date since their market launch of the **Opteinics™** solution that delivers such integrated capabilities and offered the following considerations regarding the opportunity to scale these solutions:

- Design tools with feed customer in mind
- Seek partners with complementary competencies
- Treat interoperability as a core principle
- Increase precision with relevant primary data (farm/field)
- Invest in producer/grower engagement and education

Click **here** to learn more.

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SOLUTIONS TO MEET THE NEED FOR FEED

RESPONSIBLE SOURCING

Effective public policy that supports and reinforces Responsible Sourcing should incentivize keeping grasslands and other habitats intact, while also fixing problematic policies that are proven to speed land conversion by de-risking or incentivizing transformation of the land from its natural state to another purpose. One impactful policy that would ensure native grassland protections would be to strengthen and expand the Sodsaver program by providing nationwide eligibility and making recently converted sod acreage ineligible for any crop insurance subsidy for 10 years.

Responsible Sourcing must also be considered within the grazing community through sustainable conservation and management practices. Keeping grasslands intact not only helps conserve biodiversity, but ensures cleaner streams, less fertilizer runoff, more pollinators for plants, and more carbon stored in the soil. Permanent cover of forage plants, native or eco-system appropriate trees/shrubs and ruminants in agricultural systems can keep organic carbon in soils and, if well managed, can increase soil organic carbon, improve soil ecological function by minimizing damage from tillage and fertilizers, and provide wildlife habitat.[32,33] Assessing structure and nutrient balance of pastureland soils routinely, with amendments applied as indicated based on testing, contributes to appropriate nutrient cycling.

Improved quality of forages and supplemental feedstuffs can reduce GHG emissions from large ruminants because low quality feeds, including highly fibrous ingredients, lead to poor digestion and generation of higher amounts of enteric methane.[34] Feed systems servicing grazing animals can target actions that increase pasture productivity and diversity through improved forage species (e.g., grass and/or legume mixes), as this is an important step toward more sustainable livestock production.[35] Meta-analysis of beef production in different regional management systems documented that improved pasture forages reduced GHG emissions up to 20% in one Brazilian study; globally, GHG reduction potential from this strategy averaged ~5 to 11%.[36] Further, and depending on the value used for global warming potential of methane, grazing cattle under good land management in healthy soils with active microbial life have the potential to sequester carbon and reduce greenhouse gas emissions.[37]

FEED SYSTEM INSIGHTS: RESPONSIBLE SOURCING

DEVELOPING RANCHER-CENTERED STRATEGIES FOR GRASSLAND CONSERVATION

WWF's Sustainable Ranching Initiative, started in 2011, works with landowners, corporations, industry-groups, NGOs, and government agencies to protect lands from grassland conversion, improve management on working lands, and restore cropland or degraded lands back to native grassland. We do this by:

- Empowering local groups to develop long-term conservation agreements, easements, and innovative land management strategies
- Incentivizing good conservation practices through certification programs, tailored management recommendations, and technical expertise
- Leveraging funds for on-the-ground projects
- Promoting whole ranch management

By first listening to the ranching community, trusting in their knowledge of sustainable land management, and learning from their adaptability and resiliency in a volatile marketplace, we are ensuring that our strategies and solutions will benefit both people and nature.

Click **here** to learn more.

SOLUTIONS TO MEET THE NEED FOR FEED

REGENERATIVE AGRICULTURE

Regenerative Agriculture supports a transition to conservation practices and adoption of technologies that deliver positive outcomes that are contextually relevant to the local environment including biodiversity, intact ecosystems and habitat; water balance and quality; soil health; reduced greenhouse gas emissions and increased carbon sequestration; resilience to climate change; improved producer livelihoods and rural economies; and nutritious food production, circularity, and accessibility. Considerations for activating regenerative agriculture solutions within a supply chain include focusing on understanding the value proposition for practice change while implementing with an eye towards achieving multiple outcomes through a "both/and" approach that supports sequestering carbon in healthy soils AND reducing nitrous oxide emissions to limit future global warming.

Companies can support public policy and investments that encourage a transition to producing and delivering sustainable feed to livestock producers. This could include a call to broaden the safety net for crop diversity and sustainability, improving access to whole farm crop insurance and increasing crop diversity covered within farm support programs.

> REGENERATIVE AGRICULTURE INCORPORATES PRACTICES AND TECHNOLOGIES THAT DELIVER POSITIVE OUTCOMES TO THE LOCAL ENVIRONMENT AND ENCOURAGES PRODUCTION OF DIVERSE AND SUSTAINABLE FEEDS.

