INSIGHTS ENGINE FOOD WASTE MONITOR

2020 METHODOLOGY

ReFED

CONTENTS

ACKNOWLEDGMENTS

Contract Partners & Data Contributors

Juniata Analytics is a tech start-up working at the intersection of business, sustainability, and software to help organizations calculate, analyze, and share sustainability information across internal operations and supply chains. Juniata was responsible for crafting the initial vision for the ReFED Insights Engine, managing the project and coordinating contractors, developing the methodologies, collecting and processing data, and developing a web application to automate the data modeling.

NielsenIQ is the leader in providing the most complete, unbiased view of consumer behavior, globally. Powered by a ground-breaking consumer data platform and fueled by rich analytic capabilities, NielsenIQ enables bold, confident decision-making for the world's leading consumer goods companies and retailers. Using comprehensive data sets and measuring all transactions equally, NielsenIQ gives clients a forward-looking view into consumer behavior in order to optimize performance across all retail platforms. Our open philosophy on data integration enables the most influential consumer data sets on the planet. NielsenIQ delivers the complete truth. NielsenIQ, an Advent International portfolio company, has operations in nearly 100 markets, covering more than 90% of the world's population. For more information, visit www.nielseniq.com. or https://www.linkedin.com/company/nielseniq/mycompany/

We care for the communities and markets where we live and operate our business, through responsible, sustainable business practices and our commitment to giving back: sharing consumer insights and data with the world, donating pro bono skills-based volunteering and projects to nonprofit organizations. NielsenIQ is committed to help create new solutions to social and environmental challenges and shape a smarter market. This collaboration with ReFED is one example of how NielsenIQ is taking action. NielsenIQ is donating five years of food pricing and purchase data to help ReFED launch their ReFED Insights Engine, a digital-first, continuously updated platform to house the next generation of data and insights on food waste.

Leanpath provided custom-prepared data for the ReFED Insights Engine for use in the Foodservice sector of the Food Waste Monitor Methodology. Leanpath is on a mission to make food waste prevention and measurement everyday practice in the world's kitchens. Leanpath believes that frontline foodservice workers are the real change agents in the global fight against food waste. Leanpath empowers them through measurement-focused technology to reduce food waste, thus enabling them to have a meaningful impact on the environment while improving their kitchen's efficiency and reducing costs. Since 2014 alone, Leanpath-empowered culinary teams have prevented over 61 million pounds of food from being wasted in thousands of kitchens around the world. Leanpath invented automated food waste tracking technology in 2004 and provides a complete food waste prevention solution, including data-collection tools, cloud-based analytics, and expert coaching.

ACKNOWLEDGMENTS

Contract Partners & Data Contributors (Continued)

Northstar Recycling provided custom-prepared data for the ReFED Insights Engine for use in the Manufacturing sector of the Food Waste Monitor Methodology. Founded on five generations of industry expertise, Northstar Recycling is redefining what it means to be a national waste and recycling company. They have cultivated a network of over 5,000 qualified service partners to provide their clients a seamless, single point of contact for all their waste needs. This unique business model also allows them the flexibility to provide innovative solutions that help their clients increase recycling, lower disposal volumes, and increase profits.

NRDC (Natural Resources Defense Council) provided expert feedback and guidance during the development of the ReFED Insights Engine. They also proided detailed information on the causes and destinations of food waste in the home that was used in the Residential sector of the Food Waste Monitor Methodology. NRDC works to safeguard the earth—its people, its plants and animals, and the natural systems on which all life depends. They combine the power of more than three million members and online activists with the expertise of some 700 scientists, lawyers, and policy advocates across the globe to ensure the rights of all people to the air, the water, and the wild.

Technomic provided ReFED with datasets on the sales and operator purchases of U.S. restaurant and foodservice providers. This data was used in the Foodservice sector of the of the Food Waste Monitor Methodology. For 50 years, Technomic has provided foodservice clients around the globe with the research, insights and strategic consulting support they need to enhance their business strategies, decisions and results. Its services include category and channel analyses, customer satisfaction studies, market opportunity assessments and strategic entry planning, benchmarking programs and brand equity enhancement. Technomic excels at industry intelligence, forecasts, data, training support and consumer research.

ACKNOWLEDGMENTS

Thank You To Our Funders

THE KROGER CO. ZERO HUNGER ZERO WASTE FOUNDATION

Launched with anchor funding from The Kroger Co. Zero Hunger | Zero Waste Foundation

**The views expressed herein do not necessarily represent those of The Kroger Co. Zero Hunger | Zero Waste Foundation or The Kroger Co.*

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OVERVIEW

In 2016, ReFED launched its landmark *Roadmap to Reduce U.S. Food Waste by 20%*. That initial report became a touchstone for those in the food waste space, but there was a growing need for more - and more granular - data about the issue to fill in knowledge gaps and move the food system from awareness about the issue to insight-driven action. The newly developed ReFED Insights Engine is the next generation of data, insights, and guidance on U.S. food waste. This online data and solutions hub for food loss and waste is designed to provide anyone interested in food waste reduction with the information and insights they need to take meaningful action to address the problem and move a step forward towards achieving national and international goals of reducing food waste by 50 percent by 2030.

Current ReFED Insights Engine tools include:

- **Food Waste Monitor:** Centralized, trusted repository of information built with data from more than 50 public and proprietary datasets that shows how much food is being wasted in the U.S., why it's happening, and where it goes.
- **Impact Calculator:** Quantifies the impact of wasted food on the climate, natural resources, lost meals, and the economy.
- **Solutions Database:** Provides a stakeholder-specific, comprehensive analysis of 40+ food waste reduction solutions based on impact goals, along with detailed fact sheets on each.
- **Solution Provider Directory:** Connects users with a vetted list of 700+ nonprofit and for-profit organizations ready to help implement food waste reduction initiatives.

Food Waste Monitor

The Food Waste Monitor is comprised of five sectors, each modeled independently: Farm, Manufacturing, Retail, Foodservice, and Residential. This document describes the methodology used to quantify the amount of food surplus happening in each sector, the reasons why it's happening (e.g., causes), and where the food is being sent (e.g., destinations).

Before starting development, the ReFED team sought feedback from its vast network of industry professionals from businesses, capital providers, government, nonprofits, and academia. The Food Waste Monitor was designed to incorporate this feedback and maintain the strengths of the 2016 Roadmap report while filling previous information gaps with new data and models in a continuously improved, digital format. The following thematic areas summarize the major additions and improvements made:

Roadmap to 50% Reduction by 2030

- **Aligned with national and international goals:** The previous Roadmap outlined a path to reduce U.S. food waste by 20%. This new solutions Roadmap provides a path to 50% reduction by 2030, in alignment with U.S. and international goals. This assumes, however, that there is 100% adoption of all the solutions in the database.

New and More Granular Information

- **Quantified causes of food waste:** Quantifying the reasons why food waste is happening is a necessary precursor to calculating the potential benefit of food waste solutions. Until now, this causal information has not been quantified. ReFED applied solutions only to the portions of surplus where the solution applied. For instance, a donation solution was only applied to overproduced food in restaurant kitchens, not the waste left on customers plates. By gaining this understanding, ReFED is now able to more accurately estimate the potential impact of solutions.
- **Results tailored to specific sectors and stakeholders:** Stakeholders can now quickly filter and view information that is relevant specifically to them. The previous Roadmap aggregated the costs and benefits of solutions across all stakeholders involved. It was not always clear when misaligned incentives existed (e.g., When implementing a solution required one stakeholder to bear most of the cost while others benefited). Now users are able to break out the costs and benefits for each stakeholder involved, providing a better understanding of the misaligned incentives and financial barriers that still exist for many solutions. This allows misaligned incentives to be identified and collectively addressed.
- **Food type specific data:** Improved decision making requires food type specific information (e.g., developing a strategy to increase donations of produce specifically). In the past, much of the modeling was not food type specific. ReFED's models now take food type into account at much more granular levels, leading to more accurate insights.
- **Geographically specific (state-level) data:** ReFED data now reflects major differences between states (e.g., California has a large agricultural produce sector, Wisconsin has a large dairy manufacturing sector, Hawaii has a large foodservice and hospitality sector). This analysis now enables state-level actors to filter and prioritize different solutions based on their state's local economy and food waste patterns.

Interactivity and Automation

- **Interactive digital format:** Different audiences have different needs. ReFED has moved to interactive online tools that allow stakeholders to quickly obtain data tailored to their specific needs. Some materials will still be provided in PDF format as well.
- **Quick updates and rapid feedback loop:** A custom, automated web application allows the models to be rerun and the platform to be quickly updated with the latest information. This reduces the time required to produce new results to hours instead of months or years. This rapid feedback loop allows solutions to be quickly reprioritized according to the latest learnings as solutions are implemented and scaled. ReFED is planning to update results once or twice annually.

Transparency

- **Data quality scores**: ReFED developed data quality scores to communicate how confident ReFED is in the data being shared based on the quality of the underlying data sources and how they were used. These scores are now displayed front-and-center on the website rather than only in the documentation. This addition allows ReFED to share newly emerging data while maintaining transparency about the data confidence.
- **Open source data:** Raw data and documentation is now made publicly available as much as legally possible. Confidential data is only used in cases where it yielded significant advantages over publicly available data.

Research Opportunities

- <u>**Setting a research agenda**</u>**:** ReFED's new models and data quality scores are able to succinctly highlight what data is most critical and where it is lacking. ReFED hopes that this information will be used to prioritize research funding and advance new research projects.

Adaptable Framework

- <u>**Platform can be expanded to other countries if needed**</u>**:** Because the first version of the Roadmap served as inspiration for many other food waste initiatives at the international level, this platform was intentionally designed to be expanded to other countries using geographically specific data.

NOTICE AN ISSUE WITH THE DATA?

Send us an email! The Insights Engine was designed to be radically transparent so that the community of people using this work can help spot issues and identify opportunities to continually improve the data over time. If you see any mistakes, have additional information, or have recommendations for how to improve this resource, please let us know.

INSIGHTS ENGINE FOOD WASTE MONITOR

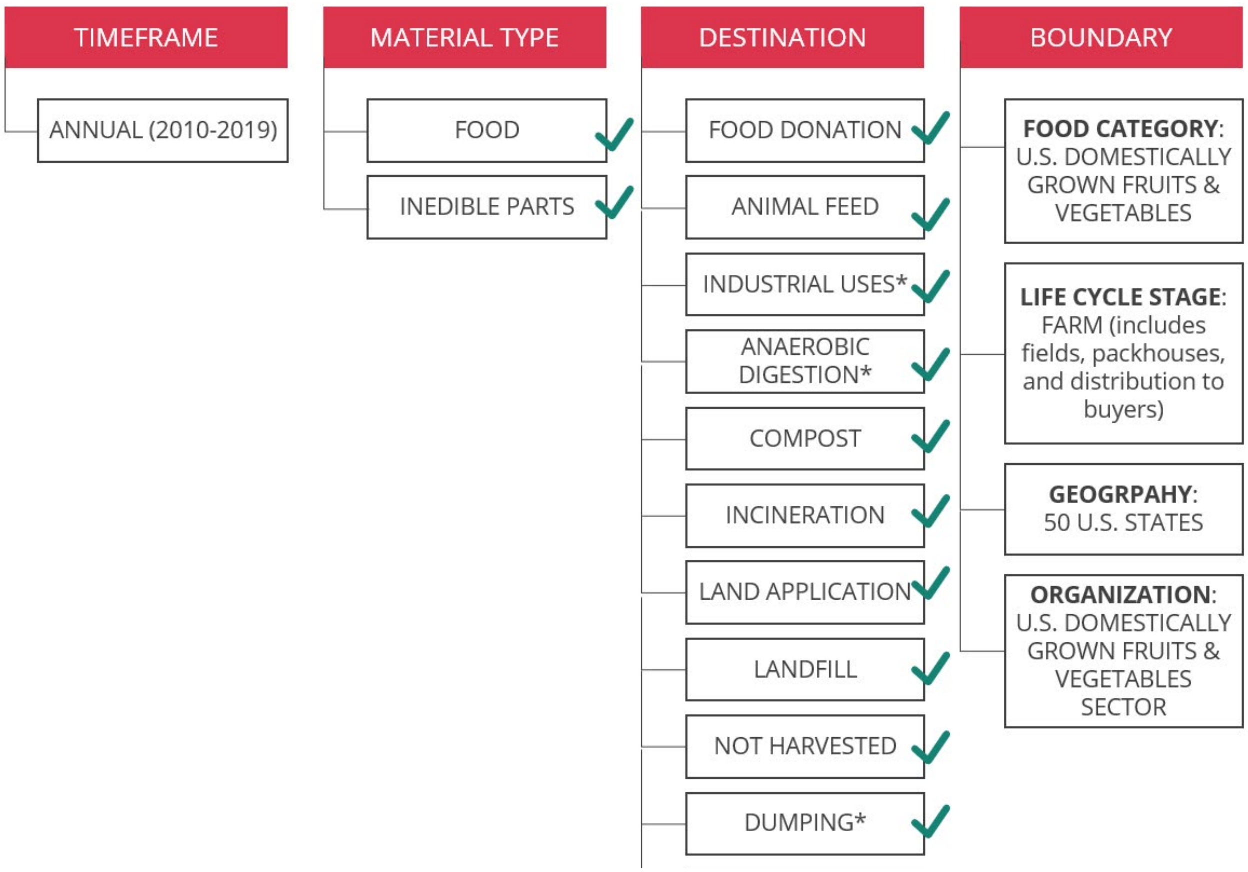
2020 FARM METHODOLOGY

ReFED

FARM METHODOLOGY

Scope Boundary

The following diagram communicates the scope boundary as aligned with the Food Loss and Waste Accounting and Reporting Standard[1]. Note that ReFED's analysis also includes food sent to donations, although donations are not considered a destination within the Standard.



***NOTES**

- "Food Donation" has been added as a Destination
- "Biomaterial Processing is referred to as "Industrial Uses" in our model
- "Co/anaerobic digestion" is referred to as "Anaerobic digestion" in our model
- "Controlled Combustion" is referred to as "Incineration" in our model
- "Refuse/discards" is referred to as "Dumping" in our model

Calculations

Surplus Food Calculations

Master Surplus Equation:
Tons Never Harvested (Walk-by Fields)
+ Tons Left Behind After Harvest
+ Tons Packhouse Losses
+ Tons Unsold Buyer Rejections

= Tons Farm Surplus

In ReFED's data model, the following calculations are repeated for every state, year, and farm produce commodity before any aggregation is done.

Table 1. Calculations Performed to Quantify U.S. Farm Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Acres Planted	USDA Surveys[2]	10,000 acres of Asparagus planted in Michigan in 2019
Acres Harvested	USDA Surveys[2]	9,400 acres of Asparagus harvested in Michigan in 2019
Acres Unharvested	= Acres Planted - Acres Harvested	= 10,000 - 9,400 = 600 acres unharvested
US Dollars Harvested	USDA Surveys[2]	$25,607,000 of Asparagus harvested in Michigan in 2019
Tons Harvested	USDA Surveys[2]	14,100 tons of Asparagus produced in Michigan in 2019
Yield Tons per Acre	= Tons Harvested / Acres Harvested	= 14,100 tons produced / 9,400 acres harvested = 1.5 tons per acre
% Maturity of Fields Never Harvested	ReFED assumption	In lieu of available data, ReFED assumed that only 50% of produce fields that are planted but never harvested reach maturity (yield produce that could be eaten) as opposed to fields that are planted but discontinued before the crop bears fruit.
Tons Never Harvested (Walk-by Fields)	= Acres Unharvested * Yield Tons per Acre * % Maturity of Fields Never Harvested	= 600 acres unharvested * 1.5 tons per acre * 50% = 450 tons never harvested
% Yield Left Behind After Harvest	Farm Case Studies[3,4,5,6]	Proxy commodity: Cabbage 2019 Santa Clara University Study 13.38% marketed yield of cabbage left behind after harvest (See Appendix A)

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Left Behind After Harvest	= Acres Harvested * Yield Tons per Acre * % Yield Left Behind After Harvest	= 9,400 acres harvested * 1.5 tons per acre * 13.38% left behind after harvest = 1,886 tons left behind after harvest
Tons Unharvested Total	= Tons Never Harvested + Tons Left Behind After Harvest	= 450 tons never harvested + 1,886 tons left behind after harvest = 2,336 total tons unharvested
% Processing (as opposed to Fresh Market)	USDA Surveys[2]	48.45% of asparagus grown in Michigan in 2019 went to the processing market
% Field Packed	Public Agriculture Websites[7,8,9,10,11,12]	According to the University of California Division of Agriculture and Natural Resources, 0% of asparagus is field packed
% Packhouse Loss Rate	WWF Specialty Crop Loss Report[6]	Proxy commodity: Potatoes 14.8% losses by weight at the packhouse
Tons Sent to Packhouses	= Tons Harvested * (100% - % Processing) * (100% - % Field Packed)	= 14,100 tons harvested * (100% - 48.45% processing) * (100% - 0% field packed) = 7,268 tons sent to packhouses
Tons Packhouse Losses	= Tons Sent to Packhouses * % Packhouse Loss Rate	= 7,268 tons sent to packhouses * 14.8% packhouse losses = 1,076 tons packhouse losses
% Buyer Rejection Rate	Expert Interviews	According to experts, about 2% of produce deliveries are rejected by the quality assurance team at buyer receiving (See Appendix C)
Tons Shipped from Packhouse	= Tons Sent to Packhouse - Tons Packhouse Losses	= 7,268 tons sent to packhouse - 1,076 tons packhouse losses = 6,192 tons shipped from packhouse
% of Buyer Rejections Sold via Discount Outlets	Expert interviews	Based on expert interviews, ReFED assumed that 25% of produce rejected by buyer quality assurance teams ends up being sold via other channels and does not get wasted.
Tons Unsold Buyer Rejections	= Tons Shipped from Packhouse * % Buyer Rejection Rate * (100% - % of Buyer Rejections Sold via Discount Outlets)	= 6,192 tons shipped from packhouse * 2% buyer rejections * (100% - 25% sold via discount outlets) = 93 tons unsold buyer rejections
Price per Ton	= US Dollars Harvested / Tons Harvested	= $25,607,000 harvested / 14,100 tons harvested = $1,816 per ton
US Dollars Never Harvested	= Tons Never Harvested * Price per Ton	= 450 tons never harvested * $1,816 per ton = $817,245 never harvested
US Dollars Left Behind After Harvest	= Tons Left Behind After Harvest * Price per Ton	= 1,886 tons left behind after harvest * $1,816 per ton = $3,425,580 left behind after harvest

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Unharvested Total	= US Dollars Never Harvested + US Dollars Left Behind After Harvest	= $817,245 never harvested + $3,425,580 left behind after harvest = $4,242,825 total unharvested
US Dollars Packhouse Losses	= Tons Packhouse Losses * Price per Ton	= 1,076 tons packhouse losses * $1,816 per ton = $1,953,524 packhouse losses
US Dollars Unsold Buyer Rejections	= Tons Unsold Buyer Rejections * Price per Ton	= 93 tons unsold buyer rejections * $1,816 per ton = $168,689 unsold buyer rejections
Tons Surplus	= Tons Never Harvested + Tons Left Behind After Harvest + Tons Packhouse Losses + Tons Unsold Buyer Rejections	= 450 tons never harvested + 1,886 tons left behind after harvest + 1,076 tons packhouse losses + 93 tons unsold buyer rejections = 3,505 tons surplus
Tons Supply	= Tons Unharvested + Tons Harvested	= 2,336 total tons unharvested + 14,100 tons harvested = 16,436 tons supply
% Surplus	= Tons Surplus / Tons Supply	= 3,505 tons surplus / 16,436 tons supply = 21.32% surplus
US Dollars Surplus	= US Dollars Never Harvested + US Dollars Left Behind After Harvest + US Dollars Packhouse Losses + US Unsold Dollars Unsold Buyer Rejections	= $817,245 never harvested + $3,425,580 left behind after harvest + $1,953,524 packhouse losses + $168,689 unsold buyer rejections = $6,365,038 surplus
US Dollars Supply	= US Dollars Unharvested + US Dollars Harvested	= $4,242,825 total unharvested + $25,607,000 harvested = $29,849,825 supply

Cause Calculations

Master Cause Equation:
Tons Surplus due to Cause = Tons Surplus * % Loss due to Cause

Table 2. Calculations Performed to Quantify the Causes of U.S. Farm Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
NEVER HARVESTED CAUSES		
% Loss due to Cause	USDA RMA Crop Insurance[13]	Proxy commodity: "All Other Crops" was used because Asparagus acreage was relatively smaller than other commodities and was aggregated into the All Other Crops category in the USDA RMA data. See example data in Appendix D Fields never harvested (bad weather): 95.43% Fields never harvested (market dynamics): 3.28% Fields never harvested (pests/disease): 1.29%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Surplus due to Cause	= Tons Never Harvested * % Loss due to Cause	Fields never harvested (bad weather): = 450 tons never harvested * 95.43% = 429 tons Fields never harvested (market dynamics): = 450 tons never harvested * 3.28% = 15 tons Fields never harvested (pests/disease): = 450 tons never harvested * 1.29% = 6 tons
US Dollars Surplus due to Cause	= US Dollars Never Harvested * % Loss due to Cause	Fields never harvested (bad weather): = $817,245 never harvested * 95.43% =$779,933 Fields never harvested (market dynamics): = $817,245 never harvested * 3.28% = $26,764 Fields never harvested (pests/disease): = $817,245 never harvested * 1.29% = $10,548
LEFT BEHIND AFTER HARVEST CAUSES		
% Loss due to Cause	Farm Case Studies[2,3]	Proxy commodity: Cabbage See example data in Appendix E 2018 NC State Study 33% Left behind after harvest (inedible) 2% Left behind after harvest (marketable) 65% Left behind after harvest (not marketable) Total = 100%
Tons Surplus due to Cause	= Tons Left Behind After Harvest * % Loss due to Cause	Left behind after harvest (inedible): = 1,886 tons left behind after harvest * 33% = 623 tons Left behind after harvest (marketable): = 1,886 tons left behind after harvest * 2% = 39 tons Left behind after harvest (not marketable): = 1,886 tons left behind after harvest * 65% = 1,224 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Surplus due to Cause	= US Dollars Left Behind After Harvest * % Loss due to Cause	Left behind after harvest (inedible): = $3,425,580 left behind after harvest * 33% = $1,132,163 Left behind after harvest (marketable): = $3,425,580 left behind after harvest * 2% = $70,981 Left behind after harvest (not marketable): = $3,425,580 left behind after harvest * 65% = $2,222,436
PACKHOUSE LOSS CAUSES		
% Loss due to Cause	WWF Specialty Crop Loss Report[6]	Proxy commodity: Tomatoes See example data in Appendix F 77% Packhouse losses (inedible) 23% Packhouse losses (not marketable) Total = 100%
Tons Surplus due to Cause	= Tons Harvested but Not Sold * % Loss due to Cause	Packhouse losses (inedible): = 1,076 tons packhouse losses * 77% = 828 tons Packhouse losses (not marketable): = 1,076 tons packhouse losses * 23% = 247 tons
US Dollars Surplus due to Cause	= US Dollars Harvested but Not Sold * % Loss due to Cause	Packhouse losses (inedible): = $1,953,524 packhouse losses * 77% = $1,504,213 Packhouse losses (not marketable): = $1,953,524 packhouse losses * 23% = $449,310
BUYER REJECTIONS		
Tons Unsold Buyer Rejections	See calculation above for Tons Unsold Buyer Rejections	= 93 tons unsold buyer rejections
US Dollars Unsold Buyer Rejections	See calculation above for US Dollars Unsold Buyer Rejections	= $168,689 unsold buyer rejections

Destination Calculations

Master Destination Equation:
Tons Surplus sent to Destination = Tons Surplus * % Sent to Destination

Table 3. Calculations Performed to Quantify the Destinations of U.S. Farm Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Packhouse Losses	WWF Specialty Crop Loss Report[6]	This was the destinations breakdown for the packhouses included in the WWF report (See Appendix G): Donated: 2.60% Animal feed: 69.67% Refuse/discards: 27.73% Trash: 0% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Michigan (Biocycle/Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 92.33% % of Trash that is Incinerated = 7.67% % Landfilled: = 0% * 92.33% = 0% % Incinerated: = 0% * 7.67% = 0%
	Breaking "Trash" into Landfill vs Incineration:	
	% Landfilled = % Trash * % of Trash that is Landfilled	
	% Incinerated = % Trash * % of Trash that is Incinerated	
Destination Breakdown of Unsold Buyer Rejections	Expert Interviews	According to expert interviews, this is what happens to buyer rejections that don't get sold via secondary outlets: Donated: 33.33% Animal feed: 33.33% Refuse/discards: 0% Trash: 33.33% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Michigan (Biocycle/Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 92.33% % of Trash that is Incinerated = 7.67%
	Breaking "Trash" into Landfill vs Incineration:	% Landfilled = 33.33% * 92.33% = 30.8%
	% Landfilled = % Trash * % of Trash that is Landfilled	% Incinerated = 33.33% * 7.67%
	% Incinerated = % Trash * % of Trash that is Incinerated	= 2.6%
Tons Not Harvested	See calculation above for Tons Unharvested Total	2,336 total tons unharvested

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Not Harvested	See calculation above for US Dollars Unharvested Total	$4,242,825 total unharvested
Tons Donated	= Tons Packhouse Losses * % Donations for Packhouse Losses + Tons Unsold Buyer Rejections * % Donations for Unsold Buyer Rejections	= 1,076 tons packhouse losses * 2.60% donated + 93 tons unsold buyer rejections * 33.33% donated = 59 tons donated
US Dollars Donated	= US Dollars Packhouse Losses * % Donations for Packhouse Losses + US Dollars Unsold Buyer Rejections * % Donations for Unsold Buyer Rejections	= $1,953,524 packhouse losses * 2.60% donated + $168,689 unsold buyer rejections * 33.33% donated = $107,009 donated
Tons Animal Feed	= Tons Packhouse Losses * % Animal feed for Packhouse Losses + Tons Unsold Buyer Rejections * % Animal feed for Unsold Buyer Rejections	= 1,076 tons packhouse losses * 69.67% Animal feed + 93 tons unsold buyer rejections * 33.33% Animal feed = 780 tons Animal feed
US Dollars Animal Feed	= US Dollars Packhouse Losses * % Animal feed for Packhouse Losses + US Dollars Unsold Buyer Rejections * % Animal feed for Unsold Buyer Rejections	= $1,953,524 packhouse losses * 69.67% Animal feed + $168,689 unsold buyer rejections * 33.33% Animal feed =$1,417,258 Animal feed
Tons Refuse / Discards	= Tons Packhouse Losses * % Refuse/ Discards for Packhouse Losses + Tons Unsold Buyer Rejections * % Refuse/Discards for Unsold Buyer Rejections	= 1,076 tons packhouse losses * 27.73% Refuse/Discards + 93 tons unsold buyer rejections * 0% Refuse/Discards = 298 tons Refuse/Discards
US Dollars Refuse / Discards	= US Dollars Packhouse Losses * % Refuse/ Discards for Packhouse Losses + US Dollars Unsold Buyer Rejections * % Refuse/Discards for Unsold Buyer Rejections	= $1,953,524 packhouse losses * 27.73% Refuse/Discards + $168,689 unsold buyer rejections * 0% Refuse/Discards = $541,705 Refuse/Discards
Tons Landfilled	Tons Packhouse Losses * % Landfilled for Packhouse Losses + Tons Unsold Buyer Rejections * % Landfilled for Unsold Buyer Rejections	= 1,076 tons packhouse losses * 0% Landfilled + 93 tons unsold buyer rejections * 30.8% Landfilled = 29 tons Landfilled
US Dollars Landfilled	= US Dollars Packhouse Losses * % Landfilled for Packhouse Losses + US Dollars Unsold Buyer Rejections * % Landfilled for Unsold Buyer Rejections	= $1,953,524 packhouse losses * 0% Landfilled + $168,689 unsold buyer rejections * 30.8% Landfilled = $51,912 Landfilled
Tons Incineration	= Tons Packhouse Losses * % Incineration for Packhouse Losses + Tons Unsold Buyer Rejections * % Incineration for Unsold Buyer Rejections	= 1,076 tons packhouse losses * 0% Incineration + 93 tons unsold buyer rejections * 2.6% Incineration = 2.4 tons Incineration
US Dollars Incineration	= US Dollars Packhouse Losses * % Incineration for Packhouse Losses + US Dollars Unsold Buyer Rejections * % Incineration for Unsold Buyer Rejections	= $1,953,524 packhouse losses * 0% Incineration + $168,689 unsold buyer rejections * 2.6% Incineration = $4,312 Incineration

Data Sources and Limitations

Planted and Harvested Acreage, Yield, and Market Price
Raw Data and Documentation:

- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_USDASurveys_Fruit-TreeCrops.xlsx
- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_USDASurveys_Vegetables-FieldCrops.xlsx

Each year the USDA National Agricultural Statistics Service conducts grower sampling surveys to estimate acreage, production, market price, and other data for dozens of domestically grown U.S. farm commodities. These surveys include about 60 fruit, vegetable, and nuts commodities. ReFED used the data from these surveys to quantify the planted acreage (bearing acreage for tree crops), harvested acreage, market price, and yield for fruits, vegetables, and nuts by commodity, state, and year back to 2010. States that produce a minor amount of a given commodity are not included in the USDA surveys. For this reason, low-producing states are estimated to have zero food loss and waste on farms for a given commodity even though they may produce and waste a small volume. Once every four years the USDA conducts a more thorough CENSUS, which captures more acreage. ReFED compared USDA Survey and USDA CENSUS data for 2017 and 2012 and found a discrepancy of only ~5% of total national acreage for the fruits, vegetables, and nuts commodities included in this analysis.

Never Harvested (Walk-by) Causes
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_NeverHarvestedCauses.xlsx

The USDA Risk Management Agency (RMA) crop insurance claim dataset from the Federal Crop Insurance Corporation (FCIC)[13] details the total number of acres claimed as loss due to various causes by state, commodity, and year. ReFED used this data to estimate the causal breakdown of why fields are left unharvested each year by commodity and by state (see Appendix D for example data). Although market surplus or demand variation has led to spikes in “Decline in price” claims for specific commodities in certain years (e.g. cherries in 2018), the vast majority of claims are due to bad weather or natural disasters. “Decline in price” claims are much more common for lower value row crops such soybeans and corn, which were out of scope for this analysis and are therefore not reflected in the data. There is some concern that this data source may not be a representative way to quantify the percentage of produce walk-by fields that occur due to market dynamics (e.g., Decline in price claims), because many growers do not place insurance claims when this happens. However, because walk-by fields already represent such a small portion of surplus (~3%) and weather events are the dominant driver of walk-by losses, any underestimation of market dynamics that may occur becomes negligible. One important limitation of this dataset, though, is that it groups together most lower volume crops into an “All Other Crops” category. ReFED used this data and assumed that the causal breakdown of walk-by losses is the same across these lower volume crop types.

