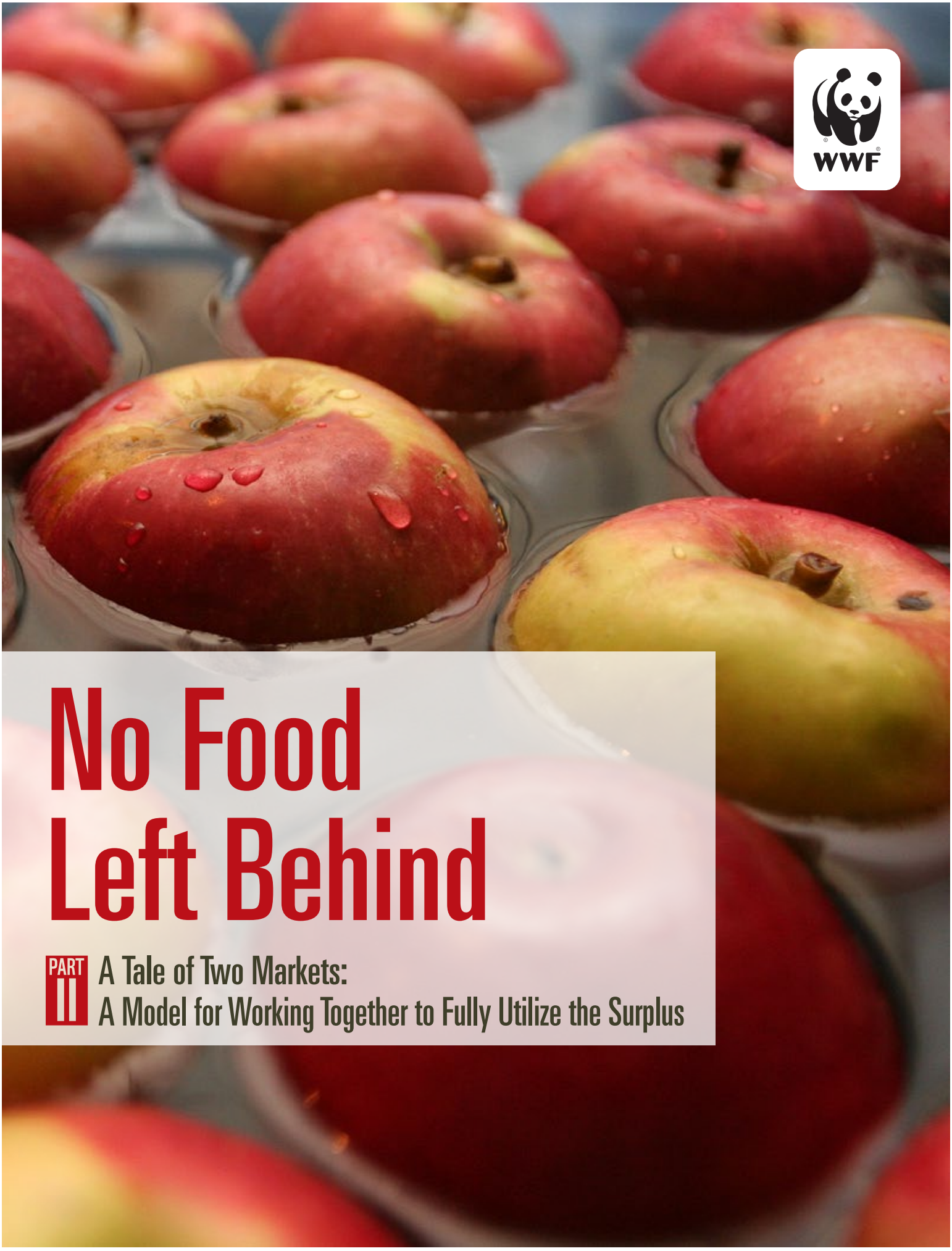

No Food Left Behind

PART II A Tale of Two Markets: A Model for Working Together to Fully Utilize the Surplus