FEED SYSTEM INSIGHTS
REGENERATIVE AGRICULTURE

A FRAMEWORK FOR FARM-LEVEL SUSTAINABILITY PROJECTS

Farmers for Sustainable Food led a multi-pronged project to develop and test a replicable pathway to assess environmental and financial outcomes driven by on-farm conservation and management practices focused on water quality and on-farm sustainability metrics. This 40,000-acre case study summarized three years of crop data (2019-2021) using bundled tools including: Field to Market's Fieldprint Platform™ for sustainability metrics, the Prioritize, Target and Measure Application (PTMApp) to define impact to local water resources, and FINPACK® software for farm financials. Benchmarks were integrated within the model for three feed crops (corn grain, corn silage and alfalfa) encompassing:

- Field-level: soil conservation, soil carbon, energy use, greenhouse gas emissions, water quality, biodiversity, and land use efficiency
- Watershed level: surface water (sediment, phosphorus, and nitrogen loss), groundwater sensitivity, and estimated pollution reduction estimates for implemented conservation
- Financial: yield, direct cost, and gross return

Overall, the initial data documented 839 conservation practices used on fields (2021 data), averaging 5 per field, with the top six identified as grassed waterways (159), cover crops (129), contouring (120), reduced tillage (112), strip-cropping (102) and no-tillage (31), resulting, over the past three years, in:

- Better performance across all environmental categories (except grain GHG) when compared to national data
- Water quality improvements, with changes in both sub- and surface water mitigation pathways
- Reduced sediment loading by 28% (2 tons/acre/year) compared to baseline scenarios
- Prediction of added cover crops in 50% of fields to reduce sedimentation a further 54% in the project watershed.

These benchmarks demonstrate how farm-level continuous improvement contributes to and performs against project/state/national levels. The project also informs farm and supply chain goal setting, monitored over time. Two additional years of data collection are expected prior to final project summarization.

Click here to learn more.

SOLUTIONS TO MEET THE NEED FOR FEED

REGENERATIVE AGRICULTURE

FEED SYSTEM INSIGHTS: REGENERATIVE AGRICULTURE

UNLOCKING LOW EMISSIONS CROPPING SYSTEMS THROUGH INCLUSION OF SMALL GRAINS IN FEED RATIONS

Sustainable Food Lab and Practical Farmers of Iowa have been convening global food and beverage companies and non-profit partners to build the business case to drive market demand of small grains grown in an extended crop rotation system. Adding a third crop like oats to the US corn-soy system is a key to unlocking more regenerative and lower emissions feed crops. A cattle feeding trial evaluated animal performance and health outcomes, greenhouse gas emissions impacts, farm feasibility, and economic implications of displacing corn with oats in a standard feed ration. There was no statistically significant difference in body weights, cattle performance, or carcass quality between the cattle fed the oat ration and the standard corn ration. At the farmgate, GHG emissions are reduced when considering the sequestration benefits of the extended rotation system and there have been observed water quality benefits of the extended rotation system compared to a standard corn/ soy rotation. However, it did cost more for the cattle operation to finish cows on the oat ration compared to the standard corn ration. While the livestock sector is a critical market to stimulate small grains grown in the Midwest, the feeding trial revealed that further exploration is needed to scale inclusion of small grains in feed rations. The Sustainable Food Lab and Practical Farmers of Iowa are actively exploring the following in their continued partnership:

- Understanding the optimal livestock small grain inclusion rate in feed rations that balances costs, performance and GHG and regenerative benefits; the economics may not be suitable at the finishing stage for certain animals
- Evaluating the manure management benefits, including GHG emissions changes, from applying manure in an extended rotation system (small grain, legume cover crop, corn/soy)
- Identifying other avenues for the feed sector to generate market demand for small grains grown in the US Midwest; for example, a "cover crop after corn" feed commitment would stimulate demand for small grain cover crop seed which would drive more small grain production in the Midwest

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SOLUTIONS TO MEET THE NEED FOR FEED

CIRCULAR INGREDIENTS

Circular Ingredients are characterized by increased use of crop residues, by- and co-products of the feed/food industries, as well as significant quantities of available human food waste streams, providing sustainable alternative ingredients in a closed system. Circularity implies recycling or upcycling feed/food nutrients or energy and may be further enhanced or integrated into feeds through processing, acknowledging constraints/evaluation as safe, nutritionally relevant, and economically viable ingredients. When optimized, these systems support balance of ingredients within rations, avoid methane emissions from landfills, contribute to reduced demand for commodity crops and can reduce the risk of land conversion for feedstuff production.