Maturity of Fields Never Harvested
ReFED was unable to identify any publicly available data sources that quantify the percentage of walk-by fields (fields that are planted and never harvested) that reach maturity or start bearing edible fruit,

so this number was assumed to be 50%. This number is needed to quantify the amount of yield left unharvested in these fields. ReFED used USDA Survey data to quantify the number of walk-by acres by subtracting the number of acres harvested from the number of acres planted. In order to estimate the amount of yield left unharvested, average yield per acre from harvested acreage was multiplied by the estimated percent maturity and then multiplied by the number of walk-by acres.

Yield Left Behind After Harvest
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_YieldLeftBehindAfterHarvest.xlsx

Multiple university case studies from NC State[3,4], UC Santa Clara[5], and WWF[6] were used to quantify the amount of yield that is left behind after harvest crews have finished harvesting the field. Because these were one-time studies conducted in specific geographies (e.g., California, North Carolina, Florida, New Jersey, and Idaho) for a limited number of commodities, ReFED had to use extensive proxy commodity and geography assignments to model yield left behind for all crops in all states. These estimates also had to be reused year over year for the modeling.

Processing Rates Versus Fresh Market
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossRates.xlsx

ReFED used data from USDA surveys on processing versus fresh market tons harvested to quantify the percentage of a given commodity that was produced for the processing market in a particular state and year. ReFED used this data along with other datasets to estimate the amount of each commodity that gets sent to produce packhouses as opposed to being sent for processing in the processing market.

Field Packing Rates
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossRates.xlsx

ReFED researched several prominent agriculture websites[7,8,9,10,11,12] and consulted experts at the University of California Davis to estimate the percentage of each fresh market commodity that is packed in the field as opposed to being sent to a packhouse. Most commodities were estimated to be 0% or 100% field packed, although a few commodities were estimated to be 50-75% field packed. See Appendix B or the documentation for a detailed list. ReFED combined this data with harvest tonnages from the USDA Surveys to estimate the amount of each commodity that gets sent to produce packhouses for packing.

Packhouse Loss Rates
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossRates.xlsx

ReFED used data from the WWF Specialty Crop Losses Report[6] to quantify the percent of produce packhouse volumes that are not utilized (e.g., culls or throws). For the packhouses included in the study, 14.8%, 14.2%, and 2.6% of incoming produce was culled for tomatoes, peaches, and potatoes respectively. Because this was a one-time study conducted for a limited number of commodities, ReFED had to use extensive proxy commodity assignments and reused these estimates for every U.S. state year over year for the modeling.

Before deciding on this data source for estimating packhouse losses, ReFED explored data available from USDA surveys on weight of commodities not sold. This was recently added to the USDA Survey data collection process in 2016. We were unable to use this data source for the time being because this newly collected information is sparsely reported by growers to date. However, when and if growers start reporting these numbers in larger quantities, ReFED recommends using the USDA Survey data to track the amount of produce harvested but not sold (e.g., packhouse losses), because the infrastructure is already in place to get updated numbers for specific commodities and states on an annual basis for statistically significant sample sizes.

Buyer Rejection Rates

Based on expert interviews, ReFED assumed that 2% of all produce and nuts shipments are rejected by the quality assurance teams of produce buyers. ReFED used USDA Survey production tonnages of domestically grown produce and nuts to estimate the weight of each commodity delivered to domestic buyers. In reality this overestimates buyer rejections for commodities that are heavily exported (e.g., almonds) and underestimates buyer rejections for commodities that are grown outside of the U.S (e.g., bananas). Future iterations of this model should address this issue by accounting for the impact that imports and exports have on total domestic delivery tonnages. Based on the USDA Food Availability Dataset[15] which lists production, import, and export tonnages, ReFED estimates that the current buyer rejection tonnages of Farm product in the Food Waste Monitor are about 20% underestimated for fruits and vegetables and about 180% overestimated for nuts. This issue is exacerbated for specific commodities with significant trade deficits (e.g., bananas are grown almost exclusively outside of the U.S.). However, since the current model estimates that buyer rejections only represent about 3% of total farm surplus, this issue is unlikely to have a significant impact on the overall Farm surplus numbers.

Left Behind After Harvest Causes

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_LeftBeindAfterHarvestCauses.xlsx

Only two public case studies are available that quantify the reasons why produce is left behind after harvest, both from NC State[3,4]. More research is needed in this area, especially among tree crops as the NC State studies only looked at field crops. Because these were one-time studies conducted in North Carolina for a limited number of commodities, ReFED had to use extensive proxy commodity assignments and reuse these estimates for every U.S. state year over year for the modeling. More sustainable, continuously updated data collection methods are needed to track these causes over time going forward.

Packhouse Loss Causes

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossCauses.xlsx

ReFED used data from the WWF Specialty Crop Losses Report[6] to quantify the reasons why post-harvest produce is culled. For the two commodities that included cause data in the report (peaches and tomatoes), over 75% of the produce culled in the packing houses was because it was deemed inedible (e.g., cracks, bruises, deterioration) and the remaining portion was culled because it did not meet buyer specifications (e.g., second grades). ReFED believes these numbers to be directionally correct, but more research is needed to confirm that this data is consistent across a larger sample size, different commodity types, different packhouses, geographies, and different times of the year.

Packhouse Loss Destinations

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossDestinations.xlsx

ReFED used data from the WWF Specialty Crop Losses Report[6] to quantify the percentage breakdown of destinations for produce that gets culled at packhouses. ReFED believes these numbers to be directionally correct, but more research is needed to confirm that this data is consistent across a larger sample size, different commodity types, different packhouses, geographies, and different times of the year.

The portion sent to "trash" was further broken down into landfill versus incineration on a state-by-state basis using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University[14]. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Buyer Rejection Destinations

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_BuyerRejectionDestinations.xlsx

Based on expert interviews, ReFED assumed the following destinations breakdown for produce that gets rejected by buyers: 25% sold to discount outlets, 25% trash, 25% donated, and 25% animal feed. The portion sold to discount outlets was subtracted from the surplus total. Better data is needed in this area to replace these anecdotal estimates.

The portion sent to "trash" was further broken down into landfill versus incineration on a state-by-state basis using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University[14]. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Data Quality Evaluation

This rubric is designed to evaluate the quality of how each data source was utilized by ReFED to estimate food loss and waste. It is not meant to rate the quality of the study itself. See Appendix AA for more information about the ReFED Data Quality Rubric.

Table 4. Data Quality Evaluation for Food Waste Monitor Farm Sector

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
FARM SURPLUS DATA								
Acres Planted	USDA Surveys[2]	5	5	5	5	5	**Very High 25/5 = 5.0**	**2%**
Acres Harvested	USDA Surveys[2]	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
US Dollars Harvested	USDA Surveys[2]	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
Tons Harvested	USDA Surveys[2]	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
% Maturity of Fields Never Harvested	ReFED Assumption	1	1	1	1	1	**Very Low 5/5 = 1.0**	**1%**
% Yield Left Behind After Harvest	Farm Case Studies[3,4,5,6]	5	1	1	3	2	**Low 12/5 = 2.4**	**40%**
Processing Rates Versus Fresh Market	USDA Surveys[2]	5	5	5	5	5	**Very High 25/5 = 5.0**	**5%**
Field Packing Rates for Fresh Market	Public Agriculture Websites[7,8,9,10,11,12]	2	1	1	5	3	**Low 12/5 = 2.4**	**5%**
% Packhouse Loss Rates	WWF Specialty Crop Losses Report[6]	5	1	1	2	1	**Very Low 10/5 = 2.0**	**5%**
% Buyer Rejections	Expert Interviews	1	1	1	1	1	**Very Low 5/5 = 1.0**	**3%**
5.0 * 2% + 5.0 * 13% + 5.0 * 13% + 5.0 * 13% + 1.0 * 1% + 2.4 * 40% + 5.0 * 5% + 2.4 * 5% + 2.0 * 5% + 1.0 * 3% = 3.52							**Medium**	
FARM CAUSES DATA								
% Loss due to Cause for walk-by fields	USDA RMA Crop Insurance[13]	5	5	5	3	5	**High 23/5 = 4.6**	**3%**

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
% Loss due to Cause for yield left behind after harvest	Farm Case Studies[3,4,5,6]	5	1	1	2	1	**Low 10/5 = 2.0**	**87%**
% Loss due to Cause for packhouse losses	WWF Specialty Crop Losses Report[6]	5	1	1	1	1	**Very Low 9/5 = 1.8**	**10%**
		4.6 * 3% + 2.0 * 87% + 1.8 * 10% = 2.06					**Low**	
FARM DESTINATIONS DATA								
Acres Planted	USDA Surveys	5	5	5	5	5	**Very High 25/5 = 5.0**	**2%**
Acres Harvested	USDA Surveys	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
US Dollars Harvested	USDA Surveys	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
Tons Harvested	USDA Surveys	5	5	5	5	5	**Very High 25/5 = 5.0**	**13%**
% Maturity of Fields Never Harvested	ReFED Assumption	1	1	1	1	1	**Very Low 5/5 = 1.0**	**1%**
% Yield Left Behind After Harvest	Farm Case Studies	5	1	1	3	2	**Low 12/5 = 2.4**	**40%**
% of packhouse losses sent to each destination	WWF Specialty Crop Losses Report[6]	5	1	1	1	1	**Very Low 9/5 = 1.8**	**9%**
% of trash landfilled vs incinerated	Biocycle/Columbia University Survey[14]	5	2	4	1	5	**Medium 17/5 = 3.4**	**1%**
% Unsold Buyer Rejections sent to each destination	Expert Interviews	1	1	1	1	1	**Very Low 5/5 = 1.0**	**3%**
5.0 * 2% + 5.0 * 14% + 5.0 * 14% + 5.0 * 14% + 1.0 * 1% + 2.4 * 42% + 1.8 * 9% + 3.4 * 1% + 1.0 * 3% = 3.44							**Medium**	

INSIGHTS ENGINE FOOD WASTE MONITOR

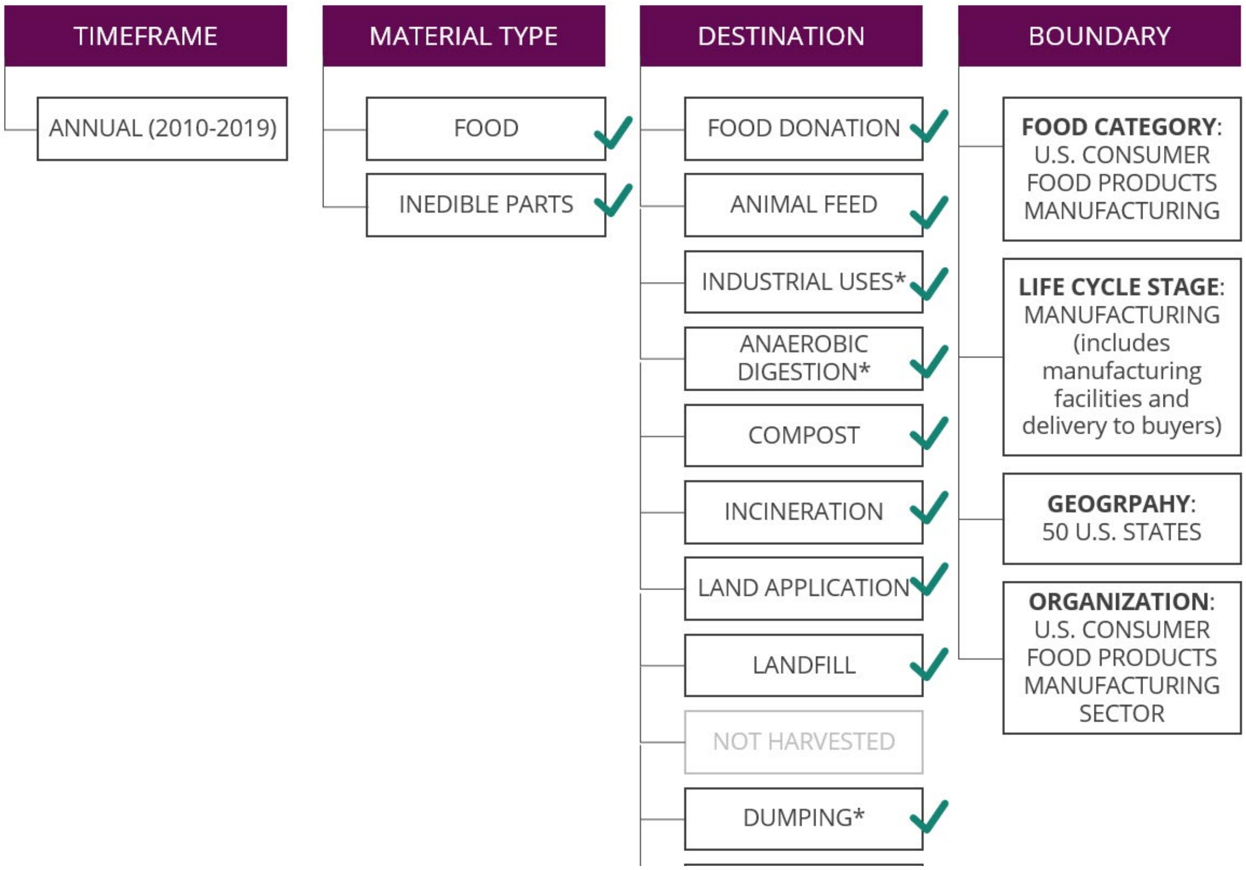
2020 MANUFACTURING METHODOLOGY

ReFED

MANUFACTURING METHODOLOGY

Scope Boundary

The following diagram communicates the scope boundary as aligned with the Food Loss and Waste Accounting and Reporting Standard[1]. Note that ReFED's analysis also includes food sent to donations, although donations are not considered a destination within the Standard.



***NOTES**

- "Food Donation" has been added as a Destination
- "Biomaterial Processing is referred to as "Industrial Uses" in our model
- "Co/anaerobic digestion" is referred to as "Anaerobic digestion" in our model
- "Controlled Combustion" is referred to as "Incineration" in our model
- "Refuse/discards" is referred to as "Dumping" in our model

Calculations

Surplus Food Calculations

Master Unsold Food Equation:
Tons Unutilized Ingredients
+ Tons Finished Product not Shipped
+ Tons Buyer Rejections

= Tons Unsold Food

In ReFED's data model, the following calculations are repeated for every state, year, and manufacturing food type before any aggregation is done.

Table 5. Calculations Performed to Quantify U.S. Manufacturing Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
National US Dollars Wholesale Value Shipped	U.S. Census Bureau Annual Survey of Manufactures[17]	$4,234,623,000 wholesale value of Tortilla manufacturing products shipped in 2018 from U.S. manufacturers
Percent of Shipments Used in Food Products	U.S. Census Bureau Annual Survey of Manufactures - Industry Product Analysis[17]	97.49% of Tortilla manufacturing shipments in 2018 were used in food products
Retail Markup	U.S. Census Bureau Annual Retail Trade Survey[18]	The average gross margin for U.S. grocery retailers in 2018 was 26.6% (See Appendix H)
National US Dollars Retail Value Shipped	= National US Dollars Wholesale Value Shipped * (100% + Retail Markup)	= $4,234,623,000 wholesale value shipped * (100% + 26.6% margin) = $5,226,320,602 retail value of manufacturing products shipped
Retail Price per Lb (National)	U.S. Grocery Retail Dollar-to-Weight Conversion Factors Report[19]	Average retail price $1.37 per lb for tortilla products
National Tons Shipped	= National US Dollars Retail Value Shipped / Retail Price per Lb / 2,000 lbs per ton	= $5,226,320,602 retail value shipped / $1.37 per lb national average retail price = 1,907,416 tons shipped from U.S. manufacturers
National Employees	U.S. Bureau of Labor Statistics Employee Levels[20]	16,208 Tortilla Manufacturing employees in the U.S. in 2018
State Employees	U.S. Bureau of Labor Statistics Employee Levels[20]	1,307 Tortilla Manufacturing employees in Illinois in 2018
State Share of Employees	= State Employees / National Employees	= 1,307 Tortilla Manufacturing employees in Illinois in 2018 / 16,208 Tortilla Manufacturing employees in the U.S. in 2018 = 8.06% of Tortilla Manufacturing employees in Illinois in 2018

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Retail Value Shipped	= US Dollars National Retail Value Shipped * State Share of Employees	= $5,226,320,602 retail value shipped from all U.S. manufacturers * 8.06% of employees located in Illinois = $421,446,263 estimated retail value of tortilla manufacturing products shipped from Illinois in 2018
Tons Shipped	= National Tons Shipped * State Share of Employees	= 1,907,416 tons shipped from all U.S. manufacturers * 8.06% of employees located in Illinois = 153,813 estimated tons of tortilla manufacturing products shipped from Illinois in 2018
Buyer Rejection Rate	Expert Interviews	According to expert interviews, about 0.5% of Bread & Bakery shipments are rejected by buyers
US Dollars Sold	= (100% - Buyer Rejection Rate) * US Dollars Retail Value Shipped	= (100% - 0.5%) * $421,446,263 shipped from Illinois = $419,339,031 sold from Illinois
Tons Sold	= (100% - Buyer Rejection Rate) * Tons Shipped	= (100% - 0.5%) * 153,813 tons shipped from Illinois = 153,043 sold from Illinois
US Dollars Buyer Rejections	= US Dollars Retail Value Shipped - US Dollars Sold	= $421,446,263 shipped from Illinois - $419,339,031 sold from Illinois = $2,107,231 buyer rejections
Tons Buyer Rejections	= Tons Shipped - Tons Sold	196,556 tons shipped from Illinois - 195,574 tons sold from Illinois = 769 tons buyer rejections
% of Buyer Rejections Sold via Discount Outlets	Expert interviews	Based on expert interviews, ReFED assumed that 25% of product rejected by buyer quality assurance teams ends up being sold via other channels and does not get wasted.
Tons Unsold Buyer Rejections	= Tons Buyer Rejections * (100% - % of Buyer Rejections Sold via Discount Outlets)	= 769 tons buyer rejections *(100% - 25% sold via discount outlets) = 577 tons unsold buyer rejections
US Dollars Unsold Buyer Rejections	= Tons Unsold Buyer Rejections * Retail Price per Lb	= 577 tons unsold buyer rejections * $1.37 per lb * 2,000 lbs per ton = $1,580,423 unsold buyer rejections
% of Finished	Tesco Supplier Case Studies[21] (See Appendix I)	In the General Mills Tesco Supplier Case study (used as a proxy as no tortilla-specific study was available), 0.26% of manufactured products are finished into a final product but never shipped.
PRODUCT NOT SHIPPED		

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Production	= Tons Shipped / (100% - % of Finished Product not Shipped)	= 153,813 tons shipped from Illinois / (100% - 0.26% of Finished Product not Shipped) = 154,213 tons Tortilla products production in Illinois
US Dollars Production	= US Dollars Retail Value Shipped / (100% - % of Finished Product not Shipped)	= $421,446,263 shipped from Illinois / (100% - 0.26% of Finished Product not Shipped) = $422,544,879 Tortilla products production in Illinois
Tons Finished Product not Shipped	= Tons Production - Tons Shipped	= 154,213 Tortilla products production in Illinois - 153,813 tons Tortilla products shipped from Illinois = 401 tons Tortilla products not shipped
US Dollars Finished Product not Shipped	= US Dollars Production - US Dollars Shipped	= $422,544,879 Tortilla products production in Illinois - $421,446,263 Tortilla products shipped from Illinois = $1,098,617 Tortilla products not shipped
Recipe Tons Ingredient per Ton Finished Product	Multiple Data Sources[23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41]	0.63 tons Out of scope ingredients (e.g., water, gums) per ton finished tortilla products 0.21 tons Flour and meal per ton finished tortilla products 0.01 tons Baking yeast per ton finished tortilla products 0.03 tons Herbs, spices, and seasonings per ton finished tortilla products 0.1 tons Shortening and lard per ton finished tortilla products 0.02 tons Baking milks per ton finished tortilla products
Tons of each Ingredient Utilized in Finished Product	= Tons Production * % by Weight of each Ingredient	Water and additives are not considered "food" in this methodology. Flour and meal: = 154,213 tons of tortilla products produced * 0.21 tons Flour and meal per ton finished product = 32,385 tons Flour and meal utilized Baking yeast: = 154,213 tons of tortilla products produced * 0.01 tons Baking yeast per ton finished product = 1,542 tons Baking yeast utilized

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Continued from above: **Tons of each Ingredient Utilized in Finished Product**	Continued from above: = Tons Production * % by Weight of each Ingredient	Herbs, spices, and seasonings: = 154,213 tons of tortilla products produced * 0.03 tons Herbs, spices, and seasonings per ton finished product = 4,626 tons Herbs, spices, and seasonings utilized Shortening and lard: = 154,213 tons of tortilla products produced * 0.10 tons Shortening and lard per ton finished product = 15,421 tons Shortening and lard utilized Baking milks: = 154,213 tons of tortilla products produced * 0.02 tons Baking milks per ton finished product = 3,084 tons Baking milks utilized
Ingredient Utilization Rates	Tesco Supplier Case Studies[21]	In the Panelto Foods Tesco Supplier Case study (a UK bakery supplier), 87% of ingredients were utilized
Tons of Ingredients Unutilized	= Tons of Ingredient Utilized * (100% - Ingredient Utilization Rate) / Ingredient Utilization Rate	Flour and meal: = 32,385 tons utilized * (100% - 87% utilized) / 87% utilized = 4,704 tons unutilized Baking yeast: = 1,542 tons utilized * (100% - 87% utilized) / 87% utilized = 224 tons unutilized Herbs, spices, and seasonings: = 4,626 tons utilized * (100% - 87% utilized) / 87% utilized = 672 tons unutilized Shortening and lard: = 15,421 tons utilized * (100% - 87% utilized) / 87% utilized = 2,240 tons unutilized Baking milks: = 3,084 tons utilized * (100% - 87% utilized) / 87% utilized = 448 tons unutilized

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Wholesale Price per Lb for each Ingredient	= Retail Price per Lb (National) * (100% - Grocery Retail Markup)	Flour and meal: = $0.70 per lb average grocery retail price * (100% - 26.6% grocery markup) = $0.51 per lb average wholesale price Baking yeast: $16.55 per lb average grocery retail price * (100% - 26.6% grocery markup) = $12.15 per lb average wholesale price Herbs, spices, and seasonings: $14.47 per lb average grocery retail price * (100% - 26.6% grocery markup) = $10.62 per lb average wholesale price Shortening and lard: $1.67 per lb average grocery retail price * (100% -26.6% grocery markup) = $1.23 per lb average wholesale price Baking milks: $1.74 per lb average grocery retail price * (100% - 26.6% grocery markup) = $1.28 per lb average wholesale price Total Tons Unutilized Ingredients: = 4,704 tons Flour and meal unutilized + 224 tons Baking yeast unutilized + 672 tons Herbs, spices, and seasonings unutilized + 2,240 tons Shortening and lard unutilized + 448 tons Baking milks unutilized = 8,287 tons unutilized ingredients

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Unutilized Ingredients	= Tons of Ingredient Unutilized * 2,000 lbs per ton * Wholesale Price per Lb	Flour and meal: = 4,704 tons unutilized * 2,000 lbs per ton * $0.51 per lb = $4,833,492 unutilized Baking yeast: = 224 tons unutilized * 2,000 lbs per ton * $12.15 per lb = $5,441,788 unutilized Herbs, spices, and seasonings: = 672 tons unutilized * 2,000 lbs per ton * $10.62 per lb = $14,273,596 unutilized Shortening and lard: = 2,240 tons unutilized * 2,000 lbs per ton * $1.23 per lb = $5,491,109 unutilized Baking milks: = 448 tons unutilized * 2,000 lbs per ton * $1.28 per lb = $1,144,255 unutilized Total US Dollars Unutilized Ingredients: = $4,833,492 Flour and meal unutilized + $5,441,788 Baking yeast unutilized + $14,273,596 Herbs, spices, and seasonings unutilized + $5,491,109 Shortening and lard unutilized + $1,144,255 Baking milks unutilized = $31,184,241 unutilized ingredients

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Ingredients Purchased	= Tons Unutilized Ingredients + Tons Ingredients Utilized in Finished Product	Flour and meal: = 4,704 tons Flour and meal unutilized + 32,385 tons Flour and meal utilized = 37,088 tons Flour and meal purchased Baking yeast: = 224 tons Baking yeast unutilized + 1,542 tons Baking yeast utilized = 1,766 tons Baking yeast purchased Herbs, spices, and seasoning: = 672 tons Herbs, spices, and seasonings unutilized + 4,626 tons Herbs, spices, and seasonings utilized = 5,298 tons Herbs, spices, and seasonings purchased Shortening and lard: = 2,240 tons Shortening and lard unutilized + 15,421 tons Shortening and lard utilized = 17,661 tons Shortening and lard purchased Baking milks = 448 tons Baking milks unutilized + 3,084 tons Baking milks utilized = 3,532 tons Baking milks purchased
US Dollars Ingredients Purchased	= Tons Ingredients Purchased * 2,000 lbs per ton * Wholesale Price per Lb	Flour and meal: = 37,088 tons Flour and meal purchased * 2,000 lbs per ton * $0.51 per lb = $38,112,139 Flour and meal purchased Baking yeast: = 1,766 tons Baking yeast purchased * 2,000 lbs per ton * $12.15 per lb = $42,908,565 Baking yeast purchased Herbs, spices, and seasonings: = 5,298 tons Herbs, spices, and seasonings purchased * 2,000 lbs per ton * $10.62 per lb = $112,547,481 Herbs, spices, and seasonings purchased Shortening and lard: = 17,661 tons Shortening and lard purchased * 2,000 lbs per ton * $1.23 per lb = $43,297,464 Shortening and lard purchased Baking milks: = 3,532 tons Baking milks purchased * 2,000 lbs per ton * $1.28 per lb = $9,022,466 Baking milks purchased

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Unsold Food	= Tons Unutilized Ingredients + Tons Unshipped Product + Tons Unsold Buyer Rejections	= 8,287 tons unutilized ingredients + 401 tons finished product not shipped + 577 tons unsold buyer rejections = 9,265 tons unsold Tortilla products manufactured in Illinois in 2018
US Dollars Unsold Food	= US Dollars Unutilized Ingredients + US Dollars Unshipped Product + US Dollars Unsold Buyer Rejections	= $31,184,241 unutilized ingredients + $1,098,617 finished product not shipped + $1,580,423 buyer rejections = $33,863,281 unsold Tortilla products in Illinois in 2018
Tons Supply	= Sum of Ingredient Tons Purchased	= 37,088 tons Flour and meal purchased + 1,766 tons Baking yeast purchased + 5,298 tons Herbs, spices, and seasonings purchased + 17,661 tons Shortening and lard purchased + 3,532 tons Baking milks purchased = 65,346 tons Tortilla product ingredients purchased in Illinois in 2018
US Dollars Supply	= Sum of Ingredient US Dollars Purchased	= $38,112,139 Flour and meal purchased + $42,908,565 Baking yeast purchased + $112,547,481 Herbs, spices, and seasonings purchased + $43,297,464 Shortening and lard purchased + $9,022,466 Baking milks purchased = $245,888,115 Tortilla product ingredients purchased in Illinois in 2018

Cause Calculations

Master Cause Equations:
Tons Unutilized Ingredients due to Cause = Tons Unutilized Ingredients * % Unutilized Ingredients due to Cause
Tons Unshipped Product due to Cause = Tons Unshipped Product * % Unshipped due to Cause
Tons Buyer Rejections = Tons Shipped * Buyer Rejection Rate

Table 6. Calculations Performed to Quantify the Causes of U.S. Manufacturing Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
UNUTILIZED INGREDIENTS		
% Unutilized due to Cause	Tesco Supplier Case Studies[21]	ReFED assumed that 100% of unutilized ingredients were Byproducts & Production Line Waste after reviewing the supplier case studies.
Tons Unutilized Ingredients due to Cause	= Tons Unutilized Ingredients * % Unutilized due to Cause	Tons unutilized due to Byproducts & Production Line Waste: = 8,287 tons unutilized ingredients * 100% unutilized due to Byproducts & Production Line Waste = 8,287 tons
US Dollars Unutilized Ingredients due to Cause	= US Dollars Unutilized Ingredients * % Unutilized due to Cause	US Dollars of ingredients unutilized due to Byproducts & Production Line Waste: = $31,184,241 unutilized ingredients * 100% unutilized due to Byproducts & Production Line Waste = $31,184,241
UNSHIPPED PRODUCT		
% Unshipped due to Cause	ReFED was unable to find any data sources that quantify the breakdown of the causes of unshipped product (e.g., misprints versus discontinued product), so this cause was not broken down any further.	100% due to 'Unshipped Finished Product'
Tons Unshipped Product due to Cause	= Tons Unshipped Product * % Unshipped due to 'Unshipped Finished Product'	= 401 tons unshipped Tortilla products * 100% = 401 tons
US Dollars Unshipped Product	= US Dollars Unshipped Product * % Unshipped due to 'Unshipped Finished Product'	= $1,098,617 unshipped Tortilla products * 100% = $1,098,617
BUYER REJECTIONS		
Tons Unsold Buyer Rejections	See calculation above for Tons Buyer Rejections	= 577 tons unsold buyer rejections
US Dollars Unsold Buyer Rejections	See calculation above for US Dollars Unsold Buyer Rejections	= $1,580,423 unsold buyer rejections

Destination Calculations

Master Destination Equations:
Tons Unutilized Ingredients sent to Destination = Tons Unutilized Ingredients * % Unutilized Ingredients sent to Destination
Tons Unshipped Product sent to Destination = Tons Unshipped Product * % Unshipped Product sent to Destination
Tons Buyer Rejections sent to Destination = Tons Buyer Rejections * % Buyer Rejections sent to Destination

Table 7. Calculations Performed to Quantify the Destinations of U.S. Manufacturing Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Unutilized Ingredients (See Appendix J)	Northstar Recycling[42]	This was the destinations breakdown for Bakery manufacturers based on aggregated data from NorthStar Recycling: Donated: 1% Animal feed: 99% Trash: 0% --- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Illinois (Biocycle/ Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100.00% % of Trash that is Incinerated = 0.00%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled: = 100% * 0% = 0% % Incinerated" = 0% * 0% = 0%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Unshipped Finished Product (See Appendix J)	Northstar Recycling	This was the destinations breakdown for Bakery manufacturers based on aggregated data from NorthStar Recycling: Donated: 1% Animal feed: 99% Trash: 0% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Illinois (Biocycle/ Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100.00% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled: = 100% * 0% = 0% % Incinerated: = 0% * 0% = 0%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Buyer Rejections	Expert Interviews	ReFED estimated the following breakdown of buyer rejections based on expert interviews: Resale: 25% (excluded from surplus) Donations: 25% Animal feed: 25% Trash: 25% -- Total: 100%
		Breakdown after excluding Resale: Donations: 33.33% Animal feed: 33.33% Trash: 33.33% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Illinois (Biocycle/ Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled = 100% * 33.33% = 33.33% % Incinerated = 0% * 33.33% = 0%
Tons Donated	= Tons Unutilized Ingredients * % Donations$_{UI}$ + Tons Unshipped Product * % Donations$_{UP}$ + Tons Unsold Buyer Rejections * % Donations$_{BR}$ Note: $_{UI}$ means Unutilized Ingredients $_{UP}$ means Unshipped Finished Product $_{BR}$ means Buyer Rejections	= 8,287 tons unutilized ingredients * 1% + 401 tons unshipped Tortilla products * 1% + 577 tons unsold buyer rejections * 33.33% = 278 tons Breads & Bakery products donated
Tons Animal Feed	= Tons Unutilized Ingredients * % Animal Feed$_{UI}$ + Tons Unshipped Product * % Animal Feed$_{UP}$ + Tons Unsold Buyer Rejections * % Animal Feed$_{BR}$	= 8,287 tons unutilized ingredients * 99% + 401 tons unshipped Tortilla products * 99% + 577 tons unsold buyer rejections * 33.33% = 8,795 tons Breads & Bakery products sent to animal feed
Tons Anaerobic Digestion	= Tons Unutilized Ingredients * % Anaerobic Digestion$_{UI}$ + Tons Unshipped Product * % Anaerobic Digestion$_{UP}$ + Tons Unsold Buyer Rejections * % Anaerobic Digestion$_{BR}$	For this particular example, anaerobic digestion was zero.

