



Upstream Food Loss Across Beef and Dairy Supply Chains in the U.S.

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In the United States, nearly one third of all food is lost or wasted as it makes its way from farms to our plates. Producing this surplus food requires substantial investments of land, water, energy, labor, and capital at every stage from farming to transport and preparation. Food loss and waste also generate significant greenhouse gas (GHG) emissions across the U.S. food system; nearly 220 million metric tons of carbon dioxide equivalent (CO₂e), and 2.6 million metric tons of methane (CH₄) according to ReFED estimates for 2024. Reducing these emissions quickly, particularly methane, is critical to near-term climate mitigation strategies.

Cattle are a significant source of agricultural methane emissions in the U.S., placing beef and dairy systems at the center of national methane reduction efforts. Therefore, upstream losses in beef and dairy systems represent an opportunity to keep more food in the supply chain while lowering emissions. ReFED's national model of surplus food across all sectors does not currently capture loss from livestock systems at the

farm level (production stage), so strengthening data on where and why losses occur in livestock systems fills that gap and will help target loss reduction strategies that represent high-impact methane mitigation opportunities.

ReFED, supported by the Global Methane Hub and the Robertson Foundation, commissioned World Wildlife Fund (WWF) to conduct a comprehensive assessment of upstream food loss in U.S. beef and dairy systems¹ from a structured review of 91 peer-reviewed scientific papers and technical reports from both U.S. and international sources, alongside 14 primary interviews. The analysis synthesizes the most current available data on upstream U.S. beef and dairy losses.² Bringing together quantitative and qualitative evidence is a necessary first step toward estimating the scale of food loss in U.S. beef and dairy production, its economic and environmental costs, and where targeted solutions can meaningfully reduce those impacts.



ReFED would like to thank World Wildlife Fund for their contribution to the research and analysis in this report.

¹ For the purposes of this analysis, "beef and dairy systems" refers to upstream stages of on-farm production, live animal and milk transport, slaughter/harvest, and pre-processing prior to full product fabrication (cutting and portioning of carcasses).

² The full report provides detailed documentation of data sources, assumptions, methodological approaches, and confidence levels, and serves as a methodological foundation for future quantification of upstream livestock loss. That report is available at <https://refed.org/downloads/FINAL-Upstream-Food-Loss-Across-the-Beef-and-Dairy-Supply-Chains.pdf>





Findings

1 Upstream Beef and Dairy Losses Occur Across the Supply Chain but Are Inconsistently Measured

Our assessment confirms that upstream losses occur across all early stages of the beef and dairy supply chains, including on-farm, transport, slaughter/harvest, and pre-processing, although the amount of loss may vary by system and stage (Table 1). These losses represent animals, milk, and edible products that have had substantial resource inputs invested in them and have generated substantial emissions in the production process.

Across the literature and interviews, upstream losses are consistently linked to a small set of recurring drivers, including animal health and environmental stress, delayed culling of compromised animals, improper transport and handling, infrastructure and capacity constraints, and limited communication and feedback across supply chain partners.





Table 1: Summary of Upstream Beef & Dairy Food Loss Evidence by Supply Chain Stage

Supply Chain Stage	Beef Systems - Loss Types	Dairy Systems - Loss Types	Selected Data Points
 <p>On-Farm</p>	<ul style="list-style-type: none"> Cow & calf mortality Involuntary culling 	<ul style="list-style-type: none"> Mastitis-related milk discard Milk withheld from sale Cow mortality involuntary culling 	<ul style="list-style-type: none"> 2.2% adult cow mortality and 6.25% calf mortality annually (≈3.9M animals and ~\$3.87B in economic losses) 0.3–1.0% of annual milk production discarded
 <p>Transport</p>	<ul style="list-style-type: none"> Dead-on-arrival (DOA) animals Injuries & bruising Shrink (weight loss) Organ condemnation linked to stress Rejected milk tanker loads 	<ul style="list-style-type: none"> Rejected milk tanker loads Transport-related losses of cull cows (animals removed from dairy or breeding herds) 	<ul style="list-style-type: none"> ~0.2 dead-on-arrival animals ~7.8% shrink in feeder cattle and ~4.9% shrink in fed cattle Bruising affecting up to ~64% of cow carcasses
 <p>Slaughter/ Harvest</p>	<ul style="list-style-type: none"> Ante-mortem rejections DOA or dead in pen Carcass condemnations Bruising & trim loss Organ condemnation 	<ul style="list-style-type: none"> Organ condemnation Carcass condemnations of dairy cows 	<ul style="list-style-type: none"> ~1% condemnation rates for cull cows; lower rates for fed cattle raised for beef Organ condemnation is particularly common in dairy cows, ~45% livers and 20–25% of major organs are condemned due to infection or trauma
 <p>Pre-Processing</p>	<ul style="list-style-type: none"> Carcasses/tissue removed pre-fabrication (cutting and portioning of carcasses) Condemned tissue diverted to rendering 	<ul style="list-style-type: none"> Rejected milk loads Off-spec dairy products Solids lost in processing 	<ul style="list-style-type: none"> National volumes not systematically quantified; facility-level rejection volumes can reach millions of pounds annually

2 Targeted Solutions Demonstrate Potential to Reduce Upstream Loss

Our analysis identified an array of solutions—tools, strategies, and technologies that are currently in practice but not widely adopted—to address causes of loss across supply chain stages (Table 2).