By-products, co-products and non-commodity ingredients represent nearly 30% of global feed intake.[34] Livestock (particularly poultry and swine) raised on various non-grain alternative feeds can decrease feed-food competition and free up about one quarter of global arable land.[38] In the US, roughly 10% of surplus food (6.9 M metric tons) is already sent to animal feed,[39] with about half (3.4 M metric tons) coming from the manufacturing sector and 1.6 M metric tons from grocery retail. While animal feed is a leading option for some of these sectors, approximately 13.3 M metric tons of food surplus ends in landfill, contributing to nearly 20% of total US methane emissions coming from waste management.[40] Total food waste generation estimates in the US are much higher (over 25 M metric tons annually),[39] but only about half (13.3 M metric tons) are estimated as effectively viable for waste-to-feed pathways with current technologies and practices.

While by- and co-products have been fed to livestock for years, their increased utilization in addition to food waste streams in animal feed is consistent with FAO recommendations for improved integration of livestock in circular bio-economies.[41] Each of these categories may also be further enhanced and integrated into animal feeds through dehydration or fermentation[42] or even upcycled through use as dietary substrate for insects.[43]

Other protein feed ingredients for livestock that contribute minimally to land conversion or GHG emissions include insects, algae, single-cell proteins, bacteria, and yeast-derived proteins.[44] Each of these has use not only as dietary ingredients; enhanced nutritional and health benefits can also be derived through fermentation technologies, and waste streams can be further utilized as fertilizers.[45-47]

LIVESTOCK FEED CAN PLAY A CRITICAL ROLE IN CAPTURING THE VALUE FROM LEFTOVERS AND WASTE STREAMS. BY-PRODUCTS, CO-PRODUCTS, AND NON-COMMODITY INGREDIENTS REPRESENT NEARLY 30% OF GLOBAL FEED INTAKE.

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FEED SYSTEM INSIGHTS: CIRCULAR FEEDING SYSTEMS

RECOVERING RETAIL MILK FOR ANIMAL FEED

Initially a problem, near-date milk previously destined for landfill became an immediate feed opportunity. In 2007, International Ingredient Corporation (IIC), with support from Green Field Solutions (GFS), began working collaboratively with milk bottlers to turn perishable liquid milk into a shelf-stable, dry powder. This upcycled product returns milk proteins, fats, and lactose to animal diets as a safe and nutritious ingredient used primarily in pet foods and milk replacers, keeping both the milk itself and packaging out of landfills. Projects like this not only solve environmental issues and animal nutrition demands, but they also create a market signal that investing in sustainability can be profitable and integrated into the existing business model of many co-product and by-product organizations. Based on the success of this project, IIC was able to access new market opportunities and apply this and other new learnings to other upcycled ingredients such as cheeses and candies.

Click here to learn more.

SOLUTIONS TO MEET THE NEED FOR FEED

CIRCULAR INGREDIENTS

Supporting standardized and updated policy recommendations that encourage broader utilization of food scraps (excesses or residuals) as animal feed reinforces a growing interest from the private sector in more circular feeding solutions. When implemented in accordance with federal laws and handling protocols, safe and nutritious ingredients can be provided that encompass all the environmental benefits of landfill diversion as well as contribute to enhanced ingredient options. Incentives for incorporation of potential waste streams into feed should be prioritized and logistics streamlined; guidance should provide clear pathways for implementation and remove unnecessary restrictions.

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FEED SYSTEM INSIGHTS: CIRCULAR FEEDING SYSTEMS

BENEFITS & TRADE-OFFS OF FOOD WASTE-TO-FEED PATHWAYS

WWF's Food Loss and Waste team published a study[48] to understand the benefits and trade-offs of food waste to feed pathways in the US laying hen diets. They evaluated the environmental impacts of producing three food-waste-based alternative feed ingredients:

- Black soldier fly meal, derived from processed black soldier fly larvae (BSFL) into meal and fed to layers. Larval feed is made from retail produce waste,
- Food waste feed, as chemically digested food-waste pellets made from retail produce waste
- Bakery meal, made from bakery waste