ACKNOWLEDGMENTS

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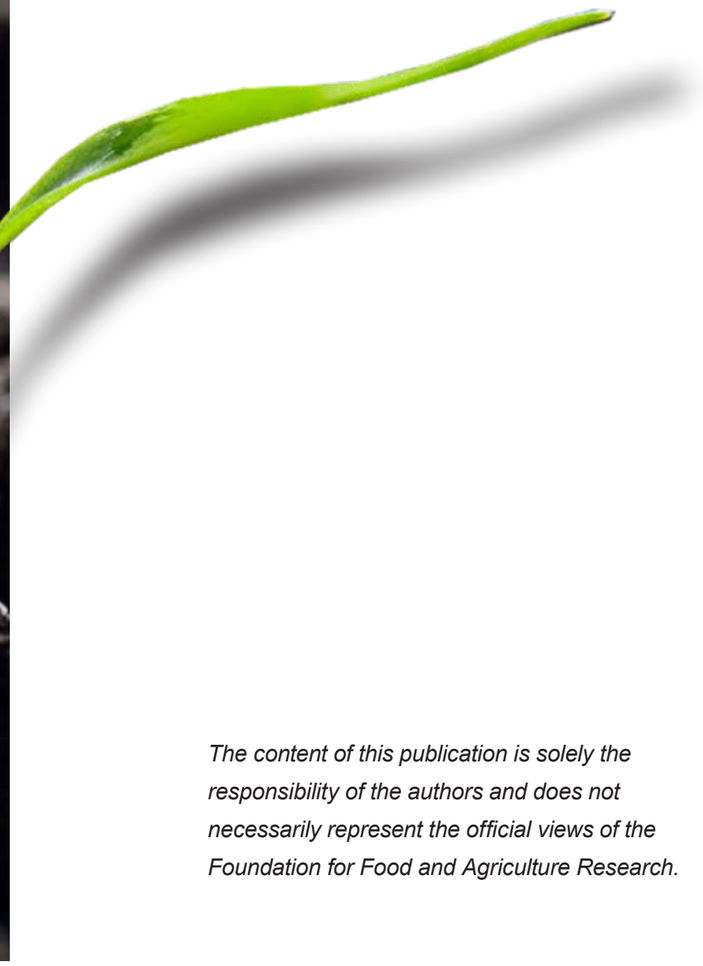


ABSTRACT

Improving the efficiency of our food production system (getting more from a smaller land and resource footprint, i.e. using less water, fertilizer, and other inputs) is critical to meeting future food demand, especially recommended daily fruit and vegetable intake for a growing population. It is also necessary to achieve World Wildlife Fund's mission of conserving natural habitats, as the food system is one of the most pressing threats to biodiversity around the world. The current fruit and vegetable production system, which functions as two primary markets, fresh and processing, experiences loss rates ranging from as low as 2% for processing vegetables to 50% for fresh leafy greens, leaving significant room for improvement. This analysis examines the volume of a subset of crops in both markets, looks at food loss drivers, compares the two models to recommend opportunities for improvement, and proposes additional research questions for future investigation. By exploring alternative harvesting models (i.e., concurrent harvesting for donation and student harvest crews) this report showcases potential options for rescuing underutilized food currently left in fields that can be enabled through real-time measurement and online food surplus marketplaces. While this report uncovers possible opportunities to reduce in-field loss, such as dynamic processing for the fresh market and the utilization of food hubs, more research is needed to understand if these models are scalable and economically viable and if they will truly address the problem of loss.

INTRODUCTION

The current food production system is a leading threat to our natural environment and the diversity of life on Earth. Food production accounts for an estimated 69% of freshwater use[1], 15-25% of greenhouse gas emissions (GHGs)[2], and 30% of soil erosion globally[3]. It's also projected to drive 70% of the future loss of terrestrial biodiversity[4]. This makes wasting two out of every five pounds of food in the United States[5] a major loss of these limited resources, at a time when more than 40 million people (including 12 million children[6]) live in food insecure households.[7] Given the environmental impacts of food production and the community needs, reducing food loss and waste (FLW) is an imperative if humanity is to live in harmony with nature.

In 2017, only 1 in 10 American adults consumed the recommended amount of fruits and vegetables. If more Americans begin to meet USDA's dietary recommendations, there will be a significant impact on the domestic specialty crop market.[8] Additionally, an increasing global population coupled with a tripling of global income by 2050 is projected to shift dietary trends towards increased consumption of animal protein products and fresh fruits and vegetables (2-28% increase)[9]. Therefore, to alleviate the pressures on the environment, it is more important than ever to maximize what we already produce through all means possible, including eliminating food loss and waste.[5]

This report, the second in a series focused on post-harvest loss of specialty crops in the US and the opportunities these nutrients could represent for the market, the food insecure, and producers, looks at processing crop losses and their drivers. It examines and compares specialty crop production for the processing market in the Midwest with the fresh model that was studied in WWF's first report, "No Food Left Behind: Underutilized Produce Ripe for Alternative Markets (Part I)". This analysis contrasts the loss rates between the two markets and explains the drivers behind their differences.

One of the biggest differences between the fresh and processing markets is the role of the buyer. In the processing markets, buyers shift the losses from the field to the processing facility, which potentially minimizes the losses overall. The processing market is more vertically integrated, and buyers typically purchase entire fields worth of crops as opposed to spot buying. This factor likely contributes to making the processing model more efficient at the farm level. In addition to comparing the loss rates and challenges faced by these two markets, this report also explores a potential harvesting and marketing model for *fresh* produce that could better align with the structure and efficiency of the *processing* market.