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Composted	= Tons Unutilized Ingredients * % Composted_{UI} + Tons Unshipped Product * % Composted_{UP} + Tons Buyer Rejections * % Composted_{BR}	For this particular example, anaerobic digestion was zero.
Tons Industrial uses	= Tons Unutilized Ingredients * % Industrial uses_{UI} + Tons Unshipped Product * % Industrial uses_{UP} + Tons Unsold Buyer Rejections * % Industrial uses_{BR}	For this particular example, anaerobic digestion was zero.
Tons Land Application	= Tons Unutilized Ingredients * % Land Application_{UI} + Tons Unshipped Product * % Land Application_{UP} + Tons Unsold Buyer Rejections * % Land Application_{BR}	For this particular example, anaerobic digestion was zero.
Tons Sewer	= Tons Unutilized Ingredients * % Sewer_{UI} + Tons Unshipped Product * % Sewer_{UP} + Tons Unsold Buyer Rejections * % Sewer_{BR}	For this particular example, anaerobic digestion was zero.
Tons Dumping	= Tons Unutilized Ingredients * % Dumping_{UI} + Tons Unshipped Product * % Dumping_{UP} + Tons Unsold Buyer Rejections * % Dumping_{BR}	For this particular example, anaerobic digestion was zero.
Tons Landfilled	= Tons Unutilized Ingredients * % Landfilled_{UI} + Tons Unshipped Product * % Landfilled_{UP} + Tons Unsold Buyer Rejections * % Landfilled_{BR}	= 8,287 tons unutilized ingredients * 0% + 401 tons unshipped Tortilla products * 0% + 577 tons buyer rejections * 33.33% = 192 tons Tortilla products sent to landfill
Tons Incinerated	= Tons Unutilized Ingredients * % Incinerated_{UI} + Tons Unshipped Product * % Incinerated_{UP} + Tons Buyer Rejections * % Incinerated_{BR}	= 8,287 tons unutilized ingredients * 0% + 401 tons unshipped Tortilla products * 0% + 577 tons unsold buyer rejections * 0% = 0 tons Tortilla products sent to incineration
US Dollars Donated	= US Dollars Unutilized Ingredients * % Donations_{UI} + US Dollars Unshipped Product * % Donations_{UP} + US Dollars Unsold Buyer Rejections * % Donations_{BR}	= $31,184,241 unutilized ingredients * 1% + $1,098,617 unshipped Tortilla products * 1% + $1,580,423 unsold buyer rejections * 33.33% = $846,355 Tortilla products donated
US Dollars Animal Feed	= US Dollars Unutilized Ingredients * % Animal Feed_{UI} + US Dollars Unshipped Product * % Animal Feed_{UP} + US Dollars Unsold Buyer Rejections * % Animal Feed_{BR}	= $31,184,241 unutilized ingredients * 99% + $1,098,617 unshipped Tortilla products * 99% + $1,580,423 unsold buyer rejections * 33.33% =$32,490,012 Tortilla products sent to animal feed

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Anaerobic Digestion	= US Dollars Unutilized Ingredients * % Anaerobic Digestion$_{UI}$ + US Dollars Unshipped Product * % Anaerobic Digestion$_{UP}$ + US Dollars Unsold Buyer Rejections * % Anaerobic Digestion$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Composted	= US Dollars Unutilized Ingredients * % Composted$_{UI}$ + US Dollars Unshipped Product * % Composted$_{UP}$ + US Dollars Buyer Rejections * % Composted$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Industrial uses	= US Dollars Unutilized Ingredients * % Industrial uses$_{UI}$ + US Dollars Unshipped Product * % Industrial uses$_{UP}$ + US Dollars Unsold Buyer Rejections * % Industrial uses$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Land Application	= US Dollars Unutilized Ingredients * % Land Application$_{UI}$ + US Dollars Unshipped Product * % Land Application$_{UP}$ + US Dollars Buyer Rejections * % Land Application$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Sewer	= US Dollars Unutilized Ingredients * % Sewer$_{UI}$ + US Dollars Unshipped Product * % Sewer$_{UP}$ + US Dollars Unsold Buyer Rejections * % Sewer$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Dumping	= US Dollars Unutilized Ingredients * % Dumping$_{UI}$ + US Dollars Unshipped Product * % Dumping$_{UP}$ + US Dollars Unsold Buyer Rejections * % Dumping$_{BR}$	For this particular example, anaerobic digestion was zero.
US Dollars Landfilled	= US Dollars Unutilized Ingredients * % Landfilled$_{UI}$ + US Dollars Unshipped Product * % Landfilled$_{UP}$ + US Dollars Unsold Buyer Rejections * % Landfilled$_{BR}$	= $31,184,241 unutilized ingredients * 0% + $1,098,617 unshipped Tortilla products * 0% + $1,580,423 unsold buyer rejections * 33.33% = $526,755 Tortilla products sent to landfill
US Dollars Incinerated	= US Dollars Unutilized Ingredients * % Incinerated$_{UI}$ + US Dollars Unshipped Product * % Incinerated$_{UP}$ + US Dollars Unsold Buyer Rejections * % Incinerated$_{BR}$	= $31,184,241 unutilized ingredients * 0% + $1,098,617 unshipped Tortilla products * 0% + $1,580,423 unsold buyer rejections * 0% = $0 Tortilla products sent to incineration

Data Sources and Limitations

National Value Shipped
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_NationalValueShipped.xlsx

Each year the U.S. Census Bureau conducts the Annual Survey of Manufactures[43], which includes the wholesale value of product shipped from manufacturers in addition to many other data points. Every business is categorized into an industry code according to the North America Industry Classification System (NAICS). ReFED used this as the data source to determine the wholesale value of food manufactured in the U.S. on an annual basis. One of the data files specifies the percentage of manufactured food shipments that are indeed food as opposed to non-edible commercial products. This information was used to discount the total shipment values to include only edible food products. Additionally, some of the NAICS codes were too broad for ReFED's purposes (e.g., Seafood processing). ReFED used Nielsen Point-of-sale (POS) data[44] in order to estimate the proportion of manufactured meat and seafood products that are fresh versus frozen versus canned, and therefore belong to different ReFED food departments (e.g., Fresh Meat & Seafood versus Frozen versus Dry Goods respectively).

Retail Markup
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_RetailMargins.xlsx

Each year the U.S. Census Bureau conducts the Annual Retail Trade Survey[45], which includes gross margins from retail firms broken out by business types including grocery food and beverage stores. ReFED used these gross margins as a proxy for retail markup of manufactured food products. These margins were used to inflate the National Wholesale Value of manufactured food shipments to estimate the equivalent retail value of food shipments. See Appendix H for a list of retail margins over the years.

Retail Price per Lb
Raw Data and Documentation: This is confidential data from Nielsen and cannot be shared.

Nielsen data represents over 85% coverage of grocery retail sales in the U.S. Each year top U.S. grocery retailers report item level point-of-sale sales data to Nielsen, including information about each item such as the grocery chain where it was sold, the brand name of the product, the food classification (department, category, subcategory), the weight of food and packaging, and many other attributes. ReFED used this data to quantify the retail value and weight of food sold by grocery retailers in the U.S. by year, state, and food type. For more information about the weight data, see U.S. Grocery Retail Dollar-to-Weight Conversion Factors Report[19].

The accuracy of these estimates is limited to the accuracy of the Nielsen sales and weight data. The weight data for UPC items comes directly from up-to-date product packaging images. For non-UPC items sold in eaches, Nielsen estimates weight using a weight conversion factor (e.g., the average weight of a lemon). For other non-UPC items, Nielsen is reliant on the retailer transaction data to provide the item sale weight units (e.g., lbs of apples sold).

ReFED mapped the Nielsen data to each Bureau of Labor Statistics food manufacturing NAICS code to estimate the national average retail price per lb by food manufacturing code. These prices were then used to estimate the weight of food manufactured and shipped from U.S. manufacturers after the national wholesale values shipped were inflated to equivalent retail values.

Employees
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_Employees.xlsx

Each year the U.S. Census Bureau releases the number of employees working in various industry types in addition to many other data points[20]. Every business is categorized into an industry code according to the North America Industry Classification System (NAICS). ReFED used the number of employees working in each food manufacturing industry type (e.g., Tortilla manufacturing) in each state on an annual basis to allocate national food manufacturing shipments to individual states.

The error in this approach is that the number of employees is not always proportional to the volume of production, but in absence of state-level manufacturing numbers, this was the best approach for estimating state-level food surplus. The result is that the state-level food surplus numbers may be high or low for particular manufacturing types.

Unshipped Product Rates
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_UnshippedProductRates.xlsx

ReFED used data from Tesco supplier food waste case studies[21] to quantify the percentage of finished manufactured food that does not ultimately get shipped to buyers. ReFED identified specific suppliers to serve as proxies for different manufacturing types (e.g., Panelto Foods case study, a UK bakery manufacturer, was selected as the proxy for U.S. Tortilla manufacturing). The resulting numbers from this approach are consistent with expert interviews with U.S. food manufacturers (all case studies indicated that <1% of finished product remains unshipped), so ReFED feels fairly confident in these estimates.

Buyer Rejection Rates
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_BuyerRejectionRates.xlsx

Based on expert interviews, ReFED assumed that 2% of all manufactured prepared food shipments and 0.5% of all other types of manufactured food are rejected by the quality assurance teams of buyers (note that fresh produce rejections are included in the Farm sector, which were assumed to be 2%). ReFED used U.S. manufacturing shipments to estimate the weight of each food type delivered to buyers. In reality this overestimates buyer rejections for foods that are heavily exported and undestimates buyer rejections for food types that are manufactured outside of the U.S. Future iterations of this model should address this issue by accounting for imports and exports. Based on data from the USDA

Global Agriculture Trade System[46] which lists import and export values, ReFED estimates that the current estimated buyer rejection tonnages in the Food Waste Monitor are not significantly affected because the overall U.S. trade deficit of manufactured food is relatively small compared to domestic production volumes. However, for specific foods with significant trade deficits (e.g., chocolate is heavily manufactured outside of the U.S.), this issue is exacerbated.

Recipes

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_RecipesAndUtilizationRates.xlsx

In order to estimate the types of food ingredients and byproducts that are used (and therefore potentially wasted) at food manufacturing plants, ReFED identified a variety of recipe data sources of varying quality[23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41]. See the Raw Data and Documentation for a complete list of recipes and data sources. ReFED aggregated all of the category-level data to a higher level before sharing the data on the Food Waste Monitor as this data is only a rough estimate (e.g., salt and flour both become Dry Goods). ReFED was unable to find recipe data for a few manufacturing types, but these categories only represented 7.57% of value shipped. Unutilized ingredients were estimated to be zero for these categories. See Appendix I for more information.

Ingredient Utilization Rates

Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_RecipesAndUtilizationRates.xlsx

ReFED used data from Tesco supplier food waste case studies[21] to quantify the percentage of purchased ingredients that get utilized in finished product. ReFED identified specific suppliers to serve as proxies for different manufacturing types (e.g., Panelto Foods case study, a UK bakery manufacturer, was selected as the proxy for U.S. Tortilla manufacturing). The resulting numbers from this approach are consistent with expert interviews with U.S. food manufacturers (all case studies indicated that 87-100% of ingredients are utilized), so ReFED feels fairly confident in these estimates. ReFED was unable to find recipe data for a few manufacturing types (only 7.57% of retail value shipped), so ingredient utilization rates were unnecessary for these categories. See Appendix I for more information.

Wholesale Ingredient Prices

Raw Data and Documentation: This contains confidential data from Nielsen and cannot be shared.

ReFED subtracted average grocery margins[45] from the Nielsen retail price per lb data[19] to estimate wholesale prices of each manufactured food ingredient. For example, in 2018 the average retail price of eggs was $2.00 per lb. Also in 2018, the average margin for grocery stores was 26.6%. Therefore, ReFED estimated the wholesale price of eggs to be $1.56 per lb. The error in this approach is that the grocery margin data is not food type specific. While this approach likely leads to underestimation and overestimation errors for specific food types when quantifying the value of unutilized ingredients, these effects balance each other out in the total sector numbers when all food types are combined.

Unutilized Ingredient Destinations
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_UnutilizedIngredientDestinations.xlsx

ReFED used custom-prepared food waste destinations data from Northstar Recycling[42] to estimate the destination breakdown of unutilized food manufacturing ingredients by food manufacturing type (See Appendix J). Northstar Recycling is a national waste and recycling company that manages waste for many food manufacturers across the U.S. and Canada. Because Northstar does not manage food waste for any meat processing facilities, ReFED assumed that 100% of unutilized ingredients at meat processing plants were sent to rendering (industrial uses). Additionally, Northstar does not have visibility to food donations data for their clients, so ReFED assumed that 1% of unutilized ingredients are donated based on data from the 2016 Food Waste Reduction Alliance survey[47] in which 9 manufacturers responded (6.2% of U.S. market share based on sales). Because these data sources are based on a single year, the data does not provide insight into changes in disposal habits over time.

The portion sent to "trash" was further broken down into landfill versus incineration on a state-by-state basis using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Unshipped Product Destinations
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_UnshippedProductDestinations.xlsx

ReFED also used the data from Northstar Recycling as described above to estimate the destination breakdown of unshipped finished product by food manufacturing type.

Retail Rejection Destinations
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_RetailRejectionRates.xlsx

Based on expert interviews, ReFED assumed the following destinations breakdown for product that gets rejected by buyers: 25% sold to discount outlets, 25% trash, 25% donated, and 25% animal feed. The portion sold to discount outlets was subtracted from the surplus total. Better data is needed in this area to replace these anecdotal estimates.

The portion sent to "trash" was further broken down into landfill versus incineration on a state-by-state basis using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Data Quality Evaluation

This rubric is designed to evaluate the quality of how each data source was utilized by ReFED to estimate food loss and waste. It is not meant to rate the quality of the study itself. See Appendix AA for more information about the ReFED Data Quality Rubric.

Table 8. Data Quality Evaluation for Food Waste Monitor Manufacturing Sector

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
MANUFACTURING SURPLUS FOOD								
National US Dollars Wholesale Value Shipped	U.S. Census Bureau Annual Survey of Manufactures[17]	5	5	5	5	3	**High 23/5 = 4.6**	**15%**
Retail Markup	U.S. Census Bureau Annual Retail Trade Survey[18]	5	5	5	1	3	**Medium 19/5 = 3.8**	**15%**
Retail Price per Lb	U.S. Grocery Retail Dollar-to-Weight Conversion Factors Report[19]	4	5	5	5	3	**High 22/5 = 4.4**	**15%**
Employees	U.S. Bureau of Labor Statistics Employee Levels[20]	5	5	5	5	5	**Very High 25/5 = 5.0**	**15%**
Buyer Rejection Rates	Expert Interviews	1	1	1	3	3	**Very Low 9/5 = 1.8**	**5%**
Unshipped Product Rates	Tesco Supplier Case Studies[21]	3	1	1	3	1	**Very Low 9/5 = 1.8**	**5%**
Recipes	Multiple Data Sources [23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41]	1	1	1	5	1	**Very Low 9/5 = 1.8**	**10%**
Ingredient Utilization Rates	Tesco Supplier Case Studies[21]	3	1	1	3	1	**Very Low 9/5 = 1.8**	**20%**
4.6 * 15% + 3.8 * 15% + 4.4 * 15% + 5.0 * 15% + 1.8 * 5% + 1.8 * 5% + 1.8 * 10% + 1.8 * 20% = 3.4							**Medium**	
MANUFACTURING CAUSES DATA								
Ingredient Utilization Rates	Tesco Supplier Case Studies[21]	3	1	1	3	1	**Very Low 9/5 = 1.8**	**80%**
Unshipped Product Rates	Tesco Supplier Case Studies[21]	3	1	1	3	1	**Very Low 9/5 = 1.8**	**10%**
Buyer Rejection Rates	Expert Interviews	1	1	1	3	3	**Very Low 9/5 = 1.8**	**10%**
1.8 * 80% + 1.8 * 10% + 1.8 * 10% = 1.8							**Very Low**	

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
MANUFACTURING DESTINATIONS DATA								
% Destinations Breakdown of Unutilized Ingredients	Northstar Recycling[42] (See Appendix J)	4	1	2	1	3	**Low 11/5 = 2.2**	**78%**
% Destinations Breakdown of Unshipped Finished Product	Northstar Recycling[42] (See Appendix J)	1	1	1	3	3	**Very Low 9/5 = 1.8**	**8%**
% Destinations Breakdown of Buyer Rejections	Expert Interviews	1	1	1	1	3	**Very Low 7/5 = 1.4**	**8%**
% of Trash Landfilled vs Incinerated	Biocycle/Columbia University Survey[14]	5	2	4	1	5	**Medium 17/5 = 3.4**	**6%**
	2.2 * 78% + 1.8 * 8% + 1.4 * 8% + 3.4 * 6% = 2.2						**Low**	

INSIGHTS ENGINE FOOD WASTE MONITOR

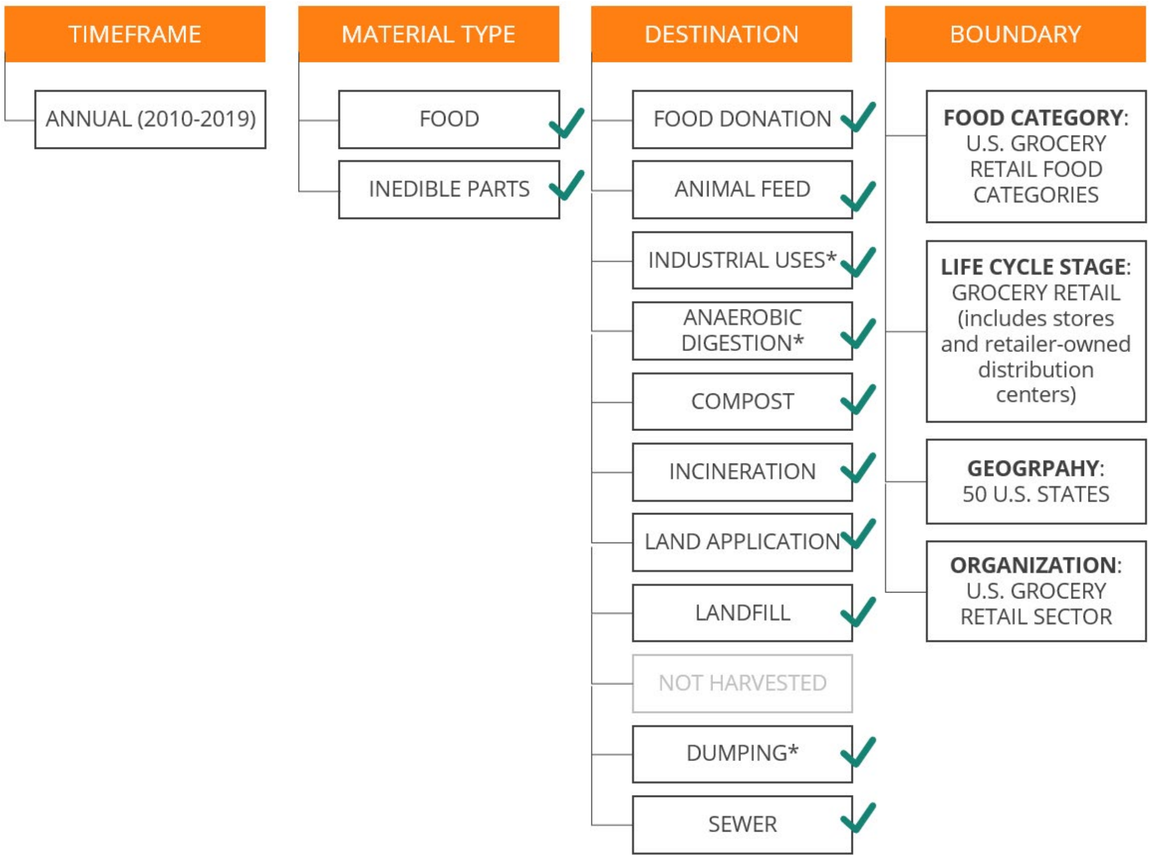
2020 RETAIL METHODOLOGY

ReFED

RETAIL METHODOLOGY

Scope Boundary

The following diagram communicates the scope boundary as aligned with the Food Loss and Waste Accounting and Reporting Standard[1]. Note that ReFED's analysis also includes food sent to donations, although donations are not considered a destination within the Standard.



***NOTES**

- "Food Donation" has been added as a Destination
- "Biomaterial Processing is referred to as "Industrial Uses" in our model
- "Co/anaerobic digestion" is referred to as "Anaerobic digestion" in our model
- "Controlled Combustion" is referred to as "Incineration" in our model
- "Refuse/discards" is referred to as "Dumping" in our model

Calculations

Unsold Food Calculations

Master Unsold Food Equation:
Tons Unsold Food = Tons Purchased by Retailers - Tons Sold

In ReFED's data model, the following calculations are repeated for every state, year, and grocery retail food category before any aggregation is done.

Table 9. Calculations Performed to Quantify U.S. Retail Surplus Food Surplus

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Sold	Nielsen Retail Point-of-Sale (POS) Data[44]	$16,095,997 tomatoes sold by grocery retailers in Arkansas in 2019
Tons Sold	Nielsen Retail Point-of-Sale (POS) Data[44]	4,507 tons tomatoes sold by grocery retailers in Arkansas in 2019
Unsold Food Rate	USDA Supermarket Shrink Estimates for ERS Loss-Adjusted Food Availability Data (LAFA)[15,48] Unsold food rates from the FMI Supermarket Security and Loss Prevention Report[49] were used for categories not covered by the USDA LAFA study See Appendix K and L for unsold food rates	According to USDA LAFA study, 14.47% by weight of fresh tomatoes goes unsold
Tons Purchased by Retailers	= Tons Sold / (100% - Unsold Food Rate)	= 4,507 tons sold / (100% - 14.47%) = 5,270 tons purchased by retailers
US Dollars Purchased by Retailers	= US Dollars Sold / (100% - Unsold Food Rate)	= $16,095,997 sold / (100% - 14.47%) = $18,818,730 retail value purchased from suppliers
Tons Unsold	= Tons Purchased by Retailers - Tons Sold	= 5,270 tons purchased - 4,507 tons sold = 762 tons unsold
US Dollars Unsold	= US Dollars Purchased - US Dollars Sold	= $18,818,730 retail value purchased - $16,095,997 sold = $2,722,733 unsold

Cause Calculations

Master Cause Equation:
Tons Unsold Food due to Cause = Tons Unsold Food * % Unsold Food due to Cause

Table 10. Calculations Performed to Quantify the Causes of U.S. Retail Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
% Unsold Food due to Cause	Expert Interviews[50] See Appendix M	% Breakdown of retail unsold food causes for Produce: Date label concerns: 63.02% Equipment issues: 4.39% Food safety recall: 0.05% Handling errors: 5.95% Spoiled: 25.09% Theft: 1.50% -- Total: 100%
Tons Unsold due to Cause	= Tons Unsold * % Unsold Food due to Cause	Date label concerns: = 762 tons unsold tomatoes * 63.02% = 480 tons Equipment issues: = 762 tons unsold tomatoes * 4.39% = 33 tons Food safety recall: = 762 tons unsold tomatoes * 0.05% = <1 tons Handling errors: = 762 tons unsold tomatoes * 5.95% = 45 tons Spoiled: = 762 tons unsold tomatoes * 25.09% = 191 tons Theft: = 762 tons unsold tomatoes * 1.50% = 11 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Unsold due to Cause	= US Dollars Unsold * % Unsold Food due to Cause	Date label concerns: = $2,722,733 unsold tomatoes * 63.02% = $1,715,776 Equipment issues: = $2,722,733 unsold tomatoes * 4.39% = $119,517 Food safety recall: = $2,722,733 unsold tomatoes * 0.05% = $1,361 Handling errors: = $2,722,733 unsold tomatoes * 5.95% = $161,971 Spoiled: = $2,722,733 unsold tomatoes * 25.09% = $683,267 Theft: = $2,722,733 unsold tomatoes * 1.50% = $40,841

Destination Calculations

Master Destination Equation:
Tons Unsold Food sent to Destination '= Tons Unsold Food * % Unsold Food Sent to Destination

Table 11. Calculations Performed to Quantify the Destinations of U.S. Retail Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Retail Surplus Food	FWRA Surveys[4]	According to the FWRA Surveys, this was the destination breakdown of retail surplus (See Appendix N): % Donations: 19.1% % Animal Feed: 18.53% % Biomaterials / processing: 4.62% % Co/anaerobic Digestion: 4.81% % Composting: 17.94% % Land Application: 1.17% % Sewer: 0% % Trash: 33.83% % Refuse / discards: 0% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Arkansas (Biocycle/Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled: = 33.83% * 100% = 33.83% % Incinerated: = 33.83% * 0% = 0%
Tons Donated	= Tons Surplus * % Donated	= 762 tons tomato surplus * 19.1% donated = 146 tons tomatoes donated
Tons Animal Feed	= Tons Surplus * % Animal Feed	= 762 tons tomato surplus * 18.53% animal feed = 141 tons tomatoes sent to animal feed
Tons Biomaterials / processing	= Tons Surplus * % Biomaterials / processing	= 762 tons tomato surplus * 4.62% biomaterials / processing = 35 tons tomatoes sent to biomaterials / processing
Tons Co/anaerobic digestion	= Tons Surplus * % Co/anaerobic digestion	= 762 tons tomato surplus * 4.81% co/anaerobic digestion = 37 tons tomatoes sent to co/anaerobic digestion
Tons Composted	= Tons Surplus * % Composted	= 762 tons tomato surplus * 17.94% composted = 137 tons tomatoes composted

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Land application	= Tons Surplus * % Land application	= 762 tons tomato surplus * 1.17% land application = 9 tons tomatoes sent to land application
Tons Sewer	= Tons Surplus * % Sewer	= 762 tons tomato surplus * 0% disposed down the drain = 0 tons tomatoes disposed via sewer
Tons Landfilled	= Tons Surplus * % Landfilled	= 762 tons tomato surplus * 33.83% landfilled = 258 tons tomatoes landfilled
Tons Incineration	= Tons Surplus * % Incineration	= 762 tons tomato surplus * 0% incinerated = 0 tons tomatoes incinerated
US Dollars Donated	= US Dollars Surplus * % Donated	= $2,722,733 US dollars tomato surplus * 19.1% donated = $520,042 US dollars tomatoes donated
US Dollars Animal Feed	= US Dollars Surplus * % Animal Feed	= $2,722,733 US dollars tomato surplus * 18.53% animal feed = $504,523 US dollars tomatoes sent to animal feed
US Dollars Biomaterials / processing	= US Dollars Surplus * % Biomaterials / processing	= $2,722,733 US dollars tomato surplus * 4.62% biomaterials / processing = $125,790 US dollars tomatoes sent to biomaterials / processing
US Dollars Co/anaerobic digestion	= US Dollars Surplus * % Co/anaerobic digestion	= $2,722,733 US dollars tomato surplus * 4.81% co/anaerobic digestion = $130,963 US dollars tomatoes sent to co/ anaerobic digestion
US Dollars Composted	= US Dollars Surplus * % Composted	= $2,722,733 US dollars tomato surplus * 17.94% composted = $488,458 US dollars tomatoes composted
US Dollars Land application	= US Dollars Surplus * % Land application	= $2,722,733 US dollars tomato surplus * 1.17% land application = $31,856 US dollars tomatoes sent to land application
US Dollars Sewer	= US Dollars Surplus * % Sewer	= $2,722,733 US dollars tomato surplus * 0% disposed down the drain = $0 US dollars tomatoes disposed via sewer
US Dollars Landfilled	= US Dollars Surplus * % Landfilled	= $2,722,733 US dollars tomato surplus * 33.83% landfilled = $921,101 US dollars tomatoes landfilled
US Dollars Incineration	= US Dollars Surplus * % Incineration	= $2,722,733 US dollars tomato surplus * 0% incinerated = $0 US dollars tomatoes incinerated

Data Sources and Limitations

Retail Value and Tons Sold

Raw data and documentation: This is confidential data from Nielsen and cannot be shared.

Nielsen data represents over 85% coverage of grocery retail sales in the U.S. Each year top U.S. grocery retailers report item level point-of-sale sales data to Nielsen[44], including information about each item such as the grocery chain where it was sold, the brand name of the product, the food classification (department, category, subcategory), the weight of food and packaging, and many other attributes. ReFED used this data to quantify the retail value and weight of food sold by grocery retailers in the U.S. by year, state, and food type. For more information about the weight data, see the U.S. Grocery Retail Dollar-to-Weight Conversion Factors report[19].