Results from the Life-Cycle Assessments (LCAs) that included food-waste-based ingredients in layer diets can lead to environmental trade-offs, mostly to increases in the carbon footprint and potential water consumption, but providing benefits on land use, land use change, and marine eutrophication. These findings indicate that the use of food waste as feed for laying hens has the potential for only modest environmental improvement, while carrying risks of significantly higher environmental impact. This report reaffirmed many assumptions that the emphasis should be kept on preventing food waste wherever possible as the top priority. However, there is a realization that there will always be some percentage of unavoidable food waste that cannot be prevented, and that unavoidable food waste must be managed via a circular system—never land-filled. The most impactful learning from this study was that waste-to-feed pathways have the potential to provide modest benefits from a land footprint perspective when replacing the commodity grains. It remains possible to reduce demand for corn and soy by utilizing larger amounts of food waste for feed, which could have a positive impact on further land use change and native habitat conversion.

Click **here** to learn more.

SOLUTIONS TO MEET THE NEED FOR FEED

FEEDING INNOVATIONS

Feeding Innovations include novel feed rations and ingredients that reduce the footprint of animal production through improved efficiency and health, and/or by lowering emissions from manure and enteric fermentation. Further, they may provide opportunities to improve animal welfare and performance along with reduced demand for commodity crops and concurrent pressure on the landscape. There are numerous alternative feed ingredients on the market or in early stages of development that hold potential to reduce environmental impacts of feed. While some have been available for many years, there are important considerations to know whenever acting on opportunities in this space such as:

- Dietary ingredients including probiotics, enzymes, and additives that all have the potential to increase feed-to-gain ratios, health and/or otherwise impact the environmental footprint of production require robust evidence relative to their use with conventional feedstuffs regarding efficacy, safety (human, animal, environmental), nutritional value, economic and social impacts
- Integration of additional ingredients in the diets of high-producing livestock and poultry breeds must be implemented carefully with attention to genetics, nutrient balance, and animal response, and additionally not lead to increased land conversion for new ingredient production
- Due to the risk and history of disease transmission associated with feeding food waste to livestock, regional policies exist presenting barriers to implementation and should be acknowledged and addressed

> **INNOVATIONS IN FEED INGREDIENTS AND PROCESSES CAN REDUCE THE FOOTPRINT OF BOTH FEED AND ANIMAL PRODUCTION SYSTEMS.**

Seaweed-based ingredients have shown great promise for improved productivity and immune function in monogastric animals, including aquaculture,[49] swine and poultry species[50] as well as continuing work with ruminants. Further research continues to determine long-term effectiveness, economic feasibility, scalability, feeding logistics, safety, palatability, food product quality (e.g., taste of meat or milk), and social and environmental sustainability, working across multiple disciplines and species.

FEED SYSTEM INSIGHTS: FEEDING INNOVATIONS

THE EFFECT OF SEAWEED AND RAPESEED PROTEIN FOR ANIMAL FEED

Solid-state lactofermentation requires less water and energy than traditional fermentation. Secondly lactofermentation—unlike yeast fermentation—makes lactic acid and not CO_2, resulting in a valuable by-product rather than a waste stream following the fermentation process. Through fermentation, we can utilize seaweed and rapeseed for an economically feasible feed, with fewer fertilizer, transportation, and deforestation/land conversion costs. Fermented feed improved the gut health and capacity, the animals utilize the fermented feed better, and consequently, less feed is needed. As a result, less nitrogen and phosphorous is deposited into the environment.

European Protein, along with their ingredient suppliers and research partners, have deployed a patented fermentation method in a study of sows to utilize a local source of protein and ingredients for feed that increases the health of sows and piglets—reducing the need for antibiotics and medicinal zinc, and produces an economically feasible protein source. Microbiome data from >1,000 sows, fecal and blood samples, and farm production data demonstrated a significant increase in gut health and productivity when fed with fermented rapeseed and seaweed:


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- More weaned piglets per litter
- Reduced feed conversion rate
- Reduced mortality
- Reduced low-grade inflammation in blood
- Increased gut microflora diversity
- Reduced number of pathogens in feces
- Price neutral or improved margin for the farmer

European Protein and Ocean Rainforest have secured additional funding to conduct the largest sow trial to date in the EU. The aim is to map the feed's mode of action, answering why the inclusion of seaweed induces health and productivity for sows and their offspring.

Click here to learn more.