1 FAO (2016). AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO).

2 Sonja J. Vermeulen, Bruce M. Campbell, John S.I. Ingram, Climate Change and Food Systems, Annual Review of Environment and Resources 2012 37:1, 195-222; EPA Global Greenhouse Gas Emissions Data.

3 The Guardian. Third of Earth's soil is acutely degraded due to agriculture. (2017). Accessed at: https://www.theguardian.com/environment/2017/sep/12/third-of-earths-soil-acutely-degraded-due-to-agriculture-study

4 Global Biodiversity Outlook 4. Convention on Biological Diversity (2014). https://www.cbd.int/gbo/gbo4/publication/gbo4-en.pdf

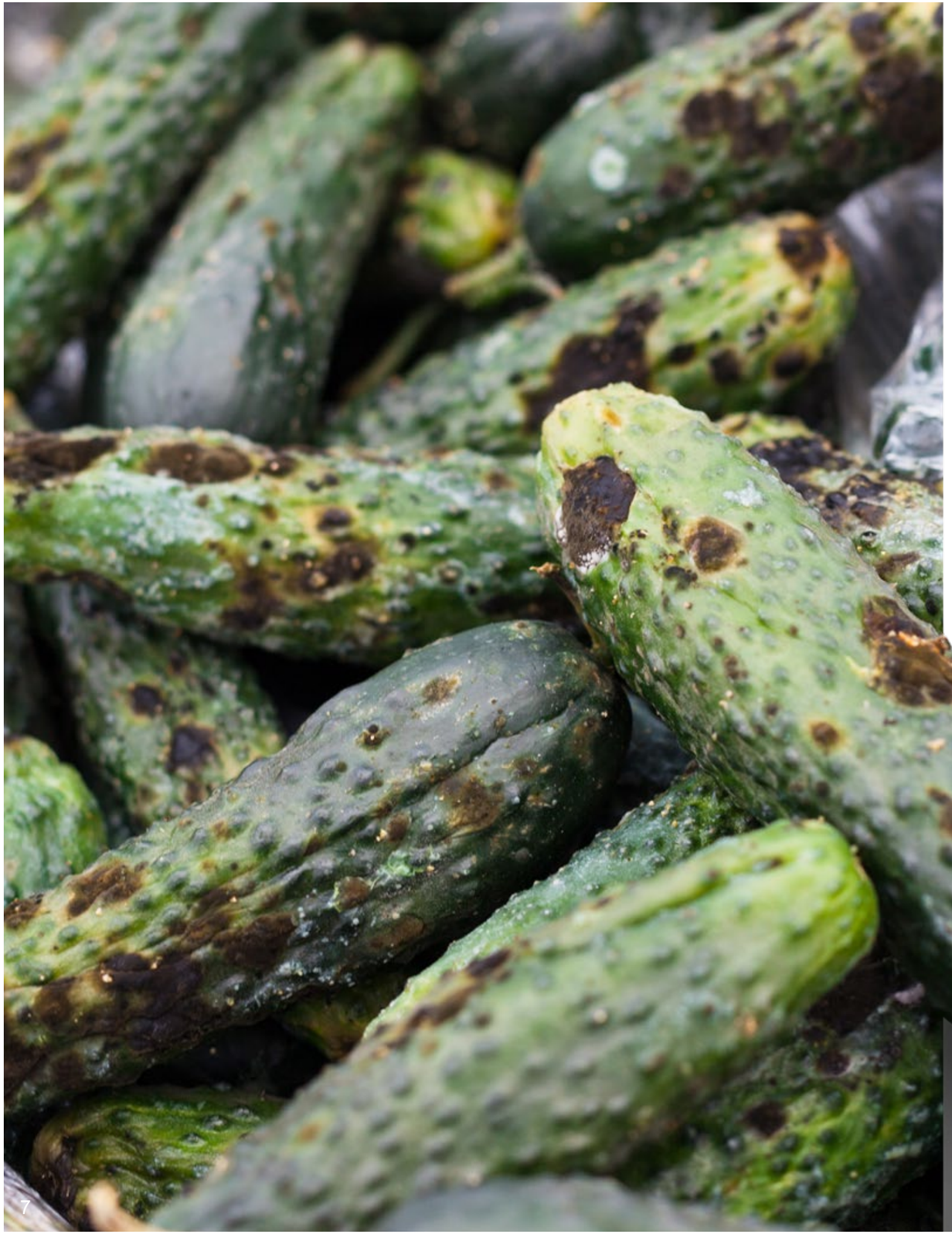
5 A Roadmap to Reduce U.S. Food Waste by 20 Percent. (2016). Rethink Food Waste Through Economics and Data. https://www.refed.com/downloads/ReFED_Report_2016.pdf

6 Coleman-Jensen A., Rabbitt M., Gregory C., and Singh, A. (2018). Household Food Security in the United States in 2017, ERR-256, U.S. Department of Agriculture, Economic Research Service

7 Economic Research Service. Food Security in the US. Accessed at: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx.