Nielsen provided point-of-sale data for the years 2016-2019. In order to estimate values for the missing years 2010-2015 each subcategory was extrapolated using category-level average year-over-year linear growth rates for both sales value and sales weight. Due to the high granularity of the categories, there were some cases where the growth rates were either extremely high or extremely low. To avoid unrealistic growth estimations over time within these outlier categories, department-level growth rates were used instead if a category had a growth rate ±15%. These outlier categories represent 0.5% of total sales.

The accuracy of these estimates is limited to the accuracy of the Nielsen sales and weight data. The weight data for UPC items comes directly from up-to-date product packaging images. For non-UPC items sold in eaches, Nielsen estimates weight using a weight conversion factor (e.g., the average weight of a lemon). For other non-UPC items, Nielsen is reliant on the retailer transaction data to provide the item sale weight units (e.g., lbs of apples sold).

Unsold Food Rates

Raw data and documentation: This contains confidential data from Nielsen and cannot be shared.

In 2016, USDA released a study using data from 2012 that quantified the percentage by weight of grocery retail supplier purchases that are not sold to customers[48]. Five individual retailers contributed supplier purchase data for the study and these numbers were compared to customer sales data. The data covered 45 states and 2,900 locations. See Appendix K for a list of unsold food rates from this study. These numbers are very credible and valuable for estimating retail food surplus in the U.S. The only limitations of using this dataset for this purpose are that the data is from 2012, and it does not cover a significant portion of items sold at grocery stores (e.g. complex products like boxed dinners, frozen meals, bakery items, etc.). ReFED used the 2012 unsold food rates for all years 2010-2019 when it was available for specific categories, so any changes in these rates over time are not reflected in the results.

For grocery retail categories not covered by the USDA LAFA dataset, ReFED used unsold food rates from the 2009 Food Marketing Institute (FMI) Supermarket Security and Loss Prevention Report[49]. Prior to 2010, FMI released this report on an annual basis, but since then it has been discontinued. The report includes food department unsold food percentages as reported by the 50 grocery retailers that participated in the confidential survey. See Appendix L for a list of unsold food rates from this report. ReFED used the retail percentages as opposed to cost. The limitations of using this dataset for estimating retail food surplus in the U.S. are the following: (1) The data is provided as a percentage of retail value rather than weight, which would be the appropriate measure to quantify the weight of food surplus. (2) Like the USDA LAFA data, this data is outdated and was reused by ReFED for all years 2010-2019, so any changes in these rates over time are not reflected in the results. (3) The data is provided at the department level (e.g. Bakery) and does reflect differences between categories in each department (e.g., Cheesecake versus Artisan bread).

Unsold Food Causes
Raw data and documentation: This contains confidential data and cannot be shared.

ReFED was not able to identify any publicly available data sources that quantify the causes of unsold food for grocery retailers in the U.S. As a placeholder until further research can be done, ReFED developed estimates using data from Leanpath on the causes of unutilized food in foodservice combined with review and input from grocery retail subject matter experts. Leanpath is a technology company that helps foodservice companies track, weigh and analyze the amount of food that is wasted in commercial kitchens. Leanpath customers also indicate the reason the food was not used as well as the food type when using Leanpath's automated software system. For more information, see Appendix M and the Foodservice Methodology section.

Steps taken to adapt the Leanpath foodservice cause data to be relevant for grocery retail:
1. Map Leanpath's food types to similar grocery retail food types (e.g., Produce, Dry goods).
2. Filter out data for causes that are not relevant to the retail sector (e.g., Catering overproduction is not relevant for a grocery retail Produce department).
3. Quantify the causal breakdown of unused food by food type.
4. Have grocery retail subject matter experts review the data and compare it with numbers they're used to seeing in the field and make adjustments accordingly.

Fortunately, the retail experts said that the resulting estimates after step 3 were close to what they're used to seeing and only recommended a few adjustments. It seems that certain types of food are handled in similar ways, and as a result are prone to disposal due to similar causes across foodservice and retail. Further research is needed, however, to validate these placeholder estimates.

Unsold Food Destinations
Raw Data and Documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Retail_UnsoldFoodDestinations.xlsx

In 2016 FWRA conducted a national food waste survey of grocery retailers in which 24 grocery retailers responded (35.3% of U.S. market share based on sales)[47]. ReFED used the data from this survey to quantify the percentage destination breakdown of unsold food from U.S. grocery retailers by year, state, and food type (See Appendix N).

There are a few limitations in using the data in this way. Because it was a national study for all food types, the data does not reflect geographic variations by state or variations in disposal patterns for different food types. Also, because it was a one-time study, the data does not provide insight into changes in disposal habits over time. See Appendix N for a breakdown of unsold food destinations.

Because landfill versus incineration facility infrastructure varies significantly from state to state, the landfill and incineration numbers from the FWRA surveys were combined into a "% Trash" number. ReFED then estimated the portion of trash that is landfilled versus incinerated in each state using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Data Quality Evaluation

This rubric is designed to evaluate the quality of how each data source was utilized by ReFED to estimate food loss and waste. It is not meant to rate the quality of the study itself. See Appendix AA for more information about the ReFED Data Quality Rubric.

Table 12. Data Quality Evaluation for Food Waste Monitor Retail Sector

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
RETAIL SURPLUS FOOD								
US Dollars Sold	Nielsen Point-of-sale (POS)[44]	4	5	5	5	5	**High 24/5 = 4.8**	**25%**
Tons Sold	Nielsen Point-of-sale (POS)[44]	4	5	5	5	5	**High 24/5 = 4.8**	**25%**
Unsold Food Rate	USDA Supermarket Shrink Estimates for ERS LAFA[15,48] FMI Supermarket Security and Loss Prevention Report[49]	4	1	2	3	3	**Low 13/5 = 2.6**	**50%**
		4.8 * 25% + 4.8 * 25% + 2.6 * 50% = 3.7					**Medium**	
RETAIL CAUSES								
% Unsold Food due to Cause	Expert Interviews[50]	1	1	1	3	1	**Very Low 7/5 = 1.4**	**100%**
		1.4 * 100% = 1.4					**Very Low**	
RETAIL DESTINATIONS								
% Destination Breakdown	FWRA Surveys[47]	4	1	2	1	3	**Low 11/5 = 2.2**	**95%**
% of Trash that is Landfilled vs Incinerated by State	Biocycle/Columbia University Survey[16]	5	1	5	1	5	**Medium 17/5 = 3.4**	**5%**
		2.2 * 95% + 3.4 * 5% = 2.3					**Low**	

INSIGHTS ENGINE FOOD WASTE MONITOR

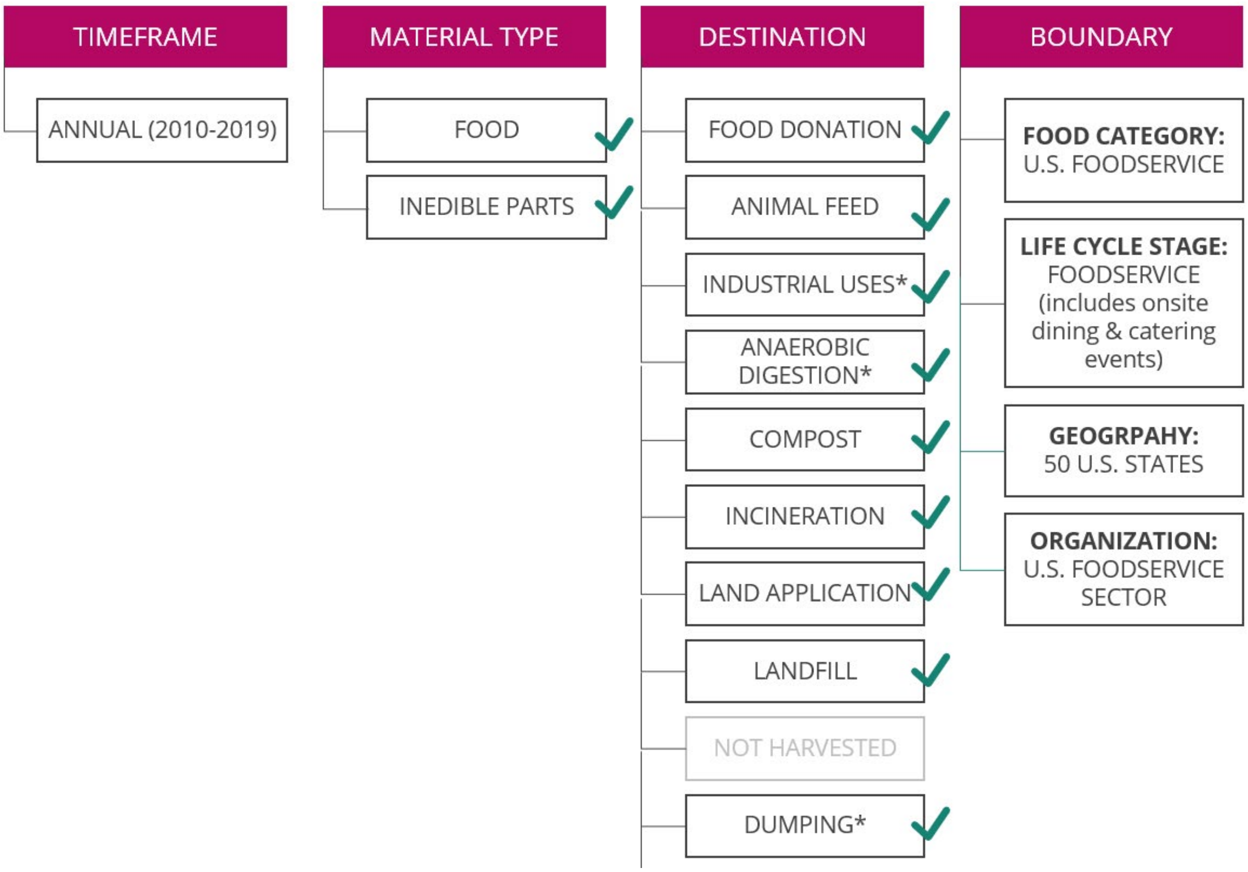
2020 FOODSERVICE METHODOLOGY

ReFED

FOODSERVICE METHODOLOGY

Scope Boundary

The following diagram communicates the scope boundary as aligned with the Food Loss and Waste Accounting and Reporting Standard[1]. Note that ReFED's analysis also includes food sent to donations, although donations are not considered a destination within the Standard.



***NOTES**

- "Food Donation" has been added as a Destination
- "Biomaterial Processing is referred to as "Industrial Uses" in our model
- "Co/anaerobic digestion" is referred to as "Anaerobic digestion" in our model
- "Controlled Combustion" is referred to as "Incineration" in our model
- "Refuse/discards" is referred to as "Dumping" in our model

Calculations

Surplus Food Calculations

Master Surplus Equation:
Tons Pre-Consumer Surplus
+ Tons Onsite Plate Waste
+ Tons Catering Overproduction
+ Tons Catering Plate Waste

= Tons Foodservice Surplus

In ReFED's data model, the following calculations are repeated for every state, year, and foodservice segment before any aggregation is done.

Table 13. Calculations Performed to Quantify U.S. Foodservice Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
SUPPLIER PURCHASES AND CUSTOMER SALES		
National Purchases from Suppliers	Technomic Ignite Platform[51]	$27,670,824,508 U.S. Limited Service Burger Restaurant purchases from suppliers and distributors
National US Dollars Sold	Technomic Ignite Platform[51]	$88,213,000,000 U.S. Limited Service Burger Restaurant sales
# US Locations for Top 500 Restaurants	Technomic Ignite Platform[51]	42,400 Limited Service Burger Restaurant locations in the U.S. for Top 500 Restaurants
# State Locations for Top 500 Restaurants	Technomic Ignite Platform[51] Note: For non-restaurant foodservice segments (e.g., corporate cafeterias), state-level employee counts from the Bureau of Labor Statistics[20] were used to allocate national supplier purchase numbers instead of Technomic locations data.	4,592 Limited Service Burger Restaurant locations in Texas for Top 500 Restaurants
State % Share of Supplier Purchases	= # State Locations for Top 500 Restaurants / # US Locations for Top 500 Restaurants	= 4,592 Texas locations / 42,400 U.S. locations = 10.83% Texas market share of Limited Service Burger locations
% In-scope Ingredients	ReFED Calculation See Appendix O for more information	ReFED estimates the following breakdown for the McDonald's menu: In-scope ingredients: 93.7% Out of scope: 6.3% -- Total: 100%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Supplier Purchases	= National Purchases from Suppliers * State % Share of Supplier Purchases * % In-scope Ingredients	= $27,670,824,508 U.S. Limited Service Burger Restaurant purchases * 10.83% Texas market share * 93.7% in-scope = $2,808,158,994 estimated Limited Service Burger supplier purchases in Texas
US Dollars Sold	= National US Dollars Sold * State % Share of Supplier Purchases * % In-scope ingredients	= $88,213,000,000 U.S. Limited Service Burger Restaurant sales * 10.83% Texas market share * 93.7% in-scope = $8,952,249,662 estimated Limited Service Burger Restaurant sales in Texas
Wholesale Price per Lb	ReFED Calculation See Appendix O for more information	ReFED estimates that the average wholesale price of food for McDonald's in 2019 was $1.84 per lb.
Tons Purchased from Suppliers	= US Dollars Supplier Purchases / Wholesale Price per Lb / 2,000 lbs per ton	= $2,808,158,994 state supplier purchases / $1.84 per lb / 2,000 lbs per ton = 762,999 tons of food purchased from suppliers for Limited Service Burger restaurants in Texas
Pre-Consumer Surplus Rate	Leanpath[52]	4.2% of food spend not utilized by kitchens
Tons Sold	= Tons Purchased from Suppliers * (100% - Pre-Consumer Surplus Rate)	= 762,999 tons of food purchased from suppliers * (100% - 4.2%) = 730,953 tons sold to customers at Limited Service Burger restaurants in Texas
PRE-CONSUMER FOOD SURPLUS		
Tons Pre-Consumer Surplus	= Tons Purchased from Suppliers * Pre-Consumer Surplus Rate	= 762,999 tons food purchased from suppliers * 4.2% surplus rate = 32,046 tons pre-consumer surplus at Limited Service Burger restaurants in Texas
% of Pre-Consumer Surplus that is Overproduction	Leanpath[52]	56.3% of pre-consumer surplus for the Hospitality sector (proxy sector for restaurants) is due to Overproduction.
Tons Overproduction	= Tons Pre-Consumer Surplus * % of Pre-Consumer Surplus that is Overproduction Note: All Overproduction was listed as "Prepared Foods" in the Food Waste Monitor.	= 32,046 tons pre-consumer surplus * 56.3% Overproduction = 18,045 tons Overproduction
Retail Price per Lb	= US Dollars Sold / Tons Sold / 2,000 lbs per ton	= $8,952,249,662 sold / 730,953 tons sold / 2,000 lbs per ton = $6.12 retail value per lb sold
US Dollars Overproduction	=Tons Overproduction * Retail Price per Lb Note: Overproduction is valued at retail rather than wholesale price, because it is ready to sell to a customer.	= 18,045 tons Overproduction * $6.12 retail value per lb sold * 2,000 lbs per ton = $221,008,321 Overproduction

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Pre-Consumer Surplus (excluding Overproduction)	= Tons Pre-Consumer Surplus - Tons Overproduction	= 32,046 tons Pre-Consumer Surplus - 18,045 tons Overproduction = 14,001 tons Pre-Consumer Surplus (excluding Overproduction) at Limited Service Burger restaurants in Texas
US Dollars Pre-Consumer Surplus (excluding Overproduction)	= Tons Pre-Consumer Surplus (excluding Overproduction) * Wholesale Price per Lb * 2,000 lbs per ton	= 14,001 tons Pre-Consumer Surplus (excluding Overproduction) * $1.84 wholesale price per lb * 2,000 lbs per ton = $51,528,065 pre-consumer surplus at Limited Service Burger restaurants in Texas
US Dollars Pre-Consumer Surplus	= US Dollars Overproduction + US Dollars Pre-Consumer Surplus (excluding Overproduction)	= $221,008,321 Overproduction + $51,528,065 other pre-consumer surplus = $272,491,348
Food Type Breakdown of Ingredients	ReFED Calculation See Appendix O for more information	ReFED estimates the following food type breakdown for the McDonald's menu: Dairy & Eggs: 29.85% Ready-to-drink Beverages: 16.72% Fresh Meat & Seafood: 16.08% Breads & Bakery: 11.73% Dry Goods: 10.39% Produce: 8.00% Frozen: 0.93% Out of scope: 6.3% -- Total: 100% Breakdown after removing out of scope foods (e.g., soft drinks, bottled water): Dairy & Eggs: 31.85% Ready-to-drink Beverages: 17.85% Fresh Meat & Seafood: 17.16% Breads & Bakery: 12.52% Dry Goods: 11.09% Produce: 8.54% Frozen: 0.99% -- Total: 100% Note: Dairy & Eggs is so high because of eggs on the breakfast menu, cheese on burgers, cream added to coffee, etc. Dry Goods includes shelf stable items such as condiments, pickles, sugar added to coffee, etc. Soft drinks and water are considered out of scope. Ready-to-drink Beverages include coffee, tea, and juices.

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Pre-Consumer Surplus by Food Type (excluding Overproduction)	= (Tons Pre-Consumer Surplus - Tons Overproduction) * % Food Type	Dairy & Eggs: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 31.85% = 4,460 tons Ready-to-drink Beverages: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 17.85% = 2,499 tons Fresh Meat & Seafood: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 17.16% = 2,403 tons Breads & Bakery: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 12.52% = 1,752 tons Dry Goods: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 11.09% = 1,552 tons Produce: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 8.54% = 1,196 tons Frozen: = (32,046 tons pre-consumer surplus - 18,045 tons Overproduction) * 0.99% = 139 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Pre-Consumer Surplus by Food Type (excluding Overproduction)	= US Dollars Pre-Consumer Surplus (excluding Overproduction) * % Food Type	Dairy & Eggs: = $51,528,065 pre-consumer surplus * 31.85% = $16,413,873 surplus Ready-to-drink Beverages: = $51,528,065 pre-consumer surplus * 17.85% = $9,196,942 surplus Fresh Meat & Seafood: = $51,528,065 pre-consumer surplus * 17.16% = $8,842,338 surplus Breads & Bakery: = $51,528,065 pre-consumer surplus * 12.52% = $6,449,288 surplus Dry Goods: = $51,528,065 pre-consumer surplus * 11.09% = $5,712,538 surplus Produce: = $51,528,065 pre-consumer surplus * 8.54% = $4,401,845 surplus Frozen: = $51,528,065 pre-consumer surplus * 0.99% = $511,241 surplus
CATERING EXCESS		
Breakdown of Sales by Customer Distribution Channel	Technomic Ignite Platform[51]	For Limited Service restaurants in 2019: Take-out: 67% Onsite Dining: 25% Catering: 8% ------------------------------- Total: 100%
% Catering Overproduction	Expert Interviews See Appendix Q	Experts estimate that 38% of food is typically left unserved at breakfast or lunch catering events.

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Catering Overproduction	= Tons Sold * % Catering * % Catering Overproduction Note: All Catering Overproduction was listed as "Prepared Foods" in the Food Waste Monitor.	= 730,953 tons sold * 8% of sales is catering * 38% food left unserved at events = 22,186 tons catering overproduction from Limited Service Burger restaurants in Texas
US Dollars Catering Overproduction	= US Dollars Sold * % Catering * % Catering Overproduction	= $8,952,249,662 sold * 8% of sales is catering * 38% food left unserved at events = $271,718,460 catering overproduction from Limited Service Burger restaurants in Texas
PLATE WASTE		
Plate Waste Rate	Plate Waste Studies[53,54,55,56,57] See Appendix P for plate waste rates used for each type of foodservice.	In the University of Guelph plate waste case study[54] in a restaurant setting, 11.3% of food served became plate waste
Tons Onsite Plate Waste	= Tons Sold * % Onsite Dining * Plate Waste Rate	= 730,953 tons sold * 25% of sales is onsite dining * 11.3% food served becomes plate waste = 20,556 tons onsite plate waste from Limited Service Burger restaurants in Texas
Tons Catering Served	= Tons Sold * % Catering - Tons Catering Overproduction	= 730,953 tons sold * 8% of sales is catering = 36,198 tons catering served from Limited Service Burger restaurants in Texas
US Dollars Catering Served	= Tons Catering Served * Retail $ per Lb * 2,000 lbs per ton	= 36,198 tons catering served * $6.12 Retail Price per Lb = $443,330,119 catering served from Limited Service Burger restaurants in Texas
Tons Catering Plate Waste	= Tons Catering Served * Plate Waste Rate	= 36,198 tons catering served * 11.3% food served becomes plate waste = 4,090 tons catering plate waste from Limited Service Burger restaurants in Texas
US Dollars Onsite Plate Waste	= US Dollars Sold * % Onsite Dining * Plate Waste Rate	= $8,952,249,662 sold * 25% of sales is onsite dining * 11.3% food served becomes plate waste = $251,753,914 onsite plate waste from Limited Service Burger restaurants in Texas
US Dollars Catering Plate Waste	= US Dollars Catering Served * Plate Waste Rate	= $443,330,119 catering served * 11.3% food served becomes plate waste = $50,096,303 catering plate waste from Limited Service Burger restaurants in Texas

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Total Tons Plate Waste	= Tons Onsite Plate Waste + Tons Catering Plate Waste Note: All Plate Waste was listed as "Prepared Foods" in the Food Waste Monitor.	= 20,556 tons onsite plate waste + 4,090 tons catering plate waste = 24,646 tons total plate waste from Limited Service Burger restaurants in Texas
Total US Dollars Plate Waste	= US Dollars Onsite Plate Waste + US Dollars Catering Plate Waste	= $251,753,914 onsite plate waste + $50,096,303 catering plate waste = $301,850,217 total plate waste from Limited Service Burger restaurants in Texas
TOTAL FOOD SURPLUS		
Tons Food Surplus	= Tons Pre-Consumer Surplus (including Overproduction) + Tons Plate Waste (including Onsite Dining and Catering) + Tons Catering Overproduction	= 32,046 tons pre-consumer surplus + 24,646 tons total plate waste + 22,186 tons catering overproduction = 78,878 tons food surplus from Limited Service Burger restaurants in Texas
US Dollars Food Surplus	= US Dollars Overproduction + US Dollars Pre-Consumer Surplus (excluding Overproduction) + US Dollars Plate Waste (including Onsite Dining and Catering) + US Dollars Catering Overproduction	= $221,008,321 overproduction + $51,528,065 pre-consumer surplus (excluding overproduction) + $301,850,217 total plate waste + $271,718,460 catering overproduction = $846,105,064 food surplus from Limited Service Burger restaurants in Texas

Cause Calculations

Table 14. Calculations Performed to Quantify the Causes of U.S. Foodservice Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
PRE-CONSUMER SURPLUS CAUSES		
Tons Overproduction	See calculation above for Tons Overproduction	= 18,045 tons Overproduction
US Dollars Overproduction	See calculation above for US Dollars Overproduction	= $221,008,321 Overproduction
% Surplus due to Cause (excluding Overproduction)	Leanpath[52] See Appendix R for causes by segment as well as proxies segments used when data was not available for a particular segment.	Pre-consumer food surplus causes (not including Overproduction) for the Hospitality segment in 2019 (used as a proxy for most restaurants). : Breads & Bakery: Cooking issues: 1.6% Date Label Concerns: 38.4% Equipment issues: 0.0% Food Safety: 0.0% Handling errors: 6.3% Other: 14.3% Spoiled: 36.7% Trimmings & Byproducts: 2.7% -- Total: 100% Dairy & Eggs: Cooking issues: 3.2% Date Label Concerns: 57.6% Equipment issues: 1.1% Food Safety: 0.0% Handling errors: 5.5% Other: 0.8% Spoiled: 29.1% Trimmings & Byproducts: 2.7% -- Total: 100% Dry Goods: Cooking issues: 19.8% Date Label Concerns: 57.8% Equipment issues: 0.5% Food Safety: 0.0% Handling errors: 3.2% Other: 0.4% Spoiled: 15.3% Trimmings & Byproducts: 3% -- Total: 100%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
> continued from previous page…	> continued from previous page…	Fresh Meat & Seafood: Cooking issues: 5.0% Date Label Concerns: 57.4% Equipment issues: 0.7% Food Safety: 0.0% Handling errors: 8.2% Other: 1.5% Spoiled: 18.4% Trimmings & Byproducts: 8.8% -- Total: 100%
% Surplus due to Cause (excluding Overproduction)	Leanpath[52] See Appendix R for causes by segment as well as proxies segments used when data was not available for a particular segment.	Frozen: Cooking issues: 0.0% Date Label Concerns: 31.1% Equipment issues: 0.0% Food Safety: 0.0% Handling errors: 22.2% Other: 2.6% Spoiled: 36.3% Trimmings & Byproducts: 7.8% -- Total: 100% Prepared Foods: Cooking issues: 9.4% Date Label Concerns: 64.6% Equipment issues: 0.3% Food Safety: 0.0% Handling errors: 5.8% Other: 0.8% Spoiled: 16.1% Trimmings & Byproducts: 3% -- Total: 100% Produce: Cooking issues: 2.4% Date Label Concerns: 25% Equipment issues: 0.0% Food Safety: 0.0% Handling errors: 2% Other: 1.2% Spoiled: 13.3% Trimmings & Byproducts: 56% -- Total: 100%

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
> continued from previous page… **% Surplus due to Cause (excluding Overproduction)**	> continued from previous page… Leanpath[52] See Appendix R for causes by segment as well as proxies segments used when data was not available for a particular segment.	Ready-to-Drink Beverages: Cooking issues: 0.0% Date Label Concerns: 29.9% Equipment issues: 0.0% Food Safety: 0.0% Handling errors: 4.2% Other: 21.2% Spoiled: 44.3% Trimmings & Byproducts: 0.4% --- Total: 100%
Tons Pre-Consumer Surplus due to Cause (excluding Overproduction)	= Tons Pre-Consumer Surplus by Food Type * % Pre-Consumer Surplus due to Cause	Tons due to Cooking Issues: = 1,752 tons surplus Breads & Bakery * 1.6% + 4,460 tons surplus Dairy & Eggs * 3.2% + 1,552 tons surplus Dry Goods * 19.8% + 2,403 tons surplus Fresh Meat & Seafood * 5.0% + 139 tons surplus Frozen * 0.0% + 1,196 tons surplus Produce * 2.4% + 2,499 tons surplus Ready-to-drink Beverages * 0.0% = 628 tons Tons due to Date Label Concerns: = 1,752 tons surplus Breads & Bakery * 38.4% + 4,460 tons surplus Dairy & Eggs * 57.6% + 1,552 tons surplus Dry Goods * 57.8% + 2,403 tons surplus Fresh Meat & Seafood * 57.4% + 139 tons surplus Frozen * 31.1% + 1,196 tons surplus Produce * 25.0% + 2,499 tons surplus Ready-to-drink Beverages * 29.9% = 6,605 tons Tons due to Equipment Issues: = 1,752 tons surplus Breads & Bakery * 0.0% + 4,460 tons surplus Dairy & Eggs * 1.1% + 1,552 tons surplus Dry Goods * 0.5% + 2,403 tons surplus Fresh Meat & Seafood * 0.7% + 139 tons surplus Frozen * 0.0% + 1,196 tons surplus Produce * 0.0% + 2,499 tons surplus Ready-to-drink Beverages * 0.0% = 75 tons Tons due to Food Safety: = 1,752 tons surplus Breads & Bakery * 0.0% + 4,460 tons surplus Dairy & Eggs * 0.0% + 1,552 tons surplus Dry Goods * 0.0% + 2,403 tons surplus Fresh Meat & Seafood * 0.0% + 139 tons surplus Frozen * 0.0% + 1,196 tons surplus Produce * 0.0% + 2,499 tons surplus Ready-to-drink Beverages * 0.0% = 0 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
> continued from previous page...	> continued from previous page...	Tons due to Handling Errors: = 1,752 tons surplus Breads & Bakery * 6.3% + 4,460 tons surplus Dairy & Eggs * 5.5% + 1,552 tons surplus Dry Goods * 3.2% + 2,403 tons surplus Fresh Meat & Seafood * 8.2% + 139 tons surplus Frozen * 22.2% + 1,196 tons surplus Produce * 2.0% + 2,499 tons surplus Ready-to-drink Beverages * 4.2% = 759 tons Tons due to Other: = 1,752 tons surplus Breads & Bakery * 14.3% + 4,460 tons surplus Dairy & Eggs * 0.8% + 1,552 tons surplus Dry Goods * 0.4% + 2,403 tons surplus Fresh Meat & Seafood * 1.5% + 139 tons surplus Frozen * 2.6% + 1,196 tons surplus Produce * 1.2% + 2,499 tons surplus Ready-to-drink Beverages * 21.2% = 879 tons
Tons Pre-Consumer Surplus due to Cause (excluding Overproduction)	= Tons Pre-Consumer Surplus by Food Type * % Pre-Consumer Surplus due to Cause	Tons due to Spoiled: = 1,752 tons surplus Breads & Bakery * 36.7% + 4,460 tons surplus Dairy & Eggs * 29.1% + 1,552 tons surplus Dry Goods * 15.3% + 2,403 tons surplus Fresh Meat & Seafood * 18.4% + 139 tons surplus Frozen * 36.3% + 1,196 tons surplus Produce * 13.3% + 2,499 tons surplus Ready-to-drink Beverages * 44.3% = 3,938 tons Tons due to Trimmings & Byproducts: = 1,752 tons surplus Breads & Bakery * 2.7% + 4,460 tons surplus Dairy & Eggs * 2.7% + 1,552 tons surplus Dry Goods * 3.0% + 2,403 tons surplus Fresh Meat & Seafood * 8.8% + 139 tons surplus Frozen * 7.8% + 1,196 tons surplus Produce * 56.0% + 2,499 tons surplus Ready-to-drink Beverages * 0.4% = 1,117 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Pre-Consumer Surplus due to Cause (excluding Overproduction)	= US Dollars Pre-Consumer Surplus by Food Type * % Pre-Consumer Surplus due to Cause	US Dollars due to Cooking Issues: = $6,449,288 surplus Breads & Bakery * 1.6% + $16,413,873 surplus Dairy & Eggs * 3.2% +$5,712,538 surplus Dry Goods * 19.8% + $8,842,338 surplus Fresh Meat & Seafood * 5.0% + $511,241 surplus Frozen * 0.0% + $4,401,845 surplus Produce * 2.4% + $9,196,942 surplus Ready-to-drink Beverages * 0.0% = $2,311,662 US Dollars due to Date Label Concerns: = $6,449,288 surplus Breads & Bakery * 38.4% + $16,413,873 surplus Dairy & Eggs * 57.6% + $5,712,538 surplus Dry Goods * 57.8% +$8,842,338 surplus Fresh Meat & Seafood * 57.4% + $511,241 surplus Frozen * 31.1% + $4,401,845 surplus Produce * 25.0% + $9,196,942 surplus Ready-to-drink Beverages * 29.9% = $24,310,424 US Dollars due to Equipment Issues: = $6,449,288 surplus Breads & Bakery * 0.0% + $16,413,873 surplus Dairy & Eggs * 1.1% + $5,712,538 surplus Dry Goods * 0.5% + $8,842,338 surplus Fresh Meat & Seafood * 0.7% + $511,241 surplus Frozen * 0.0% + $4,401,845 surplus Produce * 0.0% + $9,196,942 surplus Ready-to-drink Beverages * 0.0% = $275,069 US Dollars due to Food Safety: = $6,449,288 surplus Breads & Bakery * 0.0% + $16,413,873 surplus Dairy & Eggs * 0.0% + $5,712,538 surplus Dry Goods * 0.0% + $8,842,338 surplus Fresh Meat & Seafood * 0.0% + $511,241 surplus Frozen * 0.0% + $4,401,845 surplus Produce * 0.0% + $9,196,942 surplus Ready-to-drink Beverages * 0.0% = $0