SOLUTIONS TO MEET THE NEED FOR FEED

FEEDING INNOVATIONS

Currently, many innovations face barriers related to scale and cost of production as well as weak consumer and customer demand that limits incentive for livestock producers to change primary feeding practices. Additionally, there is limited signal from governments, livestock producers, food companies or consumers to encourage investors to finance research and development of feed solution options that would lead to price parity for sustainable feed solutions.

Feeding innovations targeted at reducing enteric methane emissions

Innovation is needed across the private and public sector to enhance opportunities to develop, market, and use methane-reducing products in the US while ensuring safety, efficacy, and public confidence. Multiple trials of feeding seaweed-based ingredients,[51-53] herbal ingredients containing phyto-active constituents, and other types of additives have demonstrated the potential to reduce enteric methane emissions from cattle by 10-90%,[51-55] acting as methane inhibitors (**Figure 7**).

A recent and comprehensive global meta-analysis of effective ruminant methane emission mitigation strategies reflects an array of options and range of efficacy, decreasing emissions on average 12% while increasing animal production 17% (Fig 7; modified from Arndt, et al.[17]). Single strategies alone were insufficient; only simultaneous adoption of multiple and the most effective strategies met climate goals, underscoring the need for multi-level approaches within the feed sector.

There is a need and opportunity to develop and deliver additives for grazing systems in particular. Enteric methane from cattle comprises over 35% of the total GHG footprint of US livestock,[3] and roughly 70% of cattle are in cow-calf beef systems.[56] However, there is greater momentum and marketing of additives to reduce methane emissions from cattle in confined (feedlot and dairy) operations with regular and controlled feeding. In a recent small survey of international feed additive manufacturers, none identified grazing as a highest priority market and only 25% said there were additives being developed for commercialization in a grazing industry.[57]

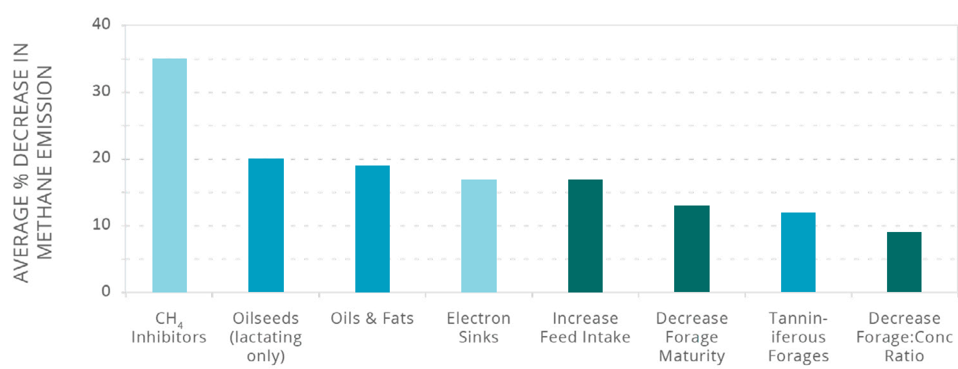

FIGURE 7. Potential impact of effective feeding management/dietary manipulation strategies for lowering ruminant methane emissions; teal bars denote product-based intensities (per unit milk or gain) whereas blue (light and medium) bars display absolute emission value changes.[17]

CALL TO ACTION

The US feed system plays a critical role in the broader food system and can take meaningful action to meet societal goals of limiting climate change, building climate resilience, and having positive impacts for nature. The unique structure and position of the feed system makes it imperative that collaboration and collective actions are brought forward to simultaneously address both environmental impacts and risks associated with feed production and manufacturing. Organizations considering feed solutions should:

- **ELEVATE FEED'S FOOTPRINT** to highlight that feed underpins sustainability of all other livestock commodities: advance better data, transparency, and awareness of the role of feed sourcing and sustainability
- **STRENGTHEN SUPPLY CHAIN ACTIONS AND MARKET SIGNALS** to promote sustainability, transparency, collaboration, and collective efforts
- **DRIVE INNOVATIONS** including new technologies, tools and frameworks that create meaningful outcomes for nature, animal health and productivity through economically sustainable models
- **CREATE AN ENABLING ENVIRONMENT** built on sound policy that favors sustainable feed production, quality data management systems and aligned standards/expectations with a clear value proposition
- **SHARE PRE-COMPETITIVE LEARNINGS AND BEST PRACTICES** to accelerate implementation and scaling across the sector

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