8 Lee-Kwan SK, Moore LV, Blanck HM, Harris DM, Galuska D. Disparities in State-Specific Adult Fruit and Vegetable Consumption- United States, 2015. MMWR Morb Mortal Wkly Rep 2017; 66:1241-1247. DOI: http://dx.doi.org/10.15585/mmwr.mm6645a1.

9 Springmann, Marco et al (2018). Options for keeping the food system within environmental limits. International Journal of Science. Nature 562, 519-525.



BACKGROUND

Quantitative in-field measurements from Part I found that about 41% of fresh tomatoes in Florida, 41% 40% of fresh peaches in New Jersey, 40% 2.5% of processing potatoes in Idaho, 2.5% and 56% of romaine lettuce in Arizona were left 56% in field during the 2017-2018 growing season.[10] Similar to other studies, the report captured only a snapshot in time for one growing season, and only for the specified crops. However, it was one of the first studies to showcase in-field data measurements as opposed to grower estimates for in-field loss. As the data revealed in Part I, grower estimates are oftentimes lower than the loss measured in-field.

The study also captured the voices of growers through qualitative interviews in California. The interviews highlighted key drivers for leaving fresh crops in-field, including a lack of market demand, the impact from weather, and labor costs and shortages. This was in contrast to potatoes grown for the processing market, which had far better utilization due to vertical integration. To further quantify this difference between in-field losses in the fresh and processing markets and to understand the structural drivers that make the processing market more efficient, WWF commissioned research that looked at various crops used for the processing market in the Midwest, chosen by market share and production volumes, as well as a model of blueberry production that straddles the fresh/processing divide.

Beginning in June 2018, researchers from North Carolina State University conducted interviews with growers and processing industry representatives for sweet corn, green bean, cucumber, and green pea processing crops and fresh and processing representatives for blueberries in Minnesota, Michigan and Wisconsin. The findings from this research, showcased below, highlight the notable differences in loss rates between fresh and processing market production. The results and subsequent discussion provide an initial analysis of the key differences between the two markets' structures and loss rates, and possible opportunities for further research into how learnings from the processed market could be applied to the fresh market.

10 https://c402277.ssl.cf1.rackcdn.com/publications/1170/files/original/WWF_No_Food_Left_Behind_111018.pdf?1542040595

RESULTS: POST-HARVEST LOSS FOR SPECIALTY CROPS IN THE PROCESSING MARKET

Overview

From August to September 2018, a total of six growers, four processing industry representatives, two food banks, and two industry support stakeholders were interviewed in Michigan, Wisconsin and Minnesota. The processing vegetable market in the Midwest is highly vertically integrated — processors often provide seed, offer planting labor and equipment, allocate acreage demands, outline guidelines for pesticide application and oversee harvest timing and harvest crews for the farms they source from. While the processing industry associations were willing and open to engage their field supervisors in interviews, peak production timing, coupled with a short growing cycle (e.g., the green pea harvest is only 35 days), led to difficulties in connecting directly with growers to complete in-field measurement for vegetable crops. Additionally, processing crops produced in this region are primarily contract grown; processors, rather than growers, dictate the time of the harvest. Given this relationship, growers could not provide the exact timing of their harvests and were hesitant to allow access to their fields. Despite the lack of quantitative loss measurements for the vegetable crops, visiting with growers, grower intermediaries and industry stakeholders provided substantial insight to the processing industry in this part of the US. Ultimately, blueberries in Michigan were the only crops to be measured for in-field losses. While the lack of quantitative data limits our ability to make specific comparisons between loss percentages in fresh and processing markets, the farmer estimates still allow for directionally correct comparisons and hypotheses that warrant more quantitative research to validate.

Blueberry production in the Midwest proved to be a unique case study in that, unlike the other crops assessed, producers grow for both the processing and fresh market. The Michigan Blueberry Cooperative (MBG) is a strong marketing partner for the blueberry industry, which is a part of the international Naturipe Berry Growers, a producer co-op owned by growers to serve growers.[11] Increasingly common, co-ops - including Naturipe Berry Growers - sell product to retailers year-round by contracting with growers in Michigan, Florida, Georgia, North Carolina, New Jersey, California, British Columbia, Argentina and Chile. Similar to the processing vegetable model, Naturipe Berry Growers orchestrates many day-to-day operational tasks such as packaging requirements, pesticide application, market and product development research, and access to value-added processing. Growers benefit from this cooperative model where the co-op purchases all of their berries because it removes quality-in-field and risk of rejection from in-field losses. Instead, berries are sorted at the processing facility for quality, which can lead to some losses, but most of the berries sorted out of the fresh supply can be utilized in the processing stream.