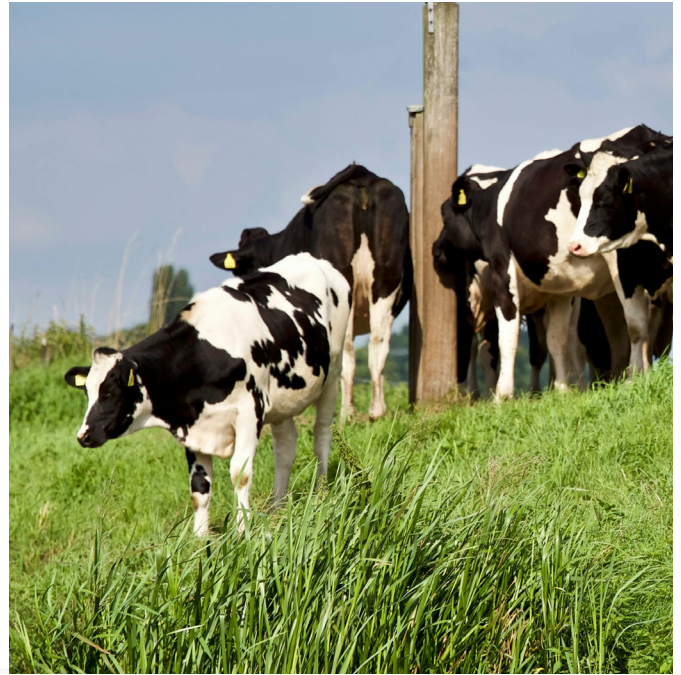
Table 2: Solutions Addressing Upstream Beef & Dairy Food Loss by Supply Chain Stage

Supply Chain Stage	Loss Types	Key Causes	Identified Solutions
 <p>On-Farm</p>	<ul style="list-style-type: none"> • Cow & calf mortality • Involuntary culling • Mastitis-related milk discard • Milk withheld from sale 	<ul style="list-style-type: none"> • Disease (pneumonia, scours, mastitis) • Weather stress (heat, mud, cold rains) • Reproductive failure • Labor shortages, overcrowding • Equipment failures • Delayed culling decisions 	<ul style="list-style-type: none"> • Improved calf care, bedding, drainage • Mastitis prevention & early somatic cell count (SCC) detection • Heat abatement & ventilation upgrades • Selective breeding for health • More timely culling • Enhanced recordkeeping/ herd software
 <p>Transport</p>	<ul style="list-style-type: none"> • Dead-on-arrival (DOA) animals • Injuries & bruising • Shrink (weight loss) • Organ condemnation linked to stress • Rejected milk tanker loads 	<ul style="list-style-type: none"> • Rough loading/handling • Overcrowding & poor grouping • Heat/cold stress & long journeys • Shipping compromised animals • Milk contamination, seal failures, temperature abuse 	<ul style="list-style-type: none"> • Low-stress handling & loading training • Fitness-for-transport screening • Improved trailer flooring, partitions, ventilation • Journey planning (avoid extreme weather, limit fasting) • Strict milk intake/seal protocols
 <p>Slaughter/ Harvest</p>	<ul style="list-style-type: none"> • Ante-mortem rejections • DOA or dead in pen • Carcass condemnations • Bruising & trim loss • Organ condemnation 	<ul style="list-style-type: none"> • Transport stress & rough handling • Disease (lymphoma, pneumonia, sepsis) • Foreign materials (buckshot, wire, needles, and non-metal materials) • Poor arrival condition (late culling) 	<ul style="list-style-type: none"> • Earlier culling & better herd health • Improved transport & handling practices • Foreign-material prevention on farms • Carcass-data feedback loops to farms & haulers
 <p>Pre-Processing</p>	<ul style="list-style-type: none"> • Rejected milk loads • Off-spec dairy products • Solids lost in processing • Carcasses/tissue removed pre-fabrication 	<ul style="list-style-type: none"> • Failed microbial, butterfat, or antibiotic tests • Temperature abuse • Seal/sanitation failures • Equipment malfunctions • Plant bottlenecks or shutdowns 	<ul style="list-style-type: none"> • Improved clean-in-place (CIP) & sanitation protocols • Better cooling & tank management • Processor-co-op communication on quality issues • Partnerships with diversion/upcycling firms • Facility-level tracking of rejected volumes & destinations

From this broader set of solutions, we selected two targeted solutions, Mastitis Prevention and Early Detection (Dairy) and Fitness-for-Transport Training (Beef and Dairy), for additional research based on the strength of available evidence. Further economic analysis and research into the potential of these two solutions is presented in the complete report.