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
> continued from previous page...	> continued from previous page...	US Dollars due to Handling Errors: = $6,449,288 surplus Breads & Bakery * 6.3% + $16,413,873 surplus Dairy & Eggs * 5.5% + $5,712,538 surplus Dry Goods * 3.2% + $8,842,338 surplus Fresh Meat & Seafood * 8.2% + $511,241 surplus Frozen * 22.2% + $4,401,845 surplus Produce * 2.0% + $9,196,942 surplus Ready-to-drink Beverages * 4.2% = $2,793,365 US Dollars due to Other: = $6,449,288 surplus Breads & Bakery * 14.3% + $16,413,873 surplus Dairy & Eggs * 0.8% + $5,712,538 surplus Dry Goods * 0.4% + $8,842,338 surplus Fresh Meat & Seafood * 1.5% + $511,241 surplus Frozen * 2.6% + $4,401,845 surplus Produce * 1.2% + $9,196,942 surplus Ready-to-drink Beverages * 21.2% = $3,233,447
US Dollars Pre-Consumer Surplus due to Cause (excluding Overproduction)	= US Dollars Pre-Consumer Surplus by Food Type * % Pre-Consumer Surplus due to Cause	US Dollars due to Spoiled: = $6,449,288 surplus Breads & Bakery * 36.7% + $16,413,873 surplus Dairy & Eggs * 29.1% + $5,712,538 surplus Dry Goods * 15.3% + $8,842,338 surplus Fresh Meat & Seafood * 18.4% + $511,241 surplus Frozen * 36.3% + $4,401,845 surplus Produce * 13.3% + $9,196,942 surplus Ready-to-drink Beverages * 44.3% = $14,493,282 US Dollars due to Trimmings & Byproducts: = $6,449,288 surplus Breads & Bakery * 2.7% + $16,413,873 surplus Dairy & Eggs * 2.7% + $5,712,538 surplus Dry Goods * 3.0% + $8,842,338 surplus Fresh Meat & Seafood * 8.8% + $511,241 surplus Frozen * 7.8% + $4,401,845 surplus Produce * 56.0% + $9,196,942 surplus Ready-to-drink Beverages * 0.4% = $4,110,817
PLATE WASTE AND CATERING OVERPRODUCTION		
Tons Plate Waste	See calculation above for Tons Plate Waste	= 24,646 tons plate waste
US Dollars Plate Waste	See calculation above for US Dollars Plate Waste	= $301,850,217 plate waste
Tons Catering Overproduction	See calculation above for Tons Catering Overproduction	= 22,186 tons catering overproduction
US Dollars Catering Overproduction	See calculation above for US Dollars Catering Overproduction	= $271,718,460 catering overproduction

Destination Calculations

Table 15. Calculations Performed to Quantify the Destinations of U.S. Foodservice Surplus Food

<table>
<tr><th>DATA ITEM</th><th>DATA SOURCE OR CALCULATION</th><th>EXAMPLE</th></tr>
<tr><td rowspan="3">Destination Breakdown of Pre-Consumer Food Surplus</td><td>Food Waste Reduction Alliance (FWRA) Survey[47]

Note: ReFED used Leanpath[52] data rather than FWRA survey data to quantify the breakdown of pre-consumer surplus for states that have organic waste recycling laws (California, Connecticut, Massachusetts, Oregon, Vermont, Washington). See Appendix S for more information.</td><td>Donated: 2.09%
Animal feed: 0.02%
Anaerobic Digestion: 0.02%
Compost: 0.38%
Land Application: 0.00%
Sewer: 0.00%
Dumping: 0.00%
Trash: 97.49%

Total: 100%

Note: ReFED excluded industrial uses (biomaterials/processing) data from the FWRA surveys, because most of this is spent cooking oil rather than pre-consumer surplus.</td></tr>
<tr><td>% of Trash that is Landfilled vs Incinerated in Texas (Biocycle/Columbia University Survey[14]) (See Appendix Z)</td><td>% of Trash that is Landfilled = 100%
% of Trash that is Incinerated = 0%</td></tr>
<tr><td>Breaking “Trash” into Landfill vs Incineration:

% Landfilled = % Trash * % of Trash that is Landfilled

% Incinerated = % Trash * % of Trash that is Incinerated</td><td>% Landfilled:
= 97.49%% * 100%
= 97.49%%

% Incinerated:
= 97.49%% * 0%
= 0%</td></tr>
</table>

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Plate Waste	ReFED assumed that plate waste was sent to "Trash" in all states, except states that have organic waste recycling laws. For those states, Leanpath[52] plate waste destinations data was used instead. See Appendix T for more information.	Assumed 100% Trash for plate waste in Texas
	% of Trash that is Landfilled vs Incinerated in Texas (Biocycle/Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled = 100% * 100% = 100% % Incinerated = 0% * 0% = 0%
Destination Breakdown of Catering Overproduction	ReFED assumed that catering overproduction was sent to "Trash" in all states, except states that have organic waste recycling laws. For those states, Leanpath[52] plate waste destinations data was used instead. See Appendix U for more information.	Donated: 0.00% Animal feed: 0.00% Anaerobic Digestion: 0.00% Compost: 0.00% Industrial uses: 0.00% Land Application: 0.00% Sewer: 0.00% Dumping: 0.00% Trash: 100% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Texas (Biocycle/Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled = 100% * 100% = 100% % Incinerated = 100% * 0% = 0%
Tons Donated	= Tons Pre-Consumer Surplus * % Donations for Pre-Consumer Surplus + Total Tons Plate Waste * % Donations for Plate Waste + Tons Catering Overproduction * % Donations for Catering Overproduction	= 32,046 tons * 2.09% + 24,646 tons * 0% + 22,186 tons * 0% = 668 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Animal Feed	= Tons Pre-Consumer Surplus * % Animal Feed for Pre-Consumer Surplus + Total Tons Plate Waste * % Animal Feed for Plate Waste + Tons Catering Overproduction * % Animal Feed for Catering Overproduction	= 32,046 tons * 0.02% + 24,646 tons * 0% + 22,186 tons * 0% = 7 tons
Tons Industrial uses	= Tons Pre-Consumer Surplus * % Industrial uses for Pre-Consumer Surplus + Total Tons Plate Waste * % Industrial uses for Plate Waste + Tons Catering Overproduction * % Industrial uses for Catering Overproduction	= 32,046 tons * 0% + 24,646 tons * 0% + 22,186 tons * 0% = 0 tons
Tons Anaerobic Digestion	= Tons Pre-Consumer Surplus * % Anaerobic Digestion for Pre-Consumer Surplus + Total Tons Plate Waste * % Anaerobic Digestion for Plate Waste + Tons Catering Overproduction * % Anaerobic Digestion for Catering Overproduction	= 32,046 tons * 0.02% + 24,646 tons * 0% + 22,186 tons * 0% = 7 tons
Tons Composted	= Tons Pre-Consumer Surplus * % Composted for Pre-Consumer Surplus + Total Tons Plate Waste * % Composted for Plate Waste + Tons Catering Overproduction * % Composted for Catering Overproduction	= 32,046 tons * 0.38% + 24,646 tons * 0% + 22,186 tons * 0% = 123 tons
Tons Land Application	= Tons Pre-Consumer Surplus * % Land Application for Pre-Consumer Surplus + Total Tons Plate Waste * % Land Application for Plate Waste + Tons Catering Overproduction * % Land Application for Catering Overproduction	= 32,046 tons * 0% + 24,646 tons * 0% + 22,186 tons * 0% = 0 tons
Tons Sewer	= Tons Pre-Consumer Surplus * % Sewer for Pre-Consumer Surplus + Total Tons Plate Waste * % Sewer for Plate Waste + Tons Catering Overproduction * % Sewer for Catering Overproduction	= 32,046 tons * 0% + 24,646 tons * 0% + 22,186 tons * 0% = 0 tons
Tons Dumping	= Tons Pre-Consumer Surplus * % Dumping for Pre-Consumer Surplus + Total Tons Plate Waste * % Dumping for Plate Waste + Tons Catering Overproduction * % Dumping for Catering Overproduction	= 32,046 tons * 0% + 24,646 tons * 0% + 22,186 tons * 0% = 0 tons
Tons Landfilled	= Tons Pre-Consumer Surplus * % Landfilled for Pre-Consumer Surplus + Total Tons Plate Waste * % Landfilled for Plate Waste + Tons Catering Overproduction * % Landfilled for Catering Overproduction	= 32,046 tons * 97.49% + 24,646 tons * 100% + 22,186 tons * 100% = 78,073 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Tons Incineration	= Tons Pre-Consumer Surplus * % Incineration for Pre-Consumer Surplus + Total Tons Plate Waste * % Incineration for Plate Waste + Tons Catering Overproduction * % Incineration for Catering Overproduction	= 32,046 tons * 0% + 24,646 tons * 0% + 22,186 tons * 0% = 0 tons
US Dollars Donated	= US Dollars Pre-Consumer Surplus * % Donations for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Donations for Plate Waste + US Dollars Catering Overproduction * % Donations for Catering Overproduction	= $272,536,386 * 2.09% + $301,850,217 * 0% + $271,718,460 * 0% = $5,683,278
US Dollars Animal Feed	= US Dollars Pre-Consumer Surplus * % Animal Feed for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Animal Feed for Plate Waste + US Dollars Catering Overproduction * % Animal Feed for Catering Overproduction	= $272,536,386 * 0.02% + $301,850,217 * 0% + $271,718,460 * 0% = $57,993
US Dollars Industrial uses	= US Dollars Pre-Consumer Surplus * % Industrial uses for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Industrial uses for Plate Waste + US Dollars Catering Overproduction * % Industrial uses for Catering Overproduction	= $272,536,386 * 0% + $301,850,217 * 0% + $271,718,460 * 0% = $0
US Dollars Anaerobic Digestion	= US Dollars Pre-Consumer Surplus * % Anaerobic Digestion for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Anaerobic Digestion for Plate Waste + US Dollars Catering Overproduction * % Anaerobic Digestion for Catering Overproduction	= $272,536,386 * 0.02% + $301,850,217 * 0% + $271,718,460 * 0% = $57,993
US Dollars Composted	= US Dollars Pre-Consumer Surplus * % Composted for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Composted for Plate Waste + US Dollars Catering Overproduction * % Composted for Catering Overproduction	= $272,536,386 * 0.37% + $301,850,217 * 0% + $271,718,460 * 0% = $1,043,867
US Dollars Land Application	= US Dollars Pre-Consumer Surplus * % Land Application for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Land Application for Plate Waste + US Dollars Catering Overproduction * % Land Application for Catering Overproduction	= $272,536,386 * 0% + $301,850,217 * 0% + $271,718,460 * 0% = $0

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Sewer	= US Dollars Pre-Consumer Surplus * % Sewer for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Sewer for Plate Waste + US Dollars Catering Overproduction * % Sewer for Catering Overproduction	= $272,536,386 * 0% + $301,850,217 * 0% + $271,718,460 * 0% = $0
US Dollars Dumping	= US Dollars Pre-Consumer Surplus * % Dumping for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Dumping for Plate Waste + US Dollars Catering Overproduction * % Dumping for Catering Overproduction	= $272,536,386 * 0% + $301,850,217 * 0% + $271,718,460 * 0% = $0
US Dollars Landfilled	= US Dollars Pre-Consumer Surplus * % Landfilled for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Landfilled for Plate Waste + US Dollars Catering Overproduction * % Landfilled for Catering Overproduction	= $272,536,386 * 97.49% + $301,850,217 *100% + $271,718,460 * 100% = $839,261,933
US Dollars Incineration	= US Dollars Pre-Consumer Surplus * % Incineration for Pre-Consumer Surplus + Total US Dollars Plate Waste * % Incineration for Plate Waste + US Dollars Catering Overproduction * % Incineration for Catering Overproduction	= $272,536,386 * 0% + $301,850,217 * 0% + $271,718,460 * 0% = $0

Data Sources and Limitations

National Foodservice Purchases and Sales
Raw data and documentation: This is confidential data from Technomic and cannot be shared.

Technomic is the leading sales and market share data company for the U.S. foodservice sector. ReFED obtained foodservice supplier purchases and customer sales data from the Technomic Ignite Platform[51]. This data is provided annually and is broken down by segment (e.g., limited service restaurants, full service restaurants, lodging, business & industry, etc.) and cuisine (e.g., burger, asian/noodle, varied menu), but is only available at the national, not state, level.

State Restaurant Locations and Employee Counts for Non-Restaurant Segments
Raw data and documentation:

- Restaurant Locations:
  This contains confidential data from Technomic and cannot be shared.
- Employee Counts for Non-Restaurant:
  https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_EmployeeCounts.xlsx

For limited service restaurants, full service restaurants, and bars & taverns, ReFED allocated national sales down to the state level using the Technomic state-level locations data for the Top 500 restaurants[51]. A limitation of this approach is that sales is not always proportional to the number of locations.

Because Technomic did not have comprehensive location data for non-restaurant foodservice segments (e.g., Healthcare, Lodging, Business & Industry, Universities, etc.), ReFED used industry employee counts from the Bureau of Labor Statistics (BLS) to allocate national Technomic sales to each state for these categories[20]. ReFED mapped each BLS NAICS industry code to the equivalent Technomic segment. Similar to the locations data, a limitation of this approach is that sales is not always proportional to the number of employees.

Wholesale Price per Lb
Raw data and documentation: This contains confidential data from Technomic and cannot be shared.

ReFED calculated average wholesale price per lb estimates for each foodservice segment by subtracting retailer price margins[45] from Nielsen retail prices[19] for hundreds of food categories. The average food category mix for each foodservice segment was estimated by combining menu data from the Technomic Ignite Platform[51] (e.g., Cheeseburger, Fries, etc.) with food type ingredient breakdown data from USDA Food Data Central[22] (e.g., A cheeseburger is 38% ground beef, 27% bread, 9% cheese, 9% tomato, 7% sauce, 7% pickles, 4% lettuce). Each foodservice segment was assigned a proxy menu based on the top restaurant by sales in each segment. For non-restaurant segments, a restaurant proxy menu was used. See Appendix O for wholesale price estimates and proxy menus used for each foodservice segment.

Pre-Consumer Surplus Rates

Leanpath is a technology company that helps foodservice companies track, weigh and analyze the amount of food that is wasted in commercial kitchens. Leanpath customers indicate the reason the food was not used, where it will be sent (e.g., composting, landfill, etc.), and the food type of the disposed food when using Leanpath's software system. Based on the data in their system across multiple clients, Leanpath estimates that on average 4.2% of food purchases are not utilized in commercial foodservice kitchens[52].

The limitations of using the Leanpath data to estimate foodservice pre-consumer surplus rates for all foodservice segments over time are the following: (1) The 4.2% estimate was a one-time estimate and does not reflect changes in performance over time. (2) Leanpath's current client base does not include restaurants, so if restaurants have significantly different pre-consumer surplus rates, this is not reflected. (3) The 4.2% estimate is not food type specific, so food type variations are not reflected.

Food Type Breakdown

Raw data and documentation: This is confidential data from Technomic and cannot be shared.

ReFED used menu data from Technomic[51] in combination with food ingredient breakdown data from USDA Food Data Central[22] to estimate the food ingredient breakdown of multiple menus. The Technomic menu data listed all of the items on a menu for the Top 500 restaurants (e.g., Cheeseburger, Fries, etc.). ReFED mapped each menu item to the closest matching food item in the USDA Food Data Central database, which provides the ingredient weight breakdown of each food (e.g., A cheeseburger is 38% ground beef, 27% bread, 9% cheese, 9% tomato, 7% sauce, 7% pickles, 4% lettuce). Each foodservice segment was assigned a proxy menu based on the top restaurant by sales in each segment (e.g., McDonald's menu was used as a proxy for Limited Service Burger Restaurants). For non-restaurant segments, a restaurant proxy menu was used. For example, since Applebee's was the proxy menu for the Varied Menu segment, it was used as the proxy for Business & Industry cafeterias since that setting has a varied menu as well. See Appendix O for a list of the proxy menus used for each foodservice segment as well as the estimated food type breakdown of their menus. This data was used to estimate the food type breakdown of Pre-Consumer Surplus by foodservice segment.

Distribution Channels (Dine in vs Takeout vs Catering)

Raw data and documentation: This is confidential data from Technomic and cannot be shared.

ReFED used proprietary data from Technomic[51] to estimate the amount of food that is eaten onsite or at catering events as opposed to takeout. In ReFED's data model, takeout is considered out of scope for the Foodservice sector and is accounted for in the Residential sector modeling instead. The distribution channel data provided by Technomic is broken out separately for different types of Limited Service Restaurants (quick service, fast casual) and Full Service Restaurants (casual dining, midscale, fine dining). ReFED assumed that 100% of food was eaten onsite for other types of foodservice (Education, Healthcare, Business & Industry, Military, Corrections, Lodging, Recreation, and Transportation).

Plate Waste Rates
Raw data and documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_PlateWasteRates.xlsx

ReFED used multiple quantitative studies conducted by nonprofits, academics, and government organizations to estimate plate waste rates[53,54,55,56,57]. ReFED identified the latest, most suitable study available to use as a proxy for plate waste rates in each foodservice segment. See Appendix P for a list of plate waste rates and proxy assignments. Because some foodservice types are under researched and because these were all one-time studies based on a few locations, a more robust, continually updated dataset is needed to better understand plate waste rates across multiple foodservice segments over time.

Catering Overproduction Rates
Based on expert interviews with catering organizations, ReFED estimates that 28% of food is never served to clients at buffet style catering events, 38% for breakfast and lunch events, and 13% for plated events. See Appendix Q for a list of which rates were used to estimate catering overproduction for each foodservice type.

Pre-Consumer Surplus Causes
Raw data and documentation: This is confidential data from Leanpath and cannot be shared.

Leanpath is a technology company that helps foodservice companies track, weigh and analyze the amount of food that is wasted in commercial kitchens. Leanpath customers indicate the reason the food was not used, where it will be sent (e.g., composting, landfill, etc.), and the food type when using Leanpath's waste tracking system. Leanpath pulled aggregated data[52] from their system to estimate the percent breakdown of pre-consumer surplus causes by food type for the following segments: Business & Industry, Hospitality, Healthcare, and Education. See Appendix R for pre-consumer surplus cause data for each of these foodservice segments as well as which segments were used as proxies for others (e.g., Hospitality data was used as a proxy for restaurants).

Pre-Consumer Surplus Destinations
Raw data and documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_PreconsumerSurplusDestinations.xlsx

For most states, ReFED used data from the 2016 Food Waste Reduction Alliance (FWRA) survey[47] of restaurants in which 28 restaurant companies responded (11.8% of U.S. market share based on sales) to estimate the destination breakdown of pre-consumer surplus. Data on industrial uses (or biomaterials/processing) was excluded because most of this is spent cooking oil rather than pre-consumer surplus. Since this data indicated that 94% of pre-consumer surplus is landfilled, which is not the case in states that have organics recycling laws, ReFED instead used data from Leanpath to estimate the pre-consumer surplus destinations for these states (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington). ReFED did not use the Leanpath data for other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

Because landfill versus incineration facility infrastructure varies significantly from state to state, the landfill and incineration numbers were combined into a "% Trash" number. ReFED then estimated the portion of trash that is landfilled versus incinerated in each state using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Plate Waste Destinations

Raw data and documentation:

- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_CateringPlateWasteDestinations.xlsx
- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_OnsitePlateWasteDestinations.xlsx

ReFED assumed that plate waste was sent to "Trash" in all states, except states that have organics recycling laws. For these states (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington), Leanpath plate waste destinations data was used instead[52]. ReFED did not use the Leanpath data for other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

ReFED then estimated the portion of trash that is landfilled versus incinerated in each state using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Catering Overproduction Destinations

Raw data and documentation:

https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Foodservice_CateringOverproductionDestinations.xlsx

ReFED assumed that catering overproduction was sent to "Trash" in all states, except states that have organic waste recycling laws. For states with organics recycling laws (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington), Leanpath catering overproduction destinations data was used instead[52]. ReFED did not use the Leanpath data for other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

ReFED then estimated the portion of trash that is landfilled versus incinerated in each state using data from BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED reused these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Data Quality Evaluation

This quality assessment is meant to evaluate the quality of how each data source was used by ReFED to estimate food loss and waste. It is not meant to rate the quality of the study itself. A high quality study used by ReFED beyond the study's intended purposes could result in a low data quality score. See Appendix AA for more information about the ReFED Data Quality Rubric.

Table 16. Data Quality Evaluation for Food Waste Monitor Foodservice Sector

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
FOODSERVICE SURPLUS								
National Purchases from Suppliers	Technomic Ignite Platform[51]	4	5	5	1	3	**Medium 18/5 = 3.6**	**10%**
National US Dollars Sold	Technomic Ignite Platform[51]	4	5	5	1	3	**Medium 18/5 = 3.6**	**8%**
State Locations for Top 500 Restaurants	Technomic Ignite Platform[51]	4	5	5	1	5	**High 20/5 = 4.0**	**8%**
State Employee Counts for Non-Restaurant Segments	U.S. Bureau of Labor Statistics Employee Levels[20]	5	5	5	1	5	**High 21/5 = 4.2**	**8%**
Food Type Breakdown	Technomic Ignite Platform Menu Data[51]	2	1	1	5	3	**Low 12/5 = 2.4**	**8%**
Wholesale Price per Lb	ReFED Calculations[19,22,45,51]	2	5	1	5	3	**Medium 16/5 = 3.2**	**8%**
Pre-Consumer Surplus Rate	Leanpath[52]	4	1	1	1	3	**Low 10/5 = 2.0**	**3%**
Distribution Channels (Dine in vs Takeout vs Catering)	Technomic Ignite Platform[51]	4	1	5	3	3	**Medium 16/5 = 3.2**	**10%**
Plate Waste Rates	Plate Waste Studies[53,54,55,56,57]	5	1	1	3	1	**Low 11/5 = 2.2**	**35%**
% Catering Overproduction	Expert Interviews	1	1	1	2	1	**Very Low 6/5 = 1.2**	**2%**
3.6 * 10% + 3.6 * 8% + 4.0 * 8% + 4.2 * 8% + 2.4 * 8% + 3.2 * 8% + 2.0 * 3% + 3.2 * 10% + 2.2 * 35% + 1.2 * 2% = 2.9							**Low**	

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
FOODSERVICE CAUSES								
% Pre-Consumer Surplus due to Cause	Leanpath[52]	4	5	1	5	3	**Medium 18/5 = 3.6**	**6%**
Distribution Channels (Dine in vs Takeout vs Catering)	Technomic Ignite Platform[51]	4	5	5	5	3	**High 22/5 = 4.4**	**20%**
Plate Waste Rates	Plate Waste Studies[53,54,55,56,57]	5	1	1	2	1	**Low 10/5 = 2.0**	**70%**
% Catering Overproduction	Expert Interviews	1	1	1	2	1	**Very Low 6/5 = 1.2**	**4%**
	3.6 * 6% + 4.4 * 20% + 2.0 * 70% + 1.2 * 4% = 2.5						**Low**	
FOODSERVICE DESTINATIONS								
% Destination Breakdown for Pre-Consumer Surplus	FWRA Surveys[47], Leanpath[52]	3	1	1	1	2	**Very Low 8/5 = 1.6**	**15%**
% Destination Breakdown for Plate Waste	Leanpath[52], ReFED Assumptions	4	5	1	5	2	**Medium 17/5 = 3.4**	**65%**
% Destination Breakdown for Catering Overproduction	Leanpath[52], ReFED Assumptions	4	5	1	5	2	**Medium 17/5 = 3.4**	**10%**
% of trash landfilled vs incinerated	Biocycle/Columbia University Survey[14]	5	1	5	1	5	**Medium 17/5 = 3.4**	**10%**
	1.6 * 15% + 3.4 * 65% + 3.4 * 10% + 3.4 * 10% = 3.1						**Medium**	

INSIGHTS ENGINE FOOD WASTE MONITOR

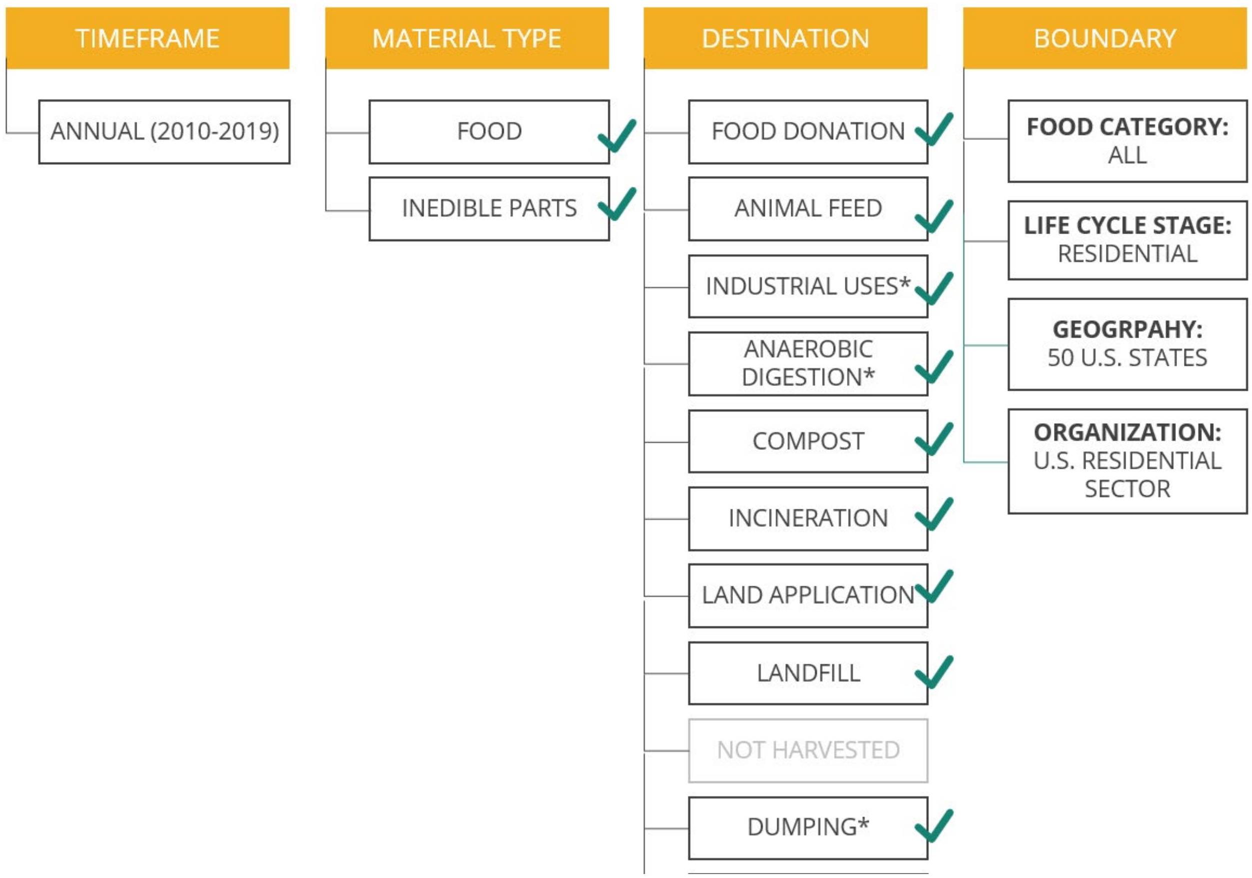
2020 RESIDENTIAL METHODOLOGY

ReFED

RESIDENTIAL METHODOLOGY

Scope Boundary

The following diagram communicates the scope boundary as aligned with the Food Loss and Waste Accounting and Reporting Standard[1]. Note that ReFED's analysis also includes food sent to donations, although donations are not considered a destination within the Standard.



*NOTES

- "Food Donation" has been added as a Destination
- "Biomaterial Processing is referred to as "Industrial Uses" in our model
- "Co/anaerobic digestion" is referred to as "Anaerobic digestion" in our model
- "Controlled Combustion" is referred to as "Incineration" in our model
- "Refuse/discards" is referred to as "Dumping" in our model

Calculations

Surplus Food Calculations

Master Surplus Equation:
(Tons Purchased from Grocery Stores + Tons Obtained Elsewhere)
x Surplus Rate

= Tons Residential Surplus

In ReFED's data model, the following calculations are repeated for every state, year, and food type before any aggregation is done.