In-Field and Processing Losses

The following graphics provide more information on each of the crops studied and highlight either the grower estimate of in-field losses, the estimated processing facility losses, or actual in-field measurements of loss. For some of the crops studied, researchers were only able to gather estimates for in-field or processing loss, and for one crop, sweet corn, they were only able to gather loss drivers without estimates.

11 http://www.naturipeberrygrowers.com/

BACKGROUND ON

Fruits & Vegetables Studied

In addition to the four crops WWF studied in Part I, WWF commissioned research on five crops in the Midwest bound for the processing market. These crops have varying production volumes, methods, locations and end markets. The information below highlights key industry statistics for the crops studied.

Where do they come from? Where do they go?

Production statistics, market facts, and harvest windows for the Midwest specialty crops studied.

MIDWEST

	Sweet corn	Blueberries	Wisconsin, Oregon, and Michigan	With 100,000–150,000 acres in pickling cucumber production, Michigan and North Carolina	Annual processing production of green peas
HARVEST	JUN – SEP	JUN – OCT	JUN – SEP	JUN – OCT	MAY – AUG
	Sweet corn is the largest processed crop after tomatoes (frozen and canned). In 2015, sweet corn totaled 2.5 million tons with a crop value of $255.5 million. The largest processing states are Minnesota, Washington and Wisconsin. (NASS 2017)	The US is the largest producer of blueberries in the world and Michigan is the nation's leading producer of cultivated blueberries. From 2015–2017, the state produced 94.4 million pounds at a value of $115 million. (NASS 2018)	Wisconsin, Oregon, and Michigan are the leading states in processed green bean production in the US.	With 100,000–150,000 acres in pickling cucumber production, Michigan and North Carolina are the top producing states.	Annual processing production of green peas is 96,503 tons at a total value of $24.5 million. The largest processing states are Minnesota, and Wisconsin. (NASS 2017).
MARKET	74% of sweet corn produced in the US goes to the fresh market while 26% is sent for processing, usually canned or frozen. (AGMC 2017)	Blueberries are almost split equally between markets, 53% sent for fresh market and 47% sent for processing market. (AGMC 2018)	From 2013–2015 more than 50% of green beans were grown for the processing market. (NASS 2015)	In 2018, pickling cucumbers accounted for more than half of cucumber production, 51–60%. (NASS 2018)	Between 2016–2018, 69–84% of pea production was processed into frozen or canned products. (NASS 2018)

How are they harvested?

Crops are harvested by people and/or machines based on their fragility, value, and end market. The following highlights some of the differences between the two harvesting methods and shows where the crops from our last two studies fall.

HAND-PICKED

Hand-picked for ripeness and fragility, some fresh crops are picked-and-packed in field while others are hand picked and sorted at the packing or processing facility. Details of the harvesting techniques for these crops can be found in Part 1.

Requires many skilled laborers

MECHANICALLY HARVESTED

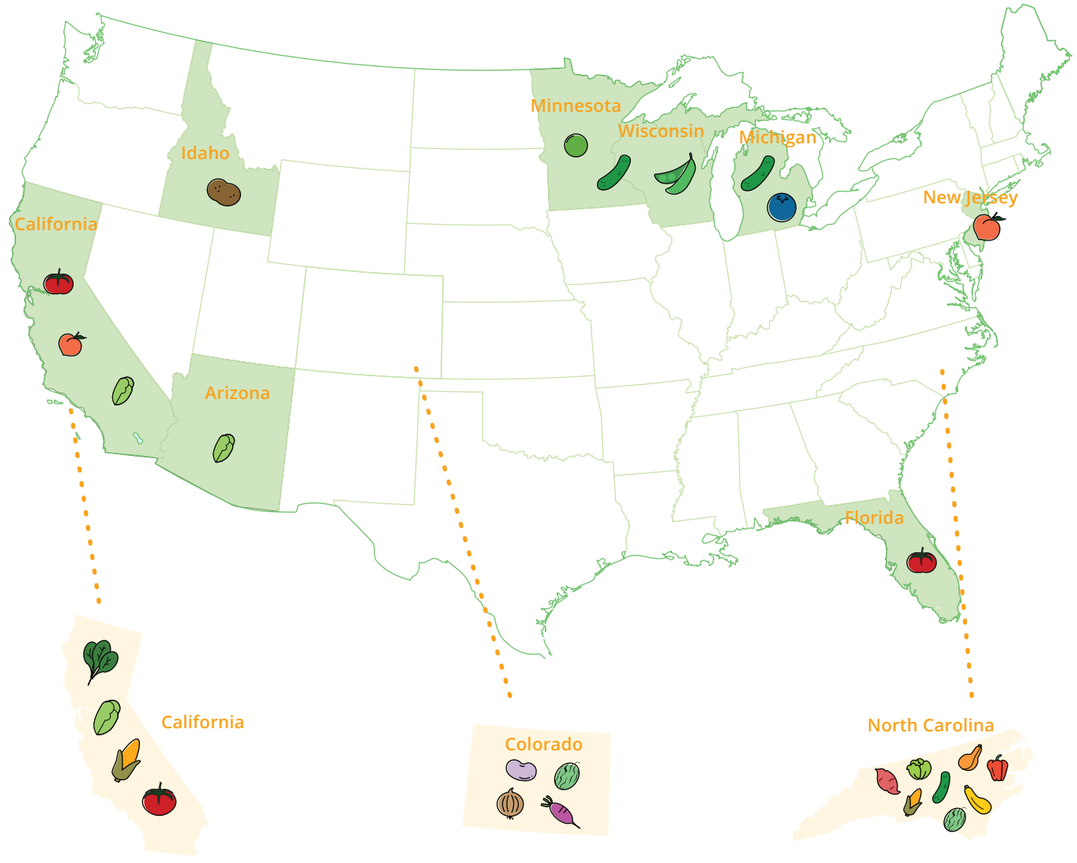
Mechanically harvested for the processing market, and hand-picked for the fresh market.