3 Data Gaps Limit Understanding and Action on Upstream Loss

Although upstream food loss in beef and dairy systems is acknowledged, we found that measurement remains fragmented and inconsistent. Key data gaps include a reliance on rates rather than mass-based measures; inconsistent measurement of transport losses; limited tracking of final loss destinations; fragmented data ownership across supply chain actors; and weak traceability linking causes to outcomes. As a result, peer-reviewed literature identifies where and how losses occur to some extent, but provides limited evidence on the total volume of food lost, the loss destinations, or their broader systemwide economic and environmental impacts.



Next Steps

1 ReFED Modeling and National Estimates

This assessment represents one of the first efforts to systematically compile and reconcile available evidence across upstream beef and dairy systems. ReFED will use these compiled data ranges and documented loss pathways to develop the first national-level estimates of upstream beef and dairy food loss and waste.

Modeling will quantify:

- Loss volumes across on-farm, transport, harvest, and pre-processing stages
- Embedded greenhouse gas emissions, including methane (CH₄) and carbon dioxide (CO₂e)
- The potential to reduce emissions through targeted interventions

Developing these estimates is a necessary step toward integrating livestock systems into broader food loss and climate mitigation strategies.

2 Near-Term Priority Actions

We also identify priority areas requiring targeted action by industry actors.

Quantify Underreported Upstream Losses

Researchers and industry partners can generate standardized, mass-based estimates (pounds, gallons, head) for loss streams that remain inconsistently measured.

Key data gaps include:

- Surplus dairy bull calves and their disposition
- Fetuses from pregnant cows at harvest
- Offal condemnation rates by organ and cause
- Transport shrink by journey type
- Emergency milk dumping and diversion pathways

Strengthen Traceability and Standardized Loss Reporting

Many loss events are recorded internally as compliance or quality events, but they are not consistently linked to volume, cause, and final destination across supply chain stages. Transport logs, condemnation records, rejected load volumes, and trim weights often remain siloed.

Industry actors could prioritize:

- Recording loss volumes in physical units alongside documented causes and destinations
- Embedding standardized food loss data fields into herd management, logistics, and processing systems
- Establishing feedback loops, so processors report bruising, trim, and condemnation data back to suppliers
- Participating in confidential, aggregated reporting systems that enable national analysis while protecting proprietary information

Stronger traceability and reporting infrastructure would improve accountability, strengthen food loss and emissions modeling, and support continuous improvement across supply chain partners.

Pilot and Evaluate High-Impact Solutions

Producers, processors, and industry programs can test targeted interventions under real-world conditions. Pilots should establish baseline loss rates, track post-intervention changes, and quantify associated greenhouse gas impacts, including methane reductions.

Priority testing should be directed at:

- Mastitis prevention and early detection technologies (e.g., somatic cell count (SCC) monitoring systems)
- Fitness-for-transport training and handling protocols
- Early culling decision-support tools
- Neonatal survival and calf health improvements
- Recovery infrastructure for rejected milk and condemned material

Systematic evaluation will identify which interventions deliver the greatest reduction in food loss per dollar invested while lowering emissions intensity across beef and dairy systems. Building this evidence base is essential for integrating livestock loss reduction into credible climate strategies.



Conclusion

By improving measurement, strengthening feedback across the supply chain, and scaling targeted solutions such as mastitis prevention and better transport management, the sector can make meaningful progress toward both food waste reduction and climate goals.

ReFED and WWF will continue to collaborate on advancing research on loss in beef and dairy production, including further investigation of the sources, causes, and solutions. This is a pivotal arena where concerted and coordinated near-term effort can keep more food in the supply chain, reduce associated methane emissions, and increase producer profitability. Please reach out if you are interested in working together.

Acknowledgements

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WWF is one of the world's leading conservation organizations, working for 60 years in nearly 100 countries to help people and nature thrive. With the support of 1 million members in the United States and more than 5 million members worldwide, WWF is dedicated to delivering science-based solutions to preserve the diversity and abundance of life on Earth, halt the degradation of the environment, and combat the climate crisis. Visit worldwildlife.org to learn more.



ReFED is a U.S.-based nonprofit that partners with food businesses, funders, solution providers, policymakers, and more to solve food waste. Its vision is a sustainable, resilient, and inclusive food system that makes the best use of the food we grow. The organization serves as the definitive source for food waste data, providing the most comprehensive analysis of the food waste problem and solutions to address it. Through its tools and resources, in-person and virtual convenings, and services tailored to help businesses, funders, and solution providers scale their impact, ReFED works to increase adoption of food waste solutions across the supply chain. To learn more about ReFED and solutions to reduce food waste, please visit www.refed.org.

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