Table 17. Calculations Performed to Quantify U.S. Residential Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Purchased from Grocery Stores	Nielsen Point-of-Sale (POS) Data[44]	$16,095,997 Million tomatoes purchased from grocery stores in Arkansas in 2019
Tons Purchased from Grocery Stores	Nielsen Point-of-Sale (POS) Data[44]	4,507 tons purchased from grocery stores in Arkansas in 2019
Retail Price per Lb	= US Dollars Purchased from Grocery Stores / Tons Purchased from Grocery Stores / 2,000 lbs per ton See U.S. Grocery Retail Dollar-to-Weight Conversion Factors Report[19] for more information on the price per lb data.	= $16,095,997 Million tomatoes purchased / 4,507 tons purchased / 2,000 lbs per ton = $1.79 per lb
% of Food Obtained from Grocery Stores	USDA NHANES Survey[58]	91% of fresh tomatoes are obtained from grocery stores (as opposed to restaurants, farmers markets, food banks, gas stations, home gardens, etc.)
Tons Obtained Elsewhere	= Tons Purchased from Grocery Stores * (100% - % of Food Obtained from Grocery Stores) / % of Food Obtained from Grocery Stores	= 4,507 tons purchased from grocery * (100% - 91%) / 91% = 457 tons tomatoes obtained elsewhere
Surplus Rate	USDA Consumer-Level Food Loss Estimates[59,15]	7% of tomatoes brought home are wasted
Tons Surplus	= (Tons Purchased from Grocery Stores + Tons Obtained Elsewhere) * Surplus Rate	= (4,507 tons purchased from grocery + 457 tons obtained elsewhere) * 7% = 347 tons tomato surplus
US Dollars Surplus	= Tons Surplus * Retail Price per Lb * 2,000 lbs per ton	= 347 tons tomato surplus * $1.79 per lb = $1,240,906 surplus

Cause Calculations

Master Cause Equation:

Tons Surplus due to Cause = Tons Surplus * % Loss due to Cause

Table 18. Calculations Performed to Quantify the Causes of U.S. Residential Surplus Food

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
% Surplus due to Cause	NRDC Home Kitchen Diaries[60]	Example data breakdown of home food waste causes for produce (See Appendix X for other food types): Considered inedible: 16.2% Cooking issues: 0.3% Date label concerns: 0.9% Didn't taste good: 2.5% Didn't want leftovers: 2.1% Inedible parts: 46.4% Left out too long: 3.7% Other: 3.8% Spoiled: 22.9% Too little to save:1.4% -- Total: 100%
Tons Surplus due to Cause	= Tons Surplus * % Surplus due to Cause	Tons due to Considered inedible: = 347 tons tomato surplus * 16.2% = 56 tons Tons due to Cooking issues: = 347 tons tomato surplus * 0.3% = 1 tons Tons due to Date label concerns: = 347 tons tomato surplus * 0.9% = 3 tons Tons due to Didn't taste good: = 347 tons tomato surplus * 2.5% = 9 tons Tons due to Didn't want leftovers: = 347 tons tomato surplus * 2.1% = 7 tons Tons due to Inedible parts: = 347 tons tomato surplus * 46.4% = 161 tons Tons due to Left out too long: = 347 tons tomato surplus * 3.7% = 13 tons

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
> continued from previous page... **Tons Surplus due to Cause**	> continued from previous page... = Tons Surplus * % Surplus due to Cause	Tons due to Other: = 347 tons tomato surplus * 3.8% = 13 tons Tons due to Spoiled: = 347 tons tomato surplus * 22.8% = 79 tons Tons due to Too little to save: = 347 tons tomato surplus * 1.4% = 5 tons
US Dollars Surplus due to Cause	= US Dollars Surplus * % Surplus due to Cause	US Dollars due to Considered inedible: = $1,240,906 tomato surplus * 16.2% = $200,998 US Dollars due to Cooking issues: = $1,240,906 tomato surplus * 0.3% = $3,172 US Dollars due to Date label concerns: = $1,240,906 tomato surplus * 0.9% = $10,576 US Dollars due to Didn't taste good: = $1,240,906 tomato surplus * 2.5% = $30,875 US Dollars due to Didn't want leftovers: = $1,240,906 tomato surplus * 2.1% = $25,505 US Dollars due to Inedible parts: = $1,240,906 tomato surplus * 46.4% = $575,990 US Dollars due to Left out too long: = $1,240,906 tomato surplus * 3.7% = $46,203 US Dollars due to Other: = $1,240,906 tomato surplus * 3.8% = $47,055 US Dollars due to Spoiled: = $1,240,906 tomato surplus * 22.8% = $283,490 US Dollars due to Too little to save: = $1,240,906 tomato surplus * 1.4% = $17,041

Destination Calculations

Master Destination Equation:

Tons Surplus sent to Destination = Tons Surplus * % Sent to Destination

Table 19. Calculations Performed to Quantify the Destinations of U.S. Residential Surplus F

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
Destination Breakdown of Residential Surplus	NRDC Home Kitchen Diaries[60]	According to the NRDC Home Kitchen Diaries, this was the destination breakdown of residential surplus for produce (See Appendix Y for other food types): Animal feed: 0.4% Compost: 45.9% Sewer: 1.3% Trash: 52.3% -- Total: 100%
	% of Trash that is Landfilled vs Incinerated in Arkansas (Biocycle/ Columbia University Survey[14]) (See Appendix Z)	% of Trash that is Landfilled = 100% % of Trash that is Incinerated = 0%
	Breaking "Trash" into Landfill vs Incineration: % Landfilled = % Trash * % of Trash that is Landfilled % Incinerated = % Trash * % of Trash that is Incinerated	% Landfilled: = 52.3% * 100% = 52.3% % Incinerated: = 52.3% * 0% = 0%
Tons Animal Feed	= Tons Surplus * % Animal Feed	= 347 tons tomato surplus * 0.4% animal feed = 2 tons tomatoes sent to animal feed
Tons Composted	= Tons Surplus * % Composted	= 347 tons tomato surplus * 45.9% composted = 160 tons tomatoes composted
Tons Sewer	= Tons Surplus * % Sewer	= 347 tons tomato surplus * 1.3% disposed down the drain = 5 tons tomatoes disposed via sewer
Tons Landfilled	= Tons Surplus * % Landfilled	= 347 tons tomato surplus * 52.3% landfilled = 182 tons tomatoes landfilled
Tons Incineration	= Tons Surplus * % Incineration	= 347 tons tomato surplus * 0% incinerated = 0 tons tomatoes incinerated
US Dollars Animal Feed	= US Dollars Surplus * % Animal Feed	= $1,240,906 tomato surplus * 0.4% animal feed = $5,553 tomatoes sent to animal feed

DATA ITEM	DATA SOURCE OR CALCULATION	EXAMPLE
US Dollars Composted	= US Dollars Surplus * % Composted	= $1,240,906 tomato surplus * 45.9% composted = $570,048 tomatoes composted
US Dollars Sewer	= US Dollars Surplus * % Sewer	= $1,240,906 tomato surplus * 1.3% disposed down the drain = $16,095 tomatoes disposed via sewer
US Dollars Landfilled	= US Dollars Surplus * % Landfilled	= $1,240,906 tomato surplus * 52.3% landfilled =$649,210 tomatoes landfilled
US Dollars Incineration	= US Dollars Surplus * % Incineration	=$1,240,906 tomato surplus * 0% incinerated = $0 tomatoes incinerated

Data Sources and Limitations

Retail Value and Tons Purchased at Grocery Stores
Raw data and documentation: This is confidential data from Nielsen and cannot be shared.

Nielsen data represents over 85% coverage of grocery retail sales in the U.S. Each year top U.S. grocery retailers report item level point-of-sale sales data to Nielsen[44], including information about each item such as the grocery chain where it was sold, the brand name of the product, the food classification (department, category, subcategory), the weight of food and packaging, and many other attributes. ReFED used this data to quantify the retail value and weight of food sold by grocery retailers in the U.S. by year, state, and food type. For more information about the weight data, see the U.S. Grocery Retail Dollar-to-Weight Conversion Factors report[19].

Nielsen provided point-of-sale data for the years 2016-2019. In order to estimate values for the missing years 2010-2015 each subcategory was extrapolated using category-level average year-over-year linear growth rates for both sales value and sales weight. Due to the high granularity of the categories, there were some cases where the growth rates were either extremely high or extremely low. To avoid unrealistic growth estimations over time within these outlier categories, department-level growth rates were used instead if a category had a growth rate ±15%. These outlier categories represent 0.5% of total sales.

The accuracy of these estimates is limited to the accuracy of the Nielsen sales and weight data. The weight data for UPC items comes directly from up-to-date product packaging images. For non-UPC items sold in eaches, Nielsen estimates weight using a weight conversion factor (e.g., the average weight of a lemon). For other non-UPC items, Nielsen is reliant on the retailer transaction data to provide the item sale weight units (e.g., lbs of apples sold).

A limitation of using this dataset to quantify residential grocery store purchases is that a small portion of grocery store sales is actually to commercial or non-residential customers (e.g., local restaurants, local food banks, etc.). Future iterations of this work should quantify the percentage of grocery store sales that is attributed to these non-residential customers by food type so that grocery sales can be discounted to only include residential sales. In the meantime, the resulting residential surplus estimates may be slightly overestimated.

Food Obtained from Grocery Stores vs Elsewhere
Raw data and documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_GroceryRates.xlsx

Every two years the National Health And Nutrition Examination Survey (NHANES)[58] is conducted as a partnership between the U.S. Department of Health and Human Services (DHHS) and the U.S. Department of Agriculture (USDA) to provide information on the health and nutritional status of people in the United States. In one portion of the study, participants are asked questions about their food intake over a two day period (e.g., food type and weight consumed, whether the food was obtained from a grocery store or restaurant, etc.). ReFED used this data to quantify the portion of each food type obtained from grocery stores versus other sources (e.g., restaurants, food pantries, convenience stores). See Appendix V as well as the raw data and documentation link above for details. The calculations were performed for each state, although the survey results are only available at the national level. Because food preferences and consumption patterns vary geographically, state-level data is needed in the future for better estimates.

Residential Food Surplus Rates
Raw data and documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_FoodSurplusRates.xlsx

ReFED used the USDA Consumer-Level Food Loss Estimates[59,15], which are the basis of the USDA ERS Loss-Adjusted Food Availability per Capita Dataset. The loss factors are based on 2004 data from Nielsen on how much food was sold at grocery stores as well as 2004 data from USDA NHANES[58] on how much food was eaten by consumers and where the food was sourced (e.g., grocery stores, restaurants, convenience stores, etc.). ReFED originally attempted to reproduce the USDA methodology using up-to-date Nielsen and NHANES data, but ended up reverting back to the original loss factors after running into the same issues that the USDA researchers faced when they originally developed the report. For several food items, the NHANES data estimates that consumers eat more than double the amount of a particular food item than was purchased in grocery stores according to the Nielsen data. The USDA research team addressed this issue by relying on expert panel estimates rather than the calculated estimates in these cases. ReFED plans to use the USDA loss factors (based on 2004 data) until more up-to-date consumption data is identified or developed. See Appendix W for details.

Residential Food Surplus Causes

Raw data and documentation:

- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_CauseBreakdown_2010-2014.xlsx
- https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_CauseBreakdown_2015-2019.xlsx

As a part of a three-city study (New York, Nashville, Denver), Natural Resources Defense Council (NRDC) conducted an in-home study[60] where participants documented the weight and type of foods wasted over a two week period. Participants also documented the reason why they wasted the food and what they did with it (e.g., disposed of down the drain, trash, fed to animals, composted). ReFED used this data to quantify the causes of residential food waste by year, state, and food type.

There are a few limitations to using this data source for this purpose: (1) Although the study results were similar across the cities covered, rural areas were not covered. If variations in disposal habits vary in rural areas versus cities, these variations are not captured in the data. (2) Another limitation is that the two week timespan may not have been long enough to capture refrigerator cleanouts, which may have resulted in an underestimation of causes such as date label expiration and unwanted leftovers if study participants postponed their refrigerator cleanouts until the study was over. (3) Finally, because it was a one-time study, the data does not provide insight into consumer changes in disposal habits over time. Although this causal data is invaluable for understanding the major drivers of food waste in homes, more research is needed to address these data gaps.

Residential Food Surplus Destinations

Raw data and documentation:

https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_FoodSurplusDestinations.xlsx

ReFED also used the NRDC Home Kitchen Diaries[60] to quantify the destination breakdown of residential food surplus. The same strengths and weaknesses of the causal data listed above apply to the destinations component of the study as well. Additionally, it's possible that the residential composting numbers may be higher than the U.S. average due to selection bias of the people that chose to participate in the study.

ReFED further broke down the NRDC "Trash" numbers into the portion that is landfilled versus incinerated in each state according to BioCycle's 2010 "State of Garbage in America" survey[16], which was conducted in partnership with the Earth Engineering Center of Columbia University. Because these surveys were discontinued in 2010 and no other state-level data sources exist, ReFED is reusing these estimates year over year to estimate the percentage of "trash" that is sent to incineration versus landfill facilities in each state.

Data Quality Evaluation

This rubric is designed to evaluate the quality of how each data source was utilized by ReFED to estimate food loss and waste. It is not meant to rate the quality of the study itself. See Appendix AA for more information about the ReFED Data Quality Rubric.

Table 20. Data Quality Evaluation for Food Waste Monitor Residential Sector

DATA	SOURCE	DATA QUALITY SCORE						
		CREDIBILITY	UPDATE FREQUENCY	COVERAGE	FOOD TYPE	GEOGRAPHY	SCORE	WEIGHT
RESIDENTIAL SURPLUS								
Retail Value Purchased at Grocery Stores	Nielsen Point-of-sale (POS) Data[44]	4	5	5	5	5	High 24/5 = 4.8	17%
Tons Purchased at Grocery Stores	Nielsen Point-of-sale (POS) Data[44]	4	5	5	5	5	High 24/5 = 4.8	17%
% of Food Obtained from Grocery Stores	USDA NHANES Survey[58]	5	5	5	5	3	High 23/5 = 4.6	33%
Surplus Rate	USDA Consumer-Level Food Loss Estimates[59,15]	5	1	5	3	3	Medium 17/5 = 3.4	33%
	4.8 * 17% + 4.8 * 17% + 4.6 * 33% + 3.4 * 33% = 4.3						**High**	
RESIDENTIAL CAUSES								
% Surplus due to Cause	NRDC Home Kitchen Diaries[60]	5	1	1	4	2	Low 13/5 = 2.6	100%
	2.2 * 100% = 2.2						**Low**	
RESIDENTIAL DESTINATIONS								
% Destination Breakdown by Destination	NRDC Home Kitchen Diaries[60]	5	1	1	4	2	Low 13/5 = 2.6	95%
% of trash landfilled vs incinerated	Biocycle/Columbia University Survey[16]	5	1	5	1	5	Medium 17/5 = 3.4	5%
	2.6 * 95% + 3.4 * 5% = 2.6						**Low**	

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APPENDIX

Appendix A: Farm Yield Left Behind After Harvest

The following table lists the percentage of yield left in fields after harvest crews were finished harvesting the fields for multiple studies. If a commodity is listed more than once, this indicates a separate field study for the same commodity. Because these studies only covered a limited number of commodities and states, these numbers were used extensively as proxies. For a complete list of proxy assignments, see ReFED's raw data and documentation here:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_YieldLeftBehindAfterHarvest.xlsx

STATE	COMMODITY	% OF HARVESTED YIELD LEFT BEHIND AFTER HARVEST
STUDY: LISA JOHNSON, 2018 NC STATE: ESTIMATING ON-FARM FOOD LOSS AT THE FIELD LEVEL: A METHODOLOGY AND APPLIED CASE STUDY ON A NORTH CAROLINA FARM		
North Carolina	Green Cabbage	18%
	Cucumber	154%
	Cucumber	96%
	Cucumber	138%
	Cucumber	68%
	Eggplant	169%
	Green Bell Pepper	24%
	Green Bell Pepper	55%
	Yellow Squash	75%
	Yellow Squash	64%
	Yellow Squash	44%
	Zucchini (field 1)	107%
	Zucchini (field 2)	85%

STATE	COMMODITY	% OF HARVESTED YIELD LEFT BEHIND AFTER HARVEST
STUDY: LISA JOHNSON, 2018 NC STATE: FIELD MEASUREMENT IN VEGETABLE CROPS INDICATES NEED FOR REEVALUATION OF ON FARM FOOD LOSS ESTIMATES IN NORTH AMERICA		
North Carolina	Cabbage	29%
	Cucumber	121%
	Bell pepper	35%
	Summer squash	85%
	Winter squash	197%
	Sweet corn	104%
	Sweetpotato	28%
	Watermelon	159%
STUDY: WWF SPECIALTY CROP LOSS REPORT		
Florida	Tomatoes	41%
New Jersey	Peaches	19%
	Peaches	45%
	Peaches	29%
	Peaches	34%
	Peaches	49%
	Peaches	41%
	Peaches	37%
	Peaches	26%
	Peaches	30%
	Peaches	47%
Idaho	Potatoes	2%
	Potatoes	2%
	Potatoes	2%
	Potatoes	2%
	Potatoes	1%
	Potatoes	2%
	Potatoes	5%
	Potatoes	3%
	Potatoes	3%

STATE	COMMODITY	% OF HARVESTED YIELD LEFT BEHIND AFTER HARVEST
STUDY: GREG BAKER, 2019 UC SANTA CLARA: ON-FARM FOOD LOSS IN NORTHERN AND CENTRAL CALIFORNIA: RESULTS OF FIELD SURVEY MEASUREMENTS		
California	Artichokes, annual	8.50%
	Artichokes, perennial	4.70%
	Broccoli	15.90%
	Brussels sprouts	13.20%
	Bunch Spinach	20.90%
	Cabbage	51.60%
	Cantaloupe, LSL	9.70%
	Cantaloupe, WS	14.20%
	Cauliflower	34.10%
	Celery	30.30%
	Green beans	21.40%
	Green Leaf Lettuce	43.30%
	Iceberg Lettuce	22.60%
	Kale	38.60%
	Napa Cabbage	42%
California	Roma Tomatoes	8.20%
	Romaine Hearts	113.60%
	Romaine Lettuce	39.50%
	Round Tomatoes	6.40%
	Strawberries	43.80%
	Sweet Corn	4.50%
	Watermelon	56.70%

Appendix B: Farm Field Packing Rates for Fresh Market Produce

ReFED researched several prominent agriculture websites[7,8,9,10,11,12] and consulted experts at the University of California Davis to estimate the percentage of each fresh market commodity that is packed in the field as opposed to being sent to a packhouse. For more information, see the field packed data tab of ReFED's raw data and documentation:
https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Farm_PackhouseLossRates.xlsx

ASSUMED 0% FIELD PACKED	ASSUMED 50% FIELD PACKED	ASSUMED 75% FIELD PACKED	ASSUMED 100% FIELD PACKED
Almonds	Blueberries	Artichokes	Blackberries
Apples	Cabbage		Boysenberries
Apricots	Pumpkins		Broccoli
Asparagus	Squash		Cantaloupe
Avocados			Cauliflower
Bananas			Celery
Carrots			Cucumbers
Cherries			Grapes
Chili peppers			Honeydew
Cranberries			Lettuce
Dates			Peppers
Figs			Raspberries
Garlic			Strawberries
Grapefruit			
Green beans			
Hazelnuts			
Kiwifruit			
Lemons			
Macadamias			
Nectarines			
Olives			
Onions			
Oranges			
Papayas			
Peaches			
Peanuts			
Pears			
Peas			
Pecans			
Pistachios			
Plums			
Potatoes			
Prunes			
Spinach			
Sweet corn			
Sweet potatoes			
Tangelos			
Tangerines			
Tomatoes			
Walnuts			
Watermelon			

Appendix C: Buyer Rejection Rates

ReFED consulted experts to estimate the percentage of food that is delivered by suppliers but rejected by commercial buyers.

REFED FOOD DEPARTMENT	ESTIMATED REJECTION RATE
Breads & Bakery	0.50%
Dairy & Eggs	
Dry Goods	
Fresh Meat & Seafood	
Frozen	
Ready-to-drink Beverages	
Prepared Foods	2.00%
Produce	

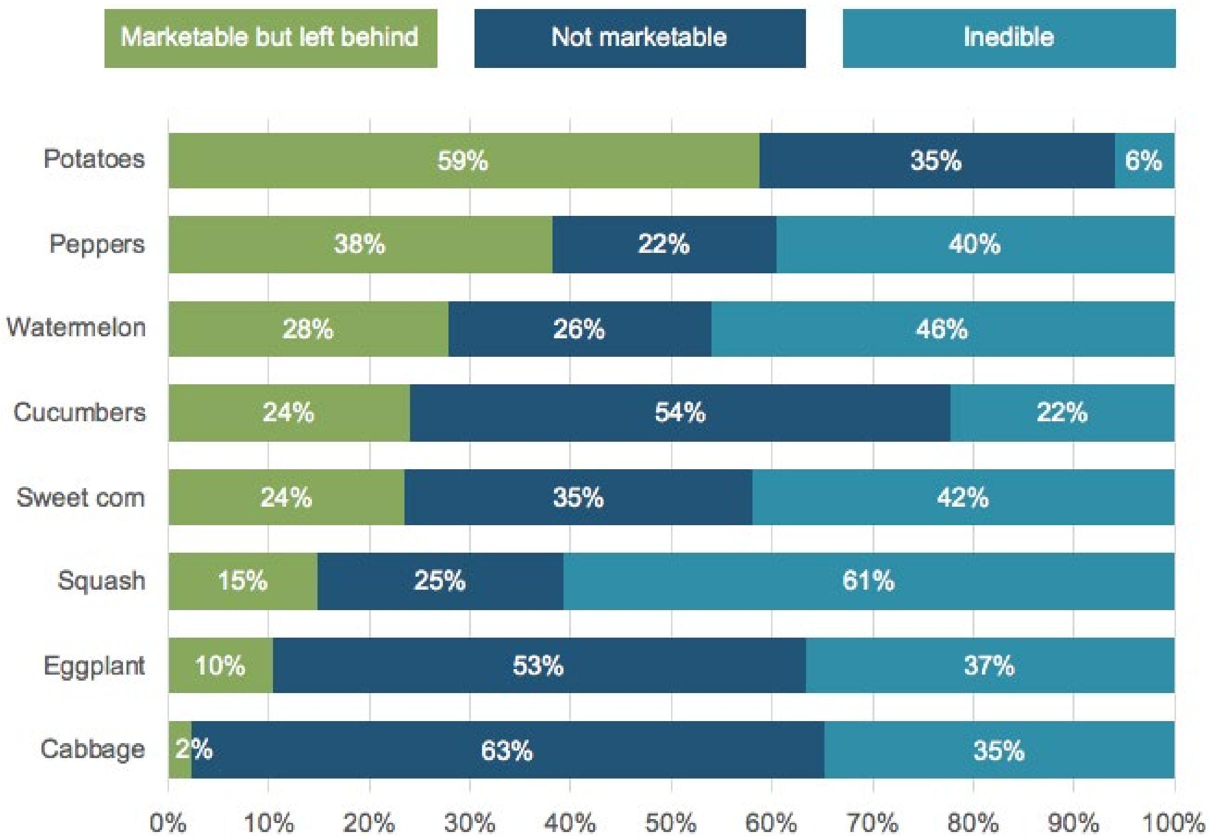
Appendix D: Causes of Fields Never Harvested (Walk-by Fields)

The following table displays example data for 2019 Michigan crop insurance claims for "All Other Crops" from the USDA Risk Management Agency[13]. Similar data is available for all years across all states for dozens of farm commodities.

EQUIVALENT REFED CAUSE NAME	USDA RISK MANAGEMENT AGENCY CROP INSURANCE CAUSE NAME	# ACRES CLAIMED DUE TO CAUSE	% OF ACRES CLAIMED DUE TO CAUSE
Fields Never Harvested (Bad Weather)	**Excess Moisture/Precipitation/Rain**	13,667	83.80%
	Drought	1,314	8.06%
	Cold Wet Weather	483	2.96%
	Freeze	39	0.24%
	Hail	34	0.21%
	Frost	27	0.17%
Fields Never Harvested (Market Dynamics)	**Decline in Price**	534	3.27%
Fields Never Harvested (Pests/disease)	**Wildlife**	174	1.07%
	Insects	24	0.15%
	Plant Disease	13	0.08%
	Totals	**16,309**	**100.00%**

Appendix E: Causes of Yield Left Behind After Harvest

2018 NC State Studies of fields in North Carolina[3,4]

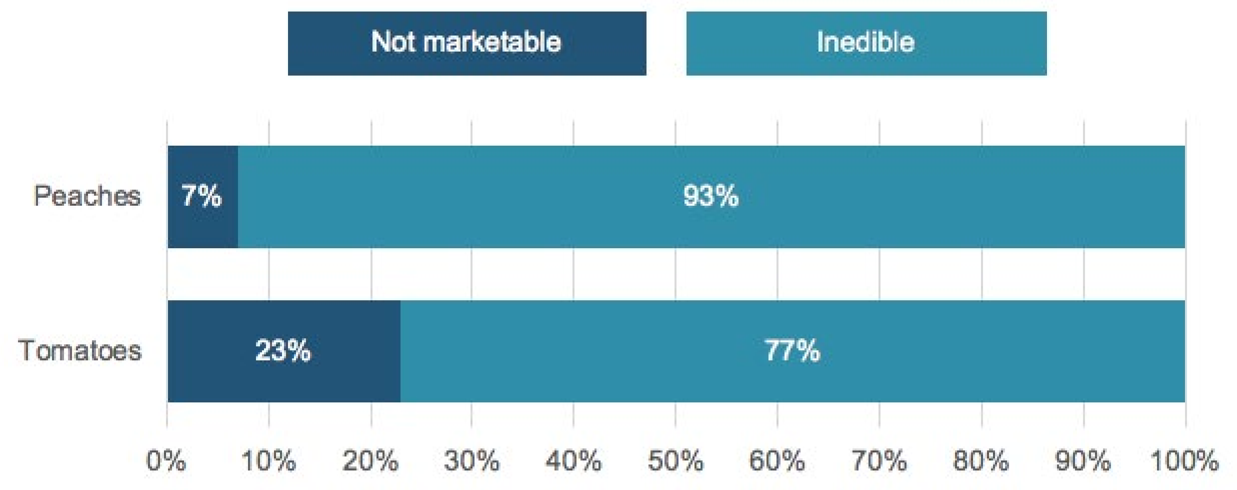


Definitions:

Marketable but left behind: U.S. No. 1 grade or higher
Not marketable: Fit for human consumption but does not meet appearance quality standards for sale
Inedible: Not fit for human consumption due to bruising, cracking, decay, or other physical damage

Appendix F: Causes of Packhouse Losses

2017 WWF Specialty Crop Loss Report[6] of 16 packhouses (6 peach packhouses, 10 tomato packhouses)



Definitions:
Not marketable: Fit for human consumption but does not meet appearance quality standards for sale
Inedible: Not fit for human consumption due to bruising, cracking, decay, or other physical damage

Appendix G: Destinations of Packhouse Losses

ReFED used data from the WWF Specialty Crop Loss Report[6] to estimate the following breakdown of produce packhouse loss destinations:

COMMODITY	# SITES	DESTINATION	MILLION LBS	% TO DESTINATION
Tomatoes	6	Animal feed	40.2	70%
Peaches	10	Donated	1.5	3%
Peaches	1	Dumped	9.2	28%
Potatoes	4	Dumped	6.8	
Total	**21**	**Total**	**57.7**	**100%**

Appendix H: Retail Margins

Each year the U.S. Census Bureau conducts the Annual Retail Trade Survey[45], which includes gross margins from retail firms broken out by business types including grocery food and beverage stores.