Mechanical harvesting is typically used for processing crops where crops ripen more uniformaly and mechanical damage is more accepted. Mechanical harvesters are engineered to fit the plants architecture, cultivar type and row spacing. Efficient in maximizing harvest of the plant's edible portion, mechanical harvesters are quite destructive to the plant's other parts.

Requires very few skilled laborers to ensure the mechanical harvesters are working appropriately

Crops and Locations for Loss Measurement

Measurement is key to understanding the opportunity for full-utilization and varies by crop and across regions. WWF continues to research the amount of loss and reasons for loss for specialty crops in the US. The map below captures the states and crops WWF has gathered data on for the No Food Left Behind reports (shown in green) in addition to other regional studies (shown in peach) that have informed our work. The results for states where WWF performed measurement are included in the Total Losses section.



Santa Clara University (SCU) post-harvest loss for crops assessed, 2016-2017[1]:

CROP	MIN	MAX
Bunch Spinach	10%	34%
Celery	11%	63%
Green Leaf Lettuce	17%	75%
Iceberg Lettuce	11%	33%
Napa Cabbage	18%	72%
Romaine Hearts	14%	257%
Romaine Lettuce	11%	75%
Sweet Corn	1%	6%
Roma Tomatoes	3%	13%
Round Tomatoes	1%	25%

UpRoot Colorado found the following breakdown for post-harvest loss of these specialty crops[2]:

ORGANIC CROP	MARKETABLE	EDIBLE	INEDIBLE
Dragon Tongue Beans	51%	41%	8%
Heirloom Watermelons	34%	38%	28%
White Onions	12%	34%	54%
Purple Daikon Radishes	88%	10%	2%

Three-year average of North Carolina marketable and edible yield left in-field[3]:

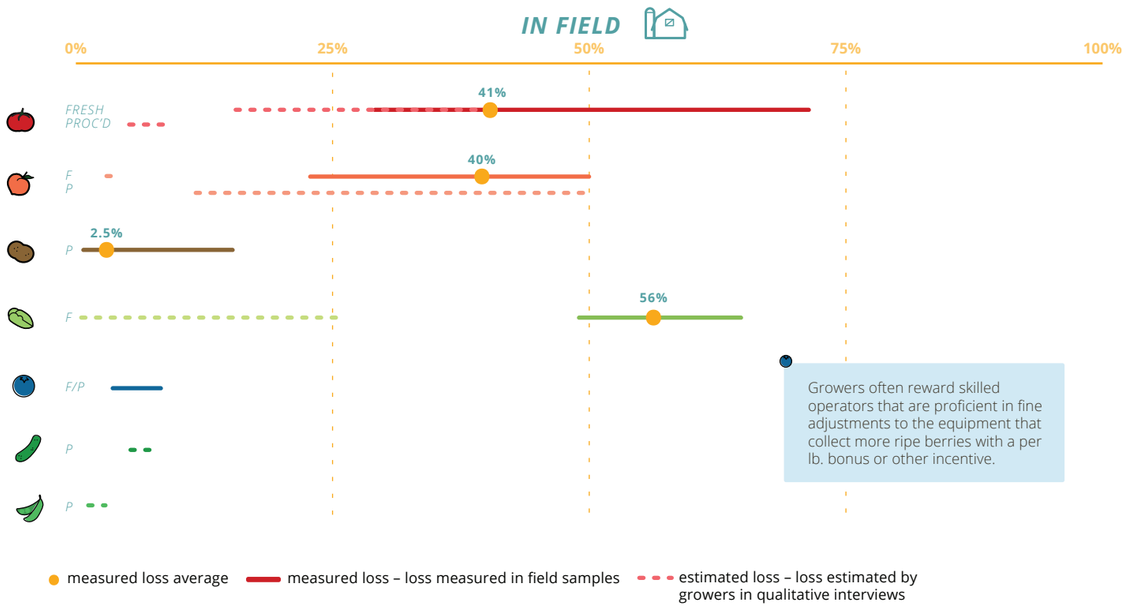
CROP	MARKETABLE	EDIBLE
Cabbage	1%	13%
Summer Squash	1%	11%
Cucumber	13%	55%
Bell Pepper	12%	13%
Sweet Corn	25%	36%
Winter Squash	17%	27%
Watermelon	44%	41%
Sweet Potato	16%	10%

1) Santa Clara (Baker GA, Gray LC, Harwood MJ, Osland TJ, Tooley JC. On-farm food loss in northern and central California: Results of field survey measurements. Resources, Conservation and Recycling. Forthcoming 2019.)

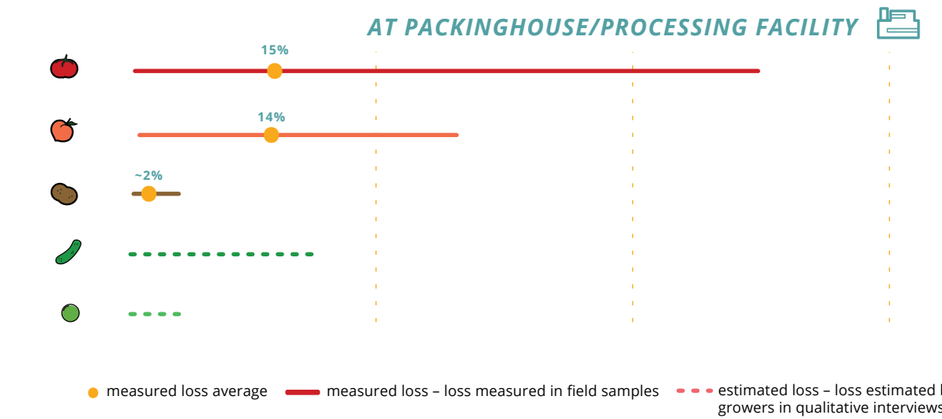
2) UpRoot (preliminary results that have not yet been published),

3) North Carolina (https://www.sciencedirect.com/science/article/pii/S0921344918301927)

Total Losses[4]



This figure illustrates the variance in loss rates across crops, between crops grown for fresh versus processed markets, and the differences between estimated and measured values of loss. The processing crops that are mechanically harvested typically had much lower levels of loss (most under 15%), but there are still areas of opportunity to reduce loss since plants are sometimes missed, crushed, or skipped in the field.



For fresh crops, losses at the packinghouse are typically lower than the in-field losses, however, for processing crops losses at the processing facility can be higher than in-field losses since this is where the crops are assessed for quality. Cucumbers and green peas are the only crops where estimates for loss at the processing facility were gathered for the 2018 growing season. For cucumbers, loss can be up to 20% at the processing facility since cucumbers still need to meet quality specifications for pickles, and while those that are graded out can be sent for relish, that system cannot always absorb all the rejects.

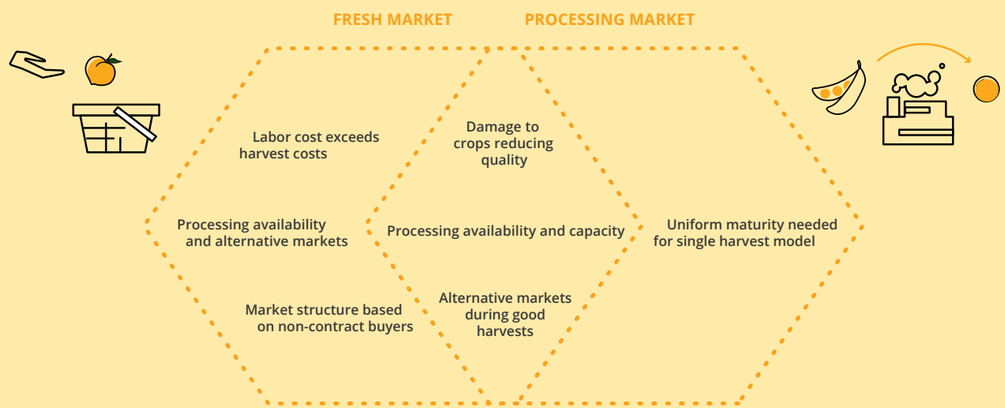
4) No Food Left Behind Part I measured peaches, tomatoes, potatoes and romaine. For full results, including sample sizes visit: https://www.worldwildlife.org/publications/no-food-left-behind-part-1-underutilized-produce-ripe-for-alternative-markets