YEAR	ESTIMATED ANNUAL GROSS MARGIN AS A PERCENTAGE OF SALES FOR FOOD AND BEVERAGE GROCERY STORES
2018	26.60%
2017	27.00%
2016	26.80%
2015	26.90%
2014	26.60%
2013	26.80%
2012	27.10%
2011	27.70%
2010	28.00%

Appendix I: Unshipped Product Rates and Ingredient Utilization Rates

ReFED used data from Tesco supplier food waste case studies[21] to quantify the percentage of food manufacturing ingredients that get utilized in finished product as well as the percentage of finished manufactured food that does not ultimately get shipped to buyers. ReFED identified specific suppliers to serve as proxies for different manufacturing types. See the raw data and documentation for more information:

- Ingredient Utilization Rates: https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_RecipesAndUtilizationRates.xlsx
- Unshipped Product Rates: https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Manufacturing_UnshippedProductRates.xlsx

PROXY TESCO SUPPLIER CASE STUDY	INGREDIENT UTILIZATION RATE	UNSHIPPED PRODUCT RATE	USED AS A PROXY FOR THESE BUREAU OF LABOR STATISTICS MANUFACTURING TYPES
General Mills (Global) Food types: Dry goods Case study: https://www.tescoplc.com/media/756422/general-mills-final-2020.pdf	N/A	0.26%	- Commercial bakeries - Retail bakeries - Tortilla manufacturing - Frozen cakes, pies, and other pastries manufacturing
Panelto Foods (Ireland) Food types: Bakery Case study: https://www.tescoplc.com/media/756440/panelto-foods-final-2020.pdf	87%	N/A	Note: There were a couple case studies for bakery suppliers, but the data they provided did not allow for the calculation of unshipped product. In those case studies, they did not specify whether the surplus was finished product or ingredients. Therefore, ReFED chose to use the General Mills case study as the proxy for bakery unshipped product rates.
General Mills (Global) Food types: Dry goods Case study: https://www.tescoplc.com/media/756422/general-mills-final-2020.pdf	95%	0.26%	- Breakfast cereal manufacturing - Other snack food manufacturing - Rice milling - Wet corn milling - Soybean and other oilseed processing
2 Sisters Food Group (UK) Food types: Prepared foods (pizzas, pies, poultry, ready meals, soups) Case study: https://www.tescoplc.com/media/756409/amt-fresh-final-2020.pdf	96%	0.10%	- Perishable prepared food manufacturing
AMT Fresh (UK) Food types: Produce and juice Case study: https://www.tescoplc.com/media/756409/amt-fresh-final-2020.pdf	99%	0.04%	- Fruit and vegetable canning - Frozen fruit, juice, and vegetable manufacturing

<table>
<tr><th>PROXY TESCO SUPPLIER CASE STUDY</th><th>INGREDIENT UTILIZATION RATE</th><th>UNSHIPPED PRODUCT RATE</th><th>USED AS A PROXY FOR THESE BUREAU OF LABOR STATISTICS MANUFACTURING TYPES</th></tr>
<tr><td>Froneri (UK)
Food types: Ice cream
Case study: https://www.tescoplc.com/media/756390/froneri-final-2020.pdf</td><td>97%</td><td>0.41%</td><td>- Ice cream and frozen dessert manufacturing</td></tr>
<tr><td>Premier Foods (UK)
Food types: Dry goods
Case study: https://www.tescoplc.com/media/756402/premier_foods-final-2020.pdf</td><td>N/A</td><td>0.13%</td><td rowspan="2">- Chocolate and confectionery manufacturing from cacao beans

Note: There were a couple case studies for confectionery suppliers, but the data they provided did not allow for the calculation of unshipped product. In those case studies, they did not specify whether the surplus was finished product or ingredients. Therefore, ReFED chose to use the Premier Foods case study as the proxy for chocolate and confectionery unshipped product rates.</td></tr>
<tr><td>Mars (Global)
Food types: Confectionery, Dry Goods
Case study: https://www.tescoplc.com/media/756426/mars-final-2020.pdf</td><td>97%</td><td>N/A</td></tr>
<tr><td>Premier Foods (UK)
Food types: Dry goods
Case study: https://www.tescoplc.com/media/756402/premier_foods-final-2020.pdf</td><td>98%</td><td>0.13%</td><td>- Beet sugar manufacturing
- Cane sugar manufacturing
- Cookie and cracker manufacturing
- Dry pasta, dough, and flour mixes manufacturing from purchased flour
- Flour milling
- Roasted nuts and peanut butter manufacturing</td></tr>
<tr><td>Arla Foods (Europe)
Food types: Dairy products
Case study: https://www.tescoplc.com/media/756410/arlafoods-final-2020.pdf</td><td>98%</td><td>0.01%</td><td>- Fluid milk manufacturing
- Cheese manufacturing
- Creamery butter manufacturing
- Dry, condensed, and evaporated dairy product manufacturing</td></tr>
<tr><td>Avara Foods (UK)
Food types: Poultry
Case study: https://www.tescoplc.com/media/756411/avara-foods-final-2020.pdf</td><td>N/A</td><td>0.02%</td><td rowspan="2">- Seafood product preparation and packaging

Note: The data provided in the Espersen case study did not allow for the calculation of unshipped product. They did not specify whether the surplus was finished product or ingredients. Therefore, ReFED chose to use the Avara Foods case study as the proxy for seafood unshipped product rates.</td></tr>
<tr><td>Espersen (Denmark, Lithuania, Poland, Russia, Vietnam)
Food types: Seafood
Case study: https://www.tescoplc.com/media/756388/espersen-final-2020.pdf</td><td>98%</td><td>N/A</td></tr>
<tr><td>Kepak (Ireland)
Food types: Beef, pork, lamb
Case study: https://www.tescoplc.com/media/756396/kepak-final-2020.pdf</td><td>98%</td><td>0.08%</td><td>- Animal (except poultry) slaughtering
- Meat processed from carcasses</td></tr>
</table>

<table>
<tr><th>PROXY TESCO SUPPLIER CASE STUDY</th><th>INGREDIENT UTILIZATION RATE</th><th>UNSHIPPED PRODUCT RATE</th><th>USED AS A PROXY FOR THESE BUREAU OF LABOR STATISTICS MANUFACTURING TYPES</th></tr>
<tr><td>Avara Foods (UK)
Food types: Poultry
Case study: https://www.tescoplc.com/media/756411/avara-foods-final-2020.pdf</td><td>99%</td><td>0.02%</td><td>- Poultry processing</td></tr>
<tr><td>Greencore Group (UK)
Food types: Chilled, frozen, and ambient convenience foods
Case study: https://www.tescoplc.com/media/756392/greencore-final-2020.pdf</td><td>91%</td><td>0.25%</td><td>- Frozen specialty food</td></tr>
<tr><td>Premier Foods (UK)
Food types: Dry goods
Case study: https://www.tescoplc.com/media/756402/premier_foods-final-2020.pdf</td><td>N/A</td><td>0.13%</td><td rowspan="2">- Confectionery manufacturing from purchased chocolate
- Coffee and tea manufacturing

Note: There were a couple case studies for confectionery suppliers, but the data they provided did not allow for the calculation of unshipped product. In those case studies, they did not specify whether the surplus was finished product or ingredients. Therefore, ReFED chose to use the Premier Foods case study as the proxy for chocolate and confectionery unshipped product rates.</td></tr>
<tr><td>Nestle (UK)
Food types: Confectionery, Healthcare nutrition, Catering products
Case study: https://www.tescoplc.com/media/756427/nestle-uk-final-2020.pdf</td><td>99%</td><td>N/A</td></tr>
<tr><td>Hilton Foods (Ireland)
Food types: Beef, pork, lamb
Case study: https://www.tescoplc.com/media/756436/hilton-foods-final-2020.pdf</td><td>99%</td><td>0.02%</td><td>- Rendering and meat byproduct processing
- Fats and oils refining and blending</td></tr>
<tr><td>Premier Foods (UK)
Food types: Dry goods
Case study: https://www.tescoplc.com/media/756402/premier_foods-final-2020.pdf</td><td>N/A

Note: ReFED was unable to find recipe data for these manufacturing types, so unutilized ingredients were estimated to be zero. These categories only represent 7.57% of value shipped.</td><td>0.13%</td><td>- All other miscellaneous food manufacturing
- Dried and dehydrated food manufacturing
- Mayonnaise, dressing, and other prepared sauce manufacturing
- Nonchocolate confectionery manufacturing
- Soft drink manufacturing - rtd coffee and tea
- Specialty canning spice and extract manufacturing</td></tr>
</table>

Appendix J: Destinations of Manufacturing Surplus

ReFED used custom-prepared food waste destinations data from Northstar Recycling[42] to estimate the destination breakdown of food surplus by food manufacturing type. Northstar Recycling is a national waste and recycling company that manages waste for many food manufacturers across the U.S. and Canada. This dataset was used to estimate the destinations of both unutilized ingredients and finished product surplus as these surplus streams are mixed together in the data.

DESTINATION	BAKERY	CONFECTIONARY	DAIRY	NON-PERISHABLES	SPECIALTY FROZEN	MEAT, POULTRY, & SEAFOOD*
Donations**	1%	1%	1%	1%	1%	--
Animal Feed	99%	37%	--	67%	88%	--
Anaerobic Digestion	--	<1%	19%	--	1%	--
Composting	--	31%	--	25%	8%	--
Land Application	--	--	80%	3%	--	--
Trash (Landfill or Incineration)	--	30%	--	3%	2%	--
Industrial Uses	--	--	--	--	--	100%
Sewer***	--	--	--	--	--	--
Dumping	--	--	--	--	--	--
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

*Because Northstar does not manage food waste for any meat processing facilities, ReFED assumed that 100% of unutilized ingredients at meat processing plants were sent to rendering (industrial uses).

**Northstar does not have visibility to food donations data for their clients, so ReFED assumed that 1% of unutilized ingredients are donated based on data from the 2016 Food Waste Reduction Alliance survey[47] in which 9 manufacturers responded (6.2% of U.S. market share based on sales).

***Northstar does not have visibility to food washed down the sewer. This data was also not included in the FWRA surveys. Further research is needed to fill in this data gap.

Appendix K: Retail Unsold Food Rates: USDA Supermarket Shrink Estimates

ReFED mapped the USDA commodities from the USDA Supermarket Shrink Estimates[15,48] to each ReFED Food Category. When no reasonable proxies existed for a specific category (e.g., Bagels), unsold food rates from Food Marketing Institute (FMI) Supermarket Security and Loss Prevention Report[49] were used instead (see Appendix K). The following numbers are based on supplier purchases and customer sales data from five individual retailers representing 45 states and 2,900 stores. Find the full report at: www.ers.usda.gov/publications/eibeconomic-informationbulletin/eib155

USDA COMMODITY	% UNSOLD FOOD BY WEIGHT
Barley products	12%
Canned asparagus	6%
Canned beans	6%
Canned cabbage	6%
Canned carrots	6%
Canned chile peppers	6%
Canned cucumbers	6%
Canned green peas	6%
Canned potatoes	6%
Canned snap beans	6%
Canned sweet corn	6%
Canned tomatoes	6%
Corn flour and meal	12%
Corn hominy and grits	12%
Corn starch	12%
Dehydrated onions	6%
Dehydrated potatoes	6%
Dry beans	6%
Dry black beans	6%
Dry great northern beans	6%
Dry lima beans	6%
Dry navy beans	6%
Dry peas and lentils	6%
Dry pinto beans	6%
Dry red kidney beans	6%
Flour and meal	12%
Oat products	12%

USDA COMMODITY	% UNSOLD FOOD BY WEIGHT
Other canned vegetables	6%
Other dry beans	6%
Potato chips	6%
Rye flour	12%
Wheat flour	12%
White and whole wheat flour	12%
Frozen asparagus	6%
Frozen broccoli	6%
Frozen carrots	6%
Frozen cauliflower	6%
Frozen green peas	6%
Frozen lima beans	6%
Frozen potatoes	6%
Frozen snap beans	6%
Frozen spinach	6%
Frozen sweet corn	6%
Misc frozen vegetables	6%
Other frozen vegetables	6%
Prepared fruit or vegetables	13%
Fresh artichokes	21%
Fresh asparagus	16%
Fresh bell peppers	11%
Fresh broccoli	7%
Fresh brussels sprouts	6%
Fresh cabbage	7%
Fresh carrots	7%
Fresh cauliflower	17%
Fresh celery	9%
Fresh collard greens	44%
Fresh cucumbers	12%
Fresh eggplant	21%
Fresh escarole	47%
Fresh garlic	5%
Fresh grapefruit	19%
Fresh head lettuce	8%

USDA COMMODITY	% UNSOLD FOOD BY WEIGHT
Fresh kale	27%
Fresh leaf lettuce	20%
Fresh lemons	5%
Fresh lima beans	12%
Fresh limes	14%
Fresh mustard greens	61%
Fresh okra	40%
Fresh onions	6%
Fresh oranges	15%
Fresh potatoes	8%
Fresh pumpkin	18%
Fresh radishes	23%
Fresh snap beans	22%
Fresh spinach	18%
Fresh squash	23%
Fresh sweet corn	2%
Fresh sweet potatoes	4%
Fresh tangerines	15%
Fresh tomatoes	14%
Fresh turnip greens	63%
Greens	49%
Lettuce	10%
Potatoes	8%
Grapefruit juice	6%
Lemon juice	6%
Lime juice	6%
Orange juice	6%

Appendix L: Retail Unsold Food Rates: FMI Supermarket Security and Loss Prevention Report

Based on 2008 FMI survey of 50 supermarket survey participants[49]

FMI FOOD DEPARTMENT	% UNSOLD FOOD BY COST	% UNSOLD FOOD BY RETAIL VALUE
Bakery	11.04%	3.93%
Deli	8.05%	4.46%
Produce	6.21%	5.14%
Meat and Seafood	5.62%	4.22%
Dairy	1.42%	0.86%
Dry Grocery	0.95%	2.06%
Frozen Foods	0.80%	0.51%

Appendix M: Causes of Retail Surplus

As a placeholder until further research can be done, ReFED developed estimates using data from Leanpath on the causes of unutilized food in foodservice combined with review and input from grocery retail subject matter experts. Leanpath is a technology company that helps foodservice companies track, weigh and analyze the amount of food that is wasted in commercial kitchens. Leanpath customers also indicate the reason the food was not used as well as the food type when using Leanpath's automated software system.

Steps taken to adapt the Leanpath foodservice cause data to be relevant for grocery retail:

1. Map Leanpath's food types to similar grocery retail food types (e.g., Produce, Dry goods).
2. Filter out data for causes that are not relevant to the retail sector (e.g., Catering overproduction is not relevant for a grocery retail Produce department).
3. Quantify the causal breakdown of unused food by food type.
4. Have grocery retail subject matter experts review the data and compare it with numbers they're used to seeing in the field and make adjustments accordingly.

% UNSOLD FOOD DUE TO CAUSE		PRODUCE	FRESH MEAT & SEAFOOD	DAIRY & EGGS	BREADS & BAKERY	DRY GOODS	FROZEN	PREPARED FOODS	READY-TO-DRINK BEVERAGES
Date label concerns		63%	63%	64%	75%	11%	10%	6%	40%
Excess	**Overproduction**	--	--	--	--	--	--	36%	--
Food safety	**Food safety recall**	0%	0%	0%	0%	0%	0%	0%	0%
Mistakes & malfunctions	**Cooking issues**	--	--	--	--	--	--	1%	--
	Equipment issues	4%	8%	15%	2%	0%	84%	0%	8%
	Handling errors	6%	5%	4%	4%	88%	5%	1%	50%
Other	**Other**	0%	0%	0%	0%	0%	0%	0%	0%
	Theft	2%	2%	2%	2%	2%	2%	2%	2%
Spoiled		25%	20%	16%	17%	0%	0%	2%	0%
Trimmings & byproducts		0%	3%	0%	0%	0%	0%	53%	0%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Appendix N: Destinations of Retail Surplus

This data was obtained from a 2016 FWRA survey[49] of grocery retailers in which 24 grocery retailers responded (35.3% of U.S. market share based on sales).

DESTINATION MILLION POUNDS IN 2016					% BY WEIGHT IN 2016				
	Large	**Medium**	**Small**	**All Sizes**	**Large**	**Medium**	**Small**	**All Sizes**	**Used for Modeling***
Donations	363.5	27.3	0.1	390.8	19.01%	16.76%	3.94%	18.81%	**19.10%**
Animal feed	359.3	15.2	0.1	378.8	19.01%	9.33%	3.94%	18.24%	**18.53%**
Industrial uses	84.7	9.3	0.5	94.5	4.43%	5.71%	19.69%	4.55%	**4.62%**
Anaerobic digestion	116.7	8.4	0	98.4	4.71%	5.16%	0.00%	4.74%	**4.81%**
Composting	349.1	16.2	1.6	366.9	18.26%	9.95%	62.99%	17.66%	**17.94%**
Incineration	161.2	0	0	95	4.97%	0.00%	0.00%	4.57%	**4.64%**
Landfill**	518.27	78.67	0.04	596.98	27.11%	48.30%	1.57%	28.74%	**29.19%**
Land application	23.7	0.2	0	23.9	1.24%	0.12%	0.00%	1.15%	**1.17%**
Other*	18.1	7.6	0.2	31.8	1.26%	4.67%	7.87%	1.53%	**0.00%**
Total	**1,911.67**	**162.87**	**2.54**	**2,077.08**	**100%**	**100%**	**100%**	**100%**	**100%**

*Note that ReFED removed the portion of disposal listed as "Other" for modeling purposes.

**For improved state-level modeling, ReFED grouped together the Incineration and Landfill numbers into a "Trash" percentage. BioCycle survey data conducted in partnership with Columbia University was used to estimate state-specific landfill and incineration numbers.

Appendix O: Foodservice Food Type Breakdown and Wholesale Prices

ReFED used menu data from Technomic[51] in combination with food ingredient breakdown data from USDA Food Data Central[22] to estimate the food ingredient breakdown of multiple menus. The Technomic menu data listed all of the items on a menu for the Top 500 restaurants (e.g., Cheeseburger, Fries, etc.). ReFED mapped each menu item to the closest matching food item in the USDA Food Data Central database, which provides the ingredient weight breakdown of each food (e.g., A cheeseburger is 38% ground beef, 27% bread, 9% cheese, 9% tomato, 7% sauce, 7% pickles, 4% lettuce). Each foodservice segment was assigned a proxy menu based on the top restaurant by sales in each segment (e.g., McDonald's menu was used as a proxy for Limited Service Burger Restaurants). For non-restaurant segments, a restaurant proxy menu was used. ReFED then calculated average wholesale price per lb estimates for each foodservice segment by subtracting retailer markups[45] from Nielsen retail prices[19] for the hundreds of food categories (e.g., Cheese) mapped to each food department (e.g., Dairy & Eggs).

FSR = Full Service Restaurants, LSR = Limited Service Restaurants

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
Applebee's	FSR: Varied Menu Business & Industry Caterers Colleges & Universities Corrections Healthcare Hospitals Long-term Care Senior Living K-12 Education Lodging Military Recreation Transportation Other	Breads & Bakery: 8% Dairy & Eggs: 11% Dry Goods: 25% Fresh Meat & Seafood: 19% Frozen: 1% Produce: 16% Ready-to-drink Beverages: 10% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.31
Buffalo Wild Wings	FSR: Sports Bar Bars and Taverns	Breads & Bakery: 9% Dairy & Eggs: 4% Dry Goods: 8% Fresh Meat & Seafood: 18% Frozen: 0% Produce: 15% Ready-to-drink Beverages: 6% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.36

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
Chick-fil-a	LSR: Chicken	Breads & Bakery: 12% Dairy & Eggs: 14% Dry Goods: 11% Fresh Meat & Seafood: 13% Frozen: 0% Produce: 9% Ready-to-drink Beverages: 20% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.90
Chuy's	FSR: Mexican	Breads & Bakery: 7% Dairy & Eggs: 10% Dry Goods: 43% Fresh Meat & Seafood: 10% Frozen: 0% Produce: 14% Ready-to-drink Beverages: 5% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.73
Custom Menu (ReFED Assumptions)	Refreshment Services	Breads & Bakery: 0% Dairy & Eggs: 8% Dry Goods: 3% Fresh Meat & Seafood: 0% Frozen: 0% Produce: 0% Ready-to-drink Beverages: 59% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.29
Dairy Queen	LSR: Frozen Dessert	Breads & Bakery: 6% Dairy & Eggs: 18% Dry Goods: 19% Fresh Meat & Seafood: 5% Frozen: 20% Produce: 6% Ready-to-drink Beverages: 5% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.73

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
Domino's	LSR: Pizza	Breads & Bakery: 3% Dairy & Eggs: 4% Dry Goods: 41% Fresh Meat & Seafood: 17% Frozen: 0% Produce: 15% Ready-to-drink Beverages: 0% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.94
Famous Dave's	FSR: All Other	Breads & Bakery: 10% Dairy & Eggs: 4% Dry Goods: 17% Fresh Meat & Seafood: 36% Frozen: 0% Produce: 18% Ready-to-drink Beverages: 9% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.81
IHOP	FSR: Family Style	Breads & Bakery: 9% Dairy & Eggs: 28% Dry Goods: 17% Fresh Meat & Seafood: 18% Frozen: 1% Produce: 14% Ready-to-drink Beverages: 9% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.10
Krispy Kreme	LSR: All Other	Breads & Bakery: 5% Dairy & Eggs: 41% Dry Goods: 9% Fresh Meat & Seafood: 0% Frozen: 0% Produce: 0% Ready-to-drink Beverages: 19% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $0.96

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
McDonald's	LSR: Burger	Breads & Bakery: 12% Dairy & Eggs: 30% Dry Goods: 10% Fresh Meat & Seafood: 16% Frozen: 1% Produce: 8% Ready-to-drink Beverages: 17% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.84
Olive Garden	FSR: Italian/pizza	Breads & Bakery: 6% Dairy & Eggs: 12% Dry Goods: 39% Fresh Meat & Seafood: 13% Frozen: 0% Produce: 5% Ready-to-drink Beverages: 15% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.94
P.F. Chang's	FSR: Asian/noodle	Breads & Bakery: 1% Dairy & Eggs: 2% Dry Goods: 26% Fresh Meat & Seafood: 20% Frozen: 0% Produce: 19% Ready-to-drink Beverages: 9% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.92
Panda Express	LSR: Asian/noodle	Breads & Bakery: 0% Dairy & Eggs: 3% Dry Goods: 18% Fresh Meat & Seafood: 20% Frozen: 0% Produce: 12% Ready-to-drink Beverages: 11% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.71

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
Red Lobster	FSR: Seafood	Breads & Bakery: 1% Dairy & Eggs: 5% Dry Goods: 16% Fresh Meat & Seafood: 35% Frozen: 0% Produce: 20% Ready-to-drink Beverages: 7% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $4.99
Starbucks	LSR: Coffee Cafe	Breads & Bakery: 5% Dairy & Eggs: 35% Dry Goods: 14% Fresh Meat & Seafood: 3% Frozen: 0% Produce: 5% Ready-to-drink Beverages: 31% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.37
Subway	LSR: Sandwich	Breads & Bakery: 17% Dairy & Eggs: 12% Dry Goods: 10% Fresh Meat & Seafood: 23% Frozen: 0% Produce: 20% Ready-to-drink Beverages: 5% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.43
Taco Bell	LSR: Mexican	Breads & Bakery: 13% Dairy & Eggs: 18% Dry Goods: 27% Fresh Meat & Seafood: 11% Frozen: 0% Produce: 7% Ready-to-drink Beverages: 4% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $1.87

MENU	USED AS PROXY FOR THESE FOODSERVICE SEGMENTS	ESTIMATED FOOD TYPE BREAKDOWN AND WHOLESALE PRICE PER LB
Texas Roadhouse	FSR: Steak	Breads & Bakery: 3% Dairy & Eggs: 7% Dry Goods: 18% Fresh Meat & Seafood: 26% Frozen: 0% Produce: 25% Ready-to-drink Beverages: 8% -- Total: 100% Estimated 2019 Wholesale Price per Lb: $2.87

Appendix P: Plate Waste Rates

ReFED used multiple quantitative studies conducted by nonprofits, academics, and government organizations to estimate plate waste rates[53,54,55,56,57]. ReFED identified the latest, most suitable study available to use as a proxy for plate waste rates in each foodservice segment.

PLATE WASTE STUDY	PLATE WASTE RATE	USED AS A PROXY FOR THESE FOODSERVICE SEGMENTS
Ohio State University Plate waste of adults in the United States measured in free-living conditions Study setting: Lab setting designed to mimic restaurants	39.06%	Full Service Restaurants: - Asian/noodle - Family style - Italian/pizza - Mexican - Seafood - Steak - Varied menu - All other Lodging Recreation
University of Guelph Restaurant Plate Waste - Relationship between Menu Items, Product Engineering and Profit Study setting: Pub-style restaurants	11.30%	Full Service Restaurants: - Sports bar Limited Service Restaurants: - Asian/noodle - Burger - Chicken - Coffee cafe - Frozen dessert - Mexican - Pizza - Sandwich - All other Bars and Taverns Transportation Other
ReFED/Compass Group Portland State University Case Study Study setting: All-you-can-eat university cafeteria	13.40%	Business & Industry Caterers Colleges & Universities Corrections Military Refreshment Services
University of Toronto Utilization of home-delivered meals by recipients 75 years of age or older Study setting: Meals-on-wheels seniors food delivery	19%	Healthcare: - Hospitals - Long-term care - Senior living

PLATE WASTE STUDY	PLATE WASTE RATE	USED AS A PROXY FOR THESE FOODSERVICE SEGMENTS
University of Northern Colorado Food choice, plate waste and nutrient intake of elementary- and middle-school students participating in the US National School Lunch Program Study setting: K-12 school cafeterias	21.50%	K-12 Education

Appendix Q: Catering Overproduction Rates

Based on expert interviews with catering organizations, ReFED estimated the percentage of food that is never served to clients at catering events. The results were the following:

CATERING STYLE	ESTIMATED OVERPRODUCTION RATE	USED AS A PROXY FOR THESE FOODSERVICE SEGMENTS
Buffets	28%	Full Service Restaurants: - Asian/noodle - Italian/pizza - Mexican - Seafood - Steak - Varied menu - All other Caterers Colleges & Universities Other
Breakfast and lunch	38%	Full Service Restaurants: - Family style - Sports bar Limited Service Restaurants: - Asian/noodle - Burger - Chicken - Coffee cafe - Frozen dessert - Mexican - Pizza - Sandwich - All other Bars and Taverns Refreshment Services
Plated	13%	This catering style was not used as a proxy for any segments.
Assumed zero catering	N/A	Healthcare: - Hospitals - Long-term care - Senior living Business & Industry Corrections K-12 Education Lodging Military Recreation Transportation

Appendix R: Causes of Foodservice Pre-Consumer Surplus

ReFED used data from Leanpath[52] to estimate the following causal breakdown of foodservice pre-consumer surplus by food type. The following data is from 2019.

Proxy assignments:

- Business & Industry used as proxy for: Military, Refreshment Services
- Education used as proxy for: Corrections, Other
- Hospitality used as proxy for : All restaurants, Bars and Taverns, Lodging, Recreation, Transportation, Caterers

CAUSES OF PRE-CONSUMER SURPLUS		FOODSERVICE SEGMENT			
		BUSINESS & INDUSTRY	HOSPITALITY	HEALTHCARE	EDUCATION
BREADS & BAKERY					
Date Label Concerns		39.50%	38.40%	63.50%	40.70%
Mistakes & Malfunctions	Cooking issues	6.80%	1.60%	5.50%	9.50%
	Equipment issues	1.10%	0.00%	0.60%	0.60%
	Handling errors	2.40%	6.30%	3.00%	4.30%
Other		3.30%	14.30%	0.20%	0.30%
Spoiled		9.10%	36.70%	12.00%	19.70%
Trimmings & Byproducts		37.80%	2.70%	15.30%	25.00%
Food Safety	Food safety recall	0%	0%	0%	0%
	Total	100%	100%	100%	100%
DAIRY & EGGS					
Date Label Concerns		44.50%	57.60%	62.90%	46.10%
Mistakes & Malfunctions	Cooking issues	3.90%	3.20%	3.70%	5.20%
	Equipment issues	10.10%	1.10%	7.00%	5.40%
	Handling errors	2.80%	5.50%	4.60%	3.10%
Other		0.20%	0.80%	0.20%	0.20%
Spoiled		11.20%	29.10%	14.10%	24.10%
Trimmings & Byproducts		27.40%	2.70%	7.40%	15.90%
Food Safety	Food safety recall	0%	0%	0%	0%
	Total	100%	100%	100%	100%

<table>
<tr><th colspan="2" rowspan="2">CAUSES OF PRE-CONSUMER SURPLUS</th><th colspan="4">FOODSERVICE SEGMENT</th></tr>
<tr><th>BUSINESS & INDUSTRY</th><th>HOSPITALITY</th><th>HEALTHCARE</th><th>EDUCATION</th></tr>
<tr><td colspan="6">DRY GOODS</td></tr>
<tr><td colspan="2">Date Label Concerns</td><td>51.40%</td><td>57.80%</td><td>56.30%</td><td>52.60%</td></tr>
<tr><td rowspan="3">Mistakes & Malfunctions</td><td>Cooking issues</td><td>10.50%</td><td>19.80%</td><td>9.10%</td><td>15.10%</td></tr>
<tr><td>Equipment issues</td><td>3.20%</td><td>0.50%</td><td>0.80%</td><td>1.40%</td></tr>
<tr><td>Handling errors</td><td>5.80%</td><td>3.20%</td><td>3.60%</td><td>5.00%</td></tr>
<tr><td colspan="2">Other</td><td>0.90%</td><td>0.40%</td><td>0.50%</td><td>0.50%</td></tr>
<tr><td colspan="2">Spoiled</td><td>5.70%</td><td>15.30%</td><td>3.80%</td><td>11.40%</td></tr>
<tr><td colspan="2">Trimmings & Byproducts</td><td>22.50%</td><td>3.00%</td><td>25.90%</td><td>14.10%</td></tr>
<tr><td>Food Safety</td><td>Food safety recall</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td colspan="6">FRESH MEAT & SEAFOOD</td></tr>
<tr><td colspan="2">Date Label Concerns</td><td>20.90%</td><td>57.40%</td><td>36.60%</td><td>27.00%</td></tr>
<tr><td rowspan="3">Mistakes & Malfunctions</td><td>Cooking issues</td><td>2.50%</td><td>5.00%</td><td>5.60%</td><td>5.10%</td></tr>
<tr><td>Equipment issues</td><td>2.60%</td><td>0.70%</td><td>1.40%</td><td>1.40%</td></tr>
<tr><td>Handling errors</td><td>1.70%</td><td>8.20%</td><td>3.30%</td><td>3.20%</td></tr>
<tr><td colspan="2">Other</td><td>0.20%</td><td>1.50%</td><td>0.30%</td><td>0.30%</td></tr>
<tr><td colspan="2">Spoiled</td><td>6.50%</td><td>18.40%</td><td>8.80%</td><td>13.60%</td></tr>
<tr><td colspan="2">Trimmings & Byproducts</td><td>65.60%</td><td>8.80%</td><td>44.10%</td><td>49.60%</td></tr>
<tr><td>Food Safety</td><td>Food safety recall</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td colspan="6">FROZEN</td></tr>
<tr><td colspan="2">Date Label Concerns</td><td>7.00%</td><td>31.10%</td><td colspan="2" rowspan="9">There was no frozen food data available for Healthcare or Education, so the Business & Industry frozen numbers were used as proxies.</td></tr>
<tr><td rowspan="3">Mistakes & Malfunctions</td><td>Cooking issues</td><td>11.80%</td><td>0.00%</td></tr>
<tr><td>Equipment issues</td><td>63.10%</td><td>0.00%</td></tr>
<tr><td>Handling errors</td><td>16.40%</td><td>22.20%</td></tr>
<tr><td colspan="2">Other</td><td>1.30%</td><td>2.60%</td></tr>
<tr><td colspan="2">Spoiled</td><td>0.00%</td><td>36.30%</td></tr>
<tr><td colspan="2">Trimmings & Byproducts</td><td>0.50%</td><td>7.80%</td></tr>
<tr><td>Food Safety</td><td>Food safety recall</td><td>0%</td><td>0%</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td></tr>
</table>

CAUSES OF PRE-CONSUMER SURPLUS		FOODSERVICE SEGMENT			
		BUSINESS & INDUSTRY	HOSPITALITY	HEALTHCARE	EDUCATION
PREPARED FOODS					
Date Label Concerns		39.70%	64.60%	54.00%	42.00%
Mistakes & Malfunctions	Cooking issues	7.20%	9.40%	11.80%	15.60%
	Equipment issues	1.90%	0.30%	1.00%	1.00%
	Handling errors	3.20%	5.80%	4.60%	5.30%
Other		1.70%	0.80%	0.50%	0.40%
Spoiled		4.70%	16.10%	5.00%	11.40%
Trimmings & Byproducts		41.60%	3.00%	23.10%	24.30%
Food Safety	Food safety recall	0%	0%	0%	0%
	Total	**100%**	**100%**	**100%**	**100%**
PRODUCE					
Date Label Concerns		4.90%	25.00%	17.50%	7.70%
Mistakes & Malfunctions	Cooking issues	0.80%	2.40%	2.60%	2.10%
	Equipment issues	0.30%	0.00%	0.30%	0.20%
	Handling errors	0.50%	2.00%	0.50%	0.90%
Other		0.10%	1.20%	0.10%	0.10%
Spoiled		1.90%	13.30%	8.00%	5.90%
Trimmings & Byproducts		91.60%	56.00%	71.10%	83.00%
Food Safety	Food safety recall	0%	0%	0%	0%
	Total	**100%**	**100%**	**100%**	**100%**
READY-TO-DRINK BEVERAGES					
Date Label Concerns		86.1	29.90%	74.50%	27.50%
Mistakes & Malfunctions	Cooking issues	1.30%	0.00%	2.00%	1.60%
	Equipment issues	4.40%	0.00%	2.50%	6.10%
	Handling errors	2.60%	4.20%	1.80%	3.90%
Other		0%	21.20%	1.60%	0.70%
Spoiled		3.20%	44.30%	8.30%	3.10%
Trimmings & Byproducts		2.40%	0.40%	9.30%	57.10%
Food Safety	Food safety recall	0%	0%	0%	0%
	Total	**100%**	**100%**	**100%**	**100%**

Appendix S: Destinations of Foodservice Pre-Consumer Surplus

For most states, ReFED used data from the 2016 Food Waste Reduction Alliance (FWRA) survey[47] of restaurants in which 28 restaurant companies responded (11.8% of U.S. market share based on sales) to estimate the destination breakdown of pre-consumer surplus. Data on industrial uses (or biomaterials/processing) was excluded because most of this is spent cooking oil rather than pre-consumer surplus. Since the FWRA data indicated that 94% of pre-consumer surplus is landfilled, which is not the case in states that have organics recycling laws, ReFED instead used data from Leanpath to estimate the pre-consumer surplus destinations for these states (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington). ReFED did not use the Leanpath data for all other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

FWRA Restaurant Survey Data:

DESTINATION MILLION POUNDS IN 2016					% BY WEIGHT IN 2016				USED FOR MODELING *
	Large	Medium	Small	All Sizes Combined	Large	Medium	Small	All Sizes Combined	
Donations	38.3	0	0.9	39.2	2.51%	0.00%	26.39%	2.01%	**2.09%**
Animal feed	0.3	0.1	0	0.4	0.02%	0.02%	0.00%	0.02%	**0.02%**
Industrial uses**	70	4.3	0.2	74.5	4.59%	1.01%	5.87%	3.81%	**0%**
Anaerobic digestion	0.4	0	0	0.4	0.03%	0.00%	0.00%	0.02%	**0.02%**
Composting	5.9	0.2	1.2	7.3	0.39%	0.05%	35.19%	0.37%	**0.38%**
Incineration***	0	0	0	0	0.00%	0.00%	0.00%	0.00%	**--**
Landfill***	1,409.43	422.08	1.11	1,832.62	92.43%	98.92%	32.55%	93.74%	**--**
Land application	0	0	0	0	0.00%	0.00%	0.00%	0.00%	**0%**
Dumping	0	0	0	0	0.00%	0.00%	0.00%	0.00%	**0%**
Sewer	0	0	0	0	0.00%	0.00%	0.00%	0.00%	**0%**
Other	0.5	0	0	0.5	0.03%	0.00%	0.00%	0.03%	**0%**
Trash	--	--	--	--	--	--	--	--	**97.49%**
Total	**1,525**	**427**	**3.41**	**1,955**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

*Note that ReFED removed the portion of disposal listed as "Other" for modeling purposes.

**Data on industrial uses (or biomaterials/processing) was excluded because most of this is spent cooking oil rather than pre-consumer surplus.

***For improved state-level modeling, ReFED grouped together the Incineration and Landfill numbers into a "Trash" percentage. BioCycle survey data conducted in partnership with Columbia University was used to estimate state-specific landfill and incineration numbers.

Leanpath pre-consumer surplus destinations data for states with organics recycling laws:

DESTINATION	% OF PRE-CONSUMER SURPLUS SENT TO EACH DESTINATION
Donations	5%
Animal feed	2%
Industrial uses	0%
Anaerobic digestion	0%
Composting	78%
Trash (includes Landfill and Incineration)	15%
Land application	0%
Total	**100%**

Appendix T: Destinations of Foodservice Plate Waste

ReFED assumed that plate waste was sent to "Trash" in all states, except states that have organics recycling laws. For these states (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington), Leanpath plate waste destinations data was used instead[52]. ReFED did not use the Leanpath data for all other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

Leanpath plate waste destinations data for states with organics recycling laws:

DESTINATION	% OF PLATE WASTE SENT TO EACH DESTINATION
Donations	0%
Animal feed	0%
Industrial uses	0%
Anaerobic digestion	11%
Composting	78%
Trash (includes Landfill and Incineration)	1%
Land application	0%
Total	**100%**

Appendix U: Destinations of Foodservice Catering Overproduction

ReFED assumed that catering overproduction was sent to "Trash" in all states, except states that have organic waste recycling laws. For states with organics recycling laws (California, Connecticut, Massachusetts, Oregon, Vermont, and Washington), Leanpath catering overproduction destinations data was used instead[52]. ReFED did not use the Leanpath data for all other states to avoid selection bias as Leanpath clients may be more likely to compost food scraps than the average foodservice business.

Leanpath catering overproduction destinations data for states with organics recycling laws:

DESTINATION	% OF CATERING OVERPRODUCTION SENT TO EACH DESTINATION
Donations	24%
Animal feed	10%
Industrial uses	0%
Anaerobic digestion	0%
Composting	44%
Trash (includes Landfill and Incineration)	22%
Land application	0%
Total	**100%**

Appendix V: % of Food Obtained From Grocery Stores

ReFED used USDA NHANES data[58] to quantify the portion of each food type that is obtained from grocery stores versus other sources (e.g., restaurants, food pantries, convenience stores). These numbers were generated for each year dating back to 2010. The numbers in the table below are for 2019, using values from the most recent NHANES survey (2015-2016). See ReFED's raw data and documentation for more information: https://refed-roadmap.s3-us-west-2.amazonaws.com/public_documentation/Documentation_Residential_GroceryRates.xlsx

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Breads & Bakery	**Artisan and specialty bread**	94%	6%
	Bagels	94%	6%
	Brownies	75%	25%
	Cake	75%	25%
	Cheesecake	75%	25%
	Cookies	75%	25%
	Cupcakes	75%	25%
	Donuts	75%	25%
	English muffins and crumpets	75%	25%
	Flatbreads and pizza crusts	94%	6%
	Muffins	75%	25%
	Naan	94%	6%
	Other desserts	75%	25%
	Pies, cobblers, and crisps	75%	25%
	Pita bread	94%	6%
	Rolls and buns	94%	6%
	Sliced bread	94%	6%
	Soft tortillas	94%	6%
	Sweet goods	75%	25%
Dairy & Eggs	**Butter, margarine, and substitutes**	96%	4%
	Buttermilk	95%	5%
	Cheese	96%	4%
	Creams and creamers	96%	4%
	Dairy milk	95%	5%
	Egg nog	96%	4%
	Eggs	92%	8%
	Lactose reduced/free milk	95%	5%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Dairy & Eggs	Liquid egg mix	92%	8%
	Plant-based dairy alternatives	95%	5%
	Refrigerated doughs	96%	4%
	Sour cream	96%	4%
	Yogurt	96%	4%
Dry Goods	Apple sauce	93%	7%
	Baby food	93%	7%
	Bagged or loose tea	93%	7%
	Baking chips and chocolate	93%	7%
	Baking cocoa	93%	7%
	Baking coconut	93%	7%
	Baking milks	93%	7%
	Baking mixes	93%	7%
	Baking nuts	93%	7%
	Baking powder	93%	7%
	Baking soda	93%	7%
	Baking sprinkles	93%	7%
	Baking yeast	93%	7%
	Bouillon	93%	7%
	Boxed dinners	93%	7%
	Breakfast syrups	93%	7%
	Broth	93%	7%
	Canned beans	93%	7%
	Canned fruit	93%	7%
	Canned meat and seafood	93%	7%
	Canned soup	93%	7%
	Canned vegetables	93%	7%
	Cereal	93%	7%
	Cereal and granola bars	93%	7%
	Chocolate candy	93%	7%
	Coating mixes and crumbs	93%	7%
	Coffee	93%	7%
	Coffee enhancers	93%	7%
	Coffee pods	93%	7%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Dry Goods	Condiments	93%	7%
	Cookies	93%	7%
	Cooking oils	93%	7%
	Cooking syrups	93%	7%
	Cooking wine and vinegar	93%	7%
	Corn and other food starch	93%	7%
	Crackers	93%	7%
	Cranberry sauce	93%	7%
	Dessert toppings	93%	7%
	Diet and nutrition	93%	7%
	Dried fruit and vegetables	93%	7%
	Dry beans	93%	7%
	Edible cake decoration	93%	7%
	Flour and meal	93%	7%
	Frosting	93%	7%
	Fruit snacks	93%	7%
	Gift baskets	93%	7%
	Gnocchi and dumplings	93%	7%
	Grits	93%	7%
	Gum	93%	7%
	Hard shell tortillas	93%	7%
	Herbs, spices, and seasonings	93%	7%
	Hot cider	93%	7%
	Hot cocoa	93%	7%
	Jams and jellies	93%	7%
	Marshmallows	93%	7%
	Milk enhancers	93%	7%
	Mints	93%	7%
	Nut butters	93%	7%
	Nuts and seeds	93%	7%
	Oatmeal and hot cereal	93%	7%
	Other candy	93%	7%
	Other grains	93%	7%
	Other noodles	93%	7%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Dry Goods	Other sauce, gravy, and marinades	93%	7%
	Pasta	93%	7%
	Pasta sauce	93%	7%
	Pickles, olives, and pickled vegetables	93%	7%
	Pie crusts	93%	7%
	Pie filling	93%	7%
	Pudding and gelatin	93%	7%
	Ramen	93%	7%
	Rice	93%	7%
	Salad dressing	93%	7%
	Salad toppings	93%	7%
	Salty snacks	93%	7%
	Sauce, soup, and seasoning mixes	93%	7%
	Shake and smoothie mix	93%	7%
	Shelf-stable dips and salsa	93%	7%
	Shortening and lard	93%	7%
	Snack cakes	93%	7%
	Specialty wraps	93%	7%
	Sugar and sweeteners	93%	7%
	Toaster pastries	93%	7%
	Tomato sauce and paste	93%	7%
Fresh Meat & Seafood	Bacon	99%	1%
	Beef ribs	>99%	<1%
	Beef roast	>99%	<1%
	Chicken breast	98%	2%
	Chicken legs	98%	2%
	Chicken thighs	98%	2%
	Chicken wings	98%	2%
	Clams and mussels	>99%	<1%
	Crab	>99%	<1%
	Fowl and exotics	93%	7%
	Ground beef	>99%	<1%
	Ground chicken	98%	2%
	Ground turkey	98%	2%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Fresh Meat & Seafood	Ham	99%	1%
	Lamb	93%	7%
	Lobster	>99%	<1%
	Lunchmeat	93%	7%
	Meat alternatives	93%	7%
	Other beef	>99%	<1%
	Other chicken	98%	2%
	Other fish	>99%	<1%
	Other meat	93%	7%
	Other seafood	>99%	<1%
	Other shellfish	>99%	<1%
	Other turkey	98%	2%
	Oysters	>99%	<1%
	Pork	99%	1%
	Salmon	>99%	<1%
	Sausage and franks	93%	7%
	Shrimp	>99%	<1%
	Steaks	>99%	<1%
	Whole chicken	98%	2%
Frozen	Frozen appetizers	93%	7%
	Frozen bagels	93%	7%
	Frozen bakery desserts	93%	7%
	Frozen beans	93%	7%
	Frozen beef	>99%	<1%
	Frozen bread	93%	7%
	Frozen breakfast foods	93%	7%
	Frozen calzones and stromboli	93%	7%
	Frozen chicken	98%	2%
	Frozen dairy desserts	88%	12%
	Frozen dessert toppings	93%	7%
	Frozen dough and batters	93%	7%
	Frozen fruit	93%	7%
	Frozen fruit juice	93%	7%
	Frozen handheld entrees	93%	7%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Frozen	Frozen lasagna	93%	7%
	Frozen mac and cheese	93%	7%
	Frozen meals	93%	7%
	Frozen meat alternatives	93%	7%
	Frozen pasta	93%	7%
	Frozen pie crust	93%	7%
	Frozen pizza	93%	7%
	Frozen pork	99%	1%
	Frozen pot pies	93%	7%
	Frozen potatoes	93%	7%
	Frozen rice	93%	7%
	Frozen rolls and buns	93%	7%
	Frozen sausage and franks	93%	7%
	Frozen seafood	>99%	<1%
	Frozen toaster pastries	93%	7%
	Frozen turkey	98%	2%
	Other frozen desserts	93%	7%
	Other frozen meat	93%	7%
	Other frozen vegetables	93%	7%
Prepared Foods	Appetizers	25%	75%
	Breakfast foods	25%	75%
	Calzones or stromboli	25%	75%
	Chilled salsa, dips, and spreads	25%	75%
	Deli cheeses	94%	6%
	Deli lunchmeat	94%	6%
	Deli salads	25%	75%
	Deli trays	25%	75%
	Fully cooked beef	25%	75%
	Fully cooked chicken	25%	75%
	Fully cooked pork	25%	75%
	Fully cooked turkey	25%	75%
	Handheld entrees	25%	75%
	Hummus	25%	75%
	Lasagna	25%	75%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Prepared Foods	Mac and cheese	25%	75%
	Meal kits	25%	75%
	Meat alternatives	94%	6%
	Other meat	25%	75%
	Pasta	25%	75%
	Pizza	25%	75%
	Pot pies	25%	75%
	Potatoes	25%	75%
	Prepared fruit or vegetables	25%	75%
	Prepared meals	25%	75%
	Rice	25%	75%
	Sandwiches	25%	75%
	Snack combos	25%	75%
	Soups, stews, and broth	25%	75%
	Sushi	25%	75%
Produce	Apples	91%	9%
	Apricots	91%	9%
	Artichokes	91%	9%
	Asparagus	91%	9%
	Avocados	91%	9%
	Bananas	91%	9%
	Bell peppers	91%	9%
	Blackberries	91%	9%
	Blueberries	91%	9%
	Broccoli	91%	9%
	Brussel sprouts	91%	9%
	Cabbage	91%	9%
	Cantaloupe	91%	9%
	Carrots	91%	9%
	Cauliflower	91%	9%
	Celery	91%	9%
	Cherries	91%	9%
	Chili peppers	91%	9%
	Clementines, mandarins, and tangerines	91%	9%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Produce	Coconut	91%	9%
	Cranberries	91%	9%
	Cucumbers	91%	9%
	Dipped fruit	91%	9%
	Eggplant	91%	9%
	Figs	91%	9%
	Fruit or vegetable trays	91%	9%
	Garlic	91%	9%
	Grapefruit	91%	9%
	Grapes	91%	9%
	Green beans	91%	9%
	Greens	91%	9%
	Honeydew	91%	9%
	Kale	91%	9%
	Kiwis	91%	9%
	Leeks	91%	9%
	Lemons	91%	9%
	Lettuce	91%	9%
	Limes	91%	9%
	Mangos	91%	9%
	Mixed vegetables	91%	9%
	Mushrooms	91%	9%
	Nectarines	91%	9%
	Onions	91%	9%
	Oranges	91%	9%
	Other beans	91%	9%
	Other berries	91%	9%
	Other citrus	91%	9%
	Other fruit	91%	9%
	Other melons	91%	9%
	Other squash	91%	9%
	Other vegetables	91%	9%
	Packaged salads	91%	9%
	Papayas	91%	9%

REFED FOOD DEPARTMENT	REFED FOOD CATEGORY	% OF FOOD OBTAINED FROM GROCERY STORES	% OF FOOD OBTAINED ELSEWHERE
Produce	Peaches	91%	9%
	Pears	91%	9%
	Peas	91%	9%
	Pineapples	91%	9%
	Plums	91%	9%
	Pomegranates	91%	9%
	Potatoes	91%	9%
	Pumpkins	91%	9%
	Radishes	91%	9%
	Raspberries	91%	9%
	Root vegetables	91%	9%
	Spinach	91%	9%
	Sprouts	91%	9%
	Squash	91%	9%
	Strawberries	91%	9%
	Sweet corn	91%	9%
	Tomatoes	91%	9%
	Value added fruit	91%	9%
	Value added vegetables	91%	9%
	Watermelons	91%	9%
Ready-to-drink Beverages	Coffee	87%	13%
	Fruit and vegetable juice	87%	13%
	Other drinks	87%	13%
	Shakes and smoothies	87%	13%
	Sparkling juice	87%	13%
	Tea	87%	13%

Appendix W: Residential Surplus Rates

ReFED used consumer loss estimates from the USDA ERS Loss-Adjusted Food Availability (LAFA) Dataset[59,15] to estimate residential losses by food type. Not all food types were covered by the LAFA dataset. When exact matches did not exist, proxies were assigned.

USDA COMMODITY	% RESIDENTIAL SURPLUS RATE
2 percent milk	20%
Apple juice	10%
Baking milks	26%
Barley products	14%
Beef	20%
Butter	35%
Butter, margarine, and substitutes	35%
Buttermilk	18%
Cane and beet sugar	34%
Canned fruit	11%
Canned meat and seafood	18%
Canned olives	25%
Canned plums	26%
Canned Tuna	17%
Canned vegetables	18%
Cheese	20%
Chicken	15%
Coconut	10%
Cooking syrups	26%
Corn flour and meal	20%
Corn hominy and grits	20%
Corn starch	20%
Dairy milk	20%
Dried fruit and vegetables	22%
Dry beans	10%
Eggnog	51%
Eggs	23%
Flour and meal	20%
Fresh and frozen fish	40%
Fresh apples	20%
Fresh apricots	10%
Fresh artichokes	18%

USDA COMMODITY	% RESIDENTIAL SURPLUS RATE
Fresh asparagus	18%
Fresh avocados	33%
Fresh bananas	20%
Fresh bell peppers	39%
Fresh blueberries	8%
Fresh broccoli	12%
Fresh Brussels sprouts	12%
Fresh cabbage	24%
Fresh cantaloupe	43%
Fresh carrots	34%
Fresh cauliflower	9%
Fresh celery	39%
Fresh cherries	51%
Fresh cranberries	26%
Fresh cucumbers	32%
Fresh eggplant	26%
Fresh garlic	43%
Fresh grapefruit	20%
Fresh grapes	33%
Fresh head lettuce	24%
Fresh honeydew	43%
Fresh kale	38%
Fresh kiwi	45%
Fresh leaf lettuce	24%
Fresh lemons	44%
Fresh limes	44%
Fresh mangoes	13%
Fresh mushrooms	21%
Fresh onions	43%
Fresh oranges	36%
Fresh papaya	20%
Fresh peaches	42%
Fresh pears	20%
Fresh pineapple	37%
Fresh plums	27%
Fresh potatoes	16%
Fresh pumpkin	69%

USDA COMMODITY	% RESIDENTIAL SURPLUS RATE
Fresh radishes	47%
Fresh raspberries	20%
Fresh snap beans	24%
Fresh spinach	9%
Fresh squash	25%
Fresh strawberries	35%
Fresh sweet corn	32%
Fresh tangerines	52%
Fresh tomatoes	7%
Fresh watermelon	13%
Frozen dairy desserts	24%
Frozen fruit	27%
Frozen lima beans	27%
Frozen potatoes	16%
Fruit and vegetable juice	11%
Greens	38%
Half and half	12%
High fructose corn syrup	34%
Ice cream	24%
Lamb	20%
Lettuce	24%
Nuts and seeds	15%
Oat products	14%
Other frozen vegetables	25%
Other meat	24%
Pork	29%
Potato chips	4%
Potatoes	21%
Rice	33%
Salad and cooking oils	15%
Shortening	35%
Sour cream	8%
Sugar and sweeteners	28%
Turkey	35%
White and whole wheat flour	20%
Yogurt	21%

Appendix X: Causes of Residential Surplus

ReFED used data from NRDC Home Kitchen Diaries[60] to estimate the causal breakdown of residential food waste. Study averages were used, because there was very little variation in results across the three areas studied (New York City, Nashville, and Denver). ReFED mapped the NRDC reason names to the ReFED equivalent cause names.

REFED RESIDENTIAL CAUSES		NRDC HOME KITCHEN STUDY EQUIVALENT	% DUE TO CAUSE
BREADS & BAKERY			
Date label concerns		Past due	5.10%
Excess	Didn't taste good	Don't like the taste	8.80%
	Didn't want leftovers	Don't want as leftovers	13.30%
	Too little to save	Too little to save	6.30%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	13.60%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.50%
Other		Other/Unknown	6.90%
Spoiled		Moldy/spoiled	41.00%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	4.60%
	Inedible parts	Inedible parts_inedible	0.00%
		Total	**100%**
DAIRY & EGGS			
Date label concerns		Past due	30.00%
Excess	Didn't taste good	Don't like the taste	2.60%
	Didn't want leftovers	Don't want as leftovers	6.10%
	Too little to save	Too little to save	2.00%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	5.70%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.20%
Other		Other/Unknown	6.60%
Spoiled		Moldy/spoiled	21.80%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	0.80%
	Inedible parts	Inedible parts_inedible	24.10%
		Total	**100%**

REFED RESIDENTIAL CAUSES		NRDC HOME KITCHEN STUDY EQUIVALENT	% DUE TO CAUSE
DRY GOODS			
Date label concerns		Past due	6.50%
Excess	Didn't taste good	Don't like the taste	8.80%
	Didn't want leftovers	Don't want as leftovers	19.20%
	Too little to save	Too little to save	9.20%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	14.50%
Mistakes & malfunctions	Cooking issues	Improperly cooked	2.30%
Other		Other/Unknown	7.70%
Spoiled		Moldy/spoiled	21.30%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	4.00%
	Inedible parts	Inedible parts_inedible	6.40%
		Total	**100%**
FRESH MEAT & SEAFOOD			
Date label concerns	Date label concerns	Past due	2.80%
Excess	Didn't taste good	Don't like the taste	2.50%
	Didn't want leftovers	Don't want as leftovers	10.50%
	Too little to save	Too little to save	2.10%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	3.70%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.10%
Other		Other/Unknown	4.80%
Spoiled		Moldy/spoiled	13.80%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	14.40%
	Inedible parts	Inedible parts_inedible	45.60%
		Total	**100%**

REFED RESIDENTIAL CAUSES		NRDC HOME KITCHEN STUDY EQUIVALENT	% DUE TO CAUSE
FROZEN			
Date label concerns		Past due	0.00%
Excess	Didn't taste good	Don't like the taste	0.00%
	Didn't want leftovers	Don't want as leftovers	17.20%
	Too little to save	Too little to save	11.10%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	0.00%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.00%
Other		Other/Unknown	2.80%
Spoiled		Moldy/spoiled	68.90%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	0.00%
	Inedible parts	Inedible parts_inedible	0.00%
		Total	**100%**
PREPARED FOODS			
Date label concerns		Past due	4.20%
Excess	Didn't taste good	Don't like the taste	7.30%
	Didn't want leftovers	Don't want as leftovers	29.20%
	Too little to save	Too little to save	10.10%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	8.60%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.80%
Other		Other/Unknown	7.90%
Spoiled		Moldy/spoiled	18.60%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	6.60%
	Inedible parts	Inedible parts_inedible	6.60%
		Total	**100%**

REFED RESIDENTIAL CAUSES		NRDC HOME KITCHEN STUDY EQUIVALENT	% DUE TO CAUSE
PRODUCE			
Date label concerns		Past due	0.90%
Excess	Didn't taste good	Don't like the taste	2.50%
	Didn't want leftovers	Don't want as leftovers	2.10%
	Too little to save	Too little to save	1.40%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	3.70%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.30%
Other		Other/Unknown	3.80%
Spoiled		Moldy/spoiled	22.80%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	16.20%
	Inedible parts	Inedible parts_inedible	46.40%
		Total	**100%**
READY-TO-DRINK BEVERAGES			
Date label concerns		Past due	2.30%
Excess	Didn't taste good	Don't like the taste	2.10%
	Didn't want leftovers	Don't want as leftovers	6.60%
	Too little to save	Too little to save	2.70%
Food safety	Food safety recall	N/A	0.00%
	Left out too long	Left out too long	8.60%
Mistakes & malfunctions	Cooking issues	Improperly cooked	0.00%
Other		Other/Unknown	5.40%
Spoiled		Moldy/spoiled	0.80%
Trimmings & byproducts	Considered inedible	Inedible parts_edible	4.60%
	Inedible parts	Inedible parts_inedible	66.80%
		Total	**100%**

Appendix Y: Destinations of Residential Surplus

ReFED used data from NRDC Home Kitchen Diaries[60] to estimate the destination breakdown of residential food waste. Study averages were used, because there was very little variation in results across the three areas studied (New York City, Nashville, and Denver).

DESTINATIONS OF RESIDENTIAL SURPLUS	
BREADS & BAKERY	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	5%
Industrial uses	0%
Composting	28%
Donations	0%
Land application	0%
Dumping	0%
Sewer	5%
Trash	63%
Total	100%
DAIRY & EGGS	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	1%
Industrial uses	0%
Composting	18%
Donations	0%
Land application	0%
Dumping	0%
Sewer	48%
Trash	34%
Total	100%

DESTINATIONS OF RESIDENTIAL SURPLUS	
DRY GOODS	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	2%
Industrial uses	0%
Composting	31%
Donations	0%
Land application	0%
Dumping	0%
Sewer	10%
Trash	57%
Total	100%
FRESH MEAT & SEAFOOD	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	2%
Industrial uses	0%
Composting	25%
Donations	0%
Land application	0%
Dumping	0%
Sewer	3%
Trash	71%
Total	100%
FROZEN	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	0%
Industrial uses	0%
Composting	11%
Donations	0%
Land application	0%
Dumping	0%
Sewer	18%
Trash	71%
Total	100%

DESTINATIONS OF RESIDENTIAL SURPLUS	
PREPARED FOODS	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	2%
Industrial uses	0%
Composting	24%
Donations	0%
Land application	0%
Dumping	0%
Sewer	14%
Trash	60%
Total	100%
PRODUCE	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	0%
Industrial uses	0%
Composting	46%
Donations	0%
Land application	0%
Dumping	0%
Sewer	1%
Trash	52%
Total	100%
READY-TO-DRINK BEVERAGES	
Destination	**% Sent to Destination**
Anaerobic digestion	0%
Animal feed	0%
Industrial uses	0%
Composting	37%
Donations	0%
Land application	0%
Dumping	0%
Sewer	27%
Trash	36%
Total	100%

Appendix Z: Landfill and Incineration Rates

Data Source: BioCycle State of Garbage in America Surveys conducted in partnership with the Earth Engineering Center at Columbia University[16]

STATE	TONS INCINERATED	TONS LANDFILLED	% OF TRASH INCINERATED	% OF TRASH LANDFILLED
Alabama	178,044	4,731,661	3.63%	96.37%
Alaska	0	646,910	0.00%	100.00%
Arizona	0	6,606,097	0.00%	100.00%
Arkansas	0	3,275,571	0.00%	100.00%
California	861,891	30,033,604	2.79%	97.21%
Colorado	0	6,135,556	0.00%	100.00%
Connecticut	2,153,083	247,075	89.71%	10.29%
Delaware	0	691,094	0.00%	100.00%
Florida	5,786,757	13,871,991	29.44%	70.56%
Georgia	0	9,869,457	0.00%	100.00%
Hawaii	547,667	2,450,907	18.26%	81.74%
Idaho	0	1,667,847	0.00%	100.00%
Illinois	0	12,130,698	0.00%	100.00%
Indiana	702,041	4,882,080	12.57%	87.43%
Iowa	39,309	2,696,572	1.44%	98.56%
Kansas	0	2,263,265	0.00%	100.00%
Kentucky	0	4,194,118	0.00%	100.00%
Louisiana	0	5,164,994	0.00%	100.00%
Maine	473,044	213,223	68.93%	31.07%
Maryland	1,391,293	2,351,654	37.17%	62.83%
Massachusetts	3,173,765	1,534,237	67.41%	32.59%
Michigan	992,175	11,947,446	7.67%	92.33%
Minnesota	1,147,771	1,787,325	39.11%	60.89%
Mississippi	0	2,728,531	0.00%	100.00%
Missouri	0	3,966,245	0.00%	100.00%
Montana	0	1,365,431	0.00%	100.00%
Nebraska	0	2,218,268	0.00%	100.00%
Nevada	0	2,808,133	0.00%	100.00%
New Hampshire	251,805	402,888	38.46%	61.54%
New Jersey	2,128,772	4,387,878	32.67%	67.33%
New Mexico	0	1,980,841	0.00%	100.00%

STATE	TONS INCINERATED	TONS LANDFILLED	% OF TRASH INCINERATED	% OF TRASH LANDFILLED
New York	3,678,169	10,271,114	26.37%	73.63%
North Carolina	0	7,702,858	0.00%	100.00%
North Dakota	0	675,070	0.00%	100.00%
Ohio	0	9,126,983	0.00%	100.00%
Oklahoma	205,496	4,396,649	4.47%	95.53%
Oregon	181,474	1,917,315	8.65%	91.35%
Pennsylvania	3,081,583	5,908,723	34.28%	65.72%
Rhode Island	0	793,333	0.00%	100.00%
South Carolina	0	3,296,946	0.00%	100.00%
South Dakota	0	646,797	0.00%	100.00%
Tennessee	0	6,037,529	0.00%	100.00%
Texas	0	23,730,742	0.00%	100.00%
Utah	126,778	2,058,868	5.80%	94.20%
Vermont	0	379,081	0.00%	100.00%
Virginia	2,042,856	10,091,402	16.84%	83.16%
Washington	272,842	4,110,230	6.22%	93.78%
West Virginia	0	1,812,675	0.00%	100.00%
Wisconsin	73,456	4,181,333	1.73%	98.27%
Wyoming	0	609,724	0.00%	100.00%

Appendix AA: Data Quality Rubric

ReFED developed the following rubric to evaluate the quality of each data source utilized to estimate food loss and waste.

CRITERIA	DATA QUALITY SCORE				
	1	2	3	4	5
Credibility	Data source undisclosed	Data lacks a full study it can be linked to	Data is self-reported and not vetted by an external organization	Data is self-reported but vetted by an external organization or is a proprietary source from a data company	Data has been vetted and approved through peer review or is a government data source
Update Frequency	One-time	Updated every 6+ years	Updated every 3-5 years	Every other year	Annual or more frequent
Coverage	Data represents less than 20% of sector	Data represents 20-49% of sector	Data represents 50-69% of sector	Data represents 70-84% of sector	Data represents 85% or more of sector
Food Type	Not food type specific	Proxy assignments made across unsimilar food types	Proxy assignments made, but within roughly similar food types	Proxy assignments made, but within very similar food types	Zero or very few proxy food type assignments necessary
Geography	Site-specific (e.g., site or city)	State-level data for 1-3 states	State-level data for 4-24 states or national data applied to individual states	State-level data for 25-39 states	State-level data for 40-50 states
				Maximum Score Possible	**25/5 = 5.0**
				Minimum Score Possible	**5/5 = 1.0**

Grading Scale: Very High: 5.0 , High: 4.0-4.9 , Medium: 3.0-3.9 , Low: 2.0-2.9 , Very Low: 1.0-1.9