DISCUSSION

In Part I, research showed that the drivers of loss in the *fresh* market included: over-ripeness, failure to meet quality standards, labor shortages or prohibitively high labor costs, and lack of market demand for a crop. This round of research into the *processing* market found that even though crop losses may be lower, there was still loss from lack of infrastructure to handle oversupply and bottlenecks during peak harvest, lack of alternative markets that accept off-size, blemished, or soft product, uneven maturity at harvest, and damage from equipment during harvest and transfer. The research began to show that loss of product for the *processing* market may just move further up the supply chain since the proportion of losses during grading and sorting at the processing facility exceeded the loss rate in-field. In comparison, the *fresh* market typically saw a higher proportion of losses in-field, where product was more likely to be left in the field than sorted later at the packinghouse. More direct measurements of losses at the packinghouse/processing facility are needed to understand how losses at this stage differ between the fresh versus processed markets. Based on our initial estimates, the processing market still comes out ahead when looking at overall lower loss rates across the two stages (in-field and the processing facility).

Maintaining quality by reducing damage to the crop, addressing processing capacity, predicting and meeting consumer demand, and developing or stabilizing robust alternative market channels are all challenges that fresh and processing crops share, albeit for different reasons. The main reason losses are higher in the fresh market relate to issues such as: labor shortages, less whole crop purchasing, and costs of harvesting below grade product. By comparison, losses are relatively lower in processing markets due to the vertical integration of the processing industry, the harvesting mechanism (mechanical versus hand-harvesting, which often leads to higher rates of loss), and the lower quality standards required for processing crops. Vertical integration for processing crops means processors contract for specific amounts to be grown, decide the price they will pay and the quality specifications they need, and provide provisions to cover specific types of crop failure. With such protective parameters in place, farmers often prefer growing for contract buyers over growing for the open market. Figure 1 outlines the reasons for loss for the fresh and processing markets.

FIGURE 1 SIMILAR AND DIFFERENT REASONS FOR LOSS IN FRESH AND PROCESSING FRUIT AND VEGETABLE MARKETS



One common challenge both industries face is the ever-changing demand of consumers, which was found to be a driver for loss in Part I. Consumers seek the highest quality and aesthetically appealing produce. This means retailers are incredibly selective when sourcing produce, setting high quality standards that leave fresh produce abandoned in-field. This is not as much of a concern for most processing crops, which is also the primary reason they are able to mechanically harvest their crops. While aesthetic appeal is not a challenge for processing crops, demand for some processed products, specifically canned fruits and vegetables, is decreasing. Processors in the Midwest spoke to this pain point: “Everybody is going more towards fresh”; and “We saw an uptick in demand when the economy crashed, so canned products are tied to a low economy.”

Being in the fresh produce business often means growing surplus since markets can change during the production cycle, and growers want to be able to meet unpredictable demand. Since most products must be transported quickly from field to consumer to ensure quality at the end market, most fresh specialty crops are sold in spot markets and are not contract-grown like the processing market. This system for fresh production unarguably lends itself to more loss. The differences in loss between processing and fresh crops that have been discussed in the No Food Left Behind reports are attributable to these varying production systems, primarily the contract-based purchase of processing crops versus spot market purchasing, mechanical harvesting versus hand harvesting and the flexible quality or grade standards for processing products versus strict quality standards for fresh. This line of inquiry keeps uncovering key questions for further research as discussed in the following sections.

BOX 1

USING MEASUREMENT TO INCREASE MARKET OPPORTUNITIES: A POTENTIAL MODEL FOR FRESH?

In 2018, the consulting company Whole Crops piloted Whole Crops Harvest (WCH), an alternative harvest model initiative, to show how to bridge the gap between farmers and markets using student harvest crews as a workforce development solution to on-farm food loss. WCH is a unique supplemental labor model for in-field measurement, marketing measured product, and then harvesting to order excess produce utilizing existing online marketplaces to better coordinate supply and demand ensuring low risk sales.[12] The WCH pilot proved on a small scale how to successfully capture and market surplus specialty crops that would have typically remained a loss, to generate additional revenue streams for farmers.[13] The pilot involved three steps for successful delivery of left behind edible produce through alternative marketing channels, as well as non-profit food rescue channels for what could not be sold: (1) measure and market; (2) harvest and glean; and (3) distribute and donate.

Measure and Market

To quantify the volume of specialty crops left in field that could be sold to alternative markets, the WCH team completed six loss measurements on farm utilizing a methodology developed by researchers at North Carolina State University – the same methodology used in this report – and tracked loss using an innovative application of LeanPath's food waste tracker.[14] This information on edible and marketable crops left in-field was then shared with digital and physical marketplace platforms and distribution companies to match with buyers. Once the product was sold, the alternate harvest crew would harvest the surplus crops alongside recruited gleaners that were assigned a portion of the field for donations of crops that were not able to be sold. The team utilized two online marketplaces to solicit buyers: FarmDrop.us (direct-to-consumer) and Spoiler Alert New England Marketplace (business to business), and partnered with two distribution companies Dirigo Wholesale and Native Maine, where larger amounts of product being sold to processing partners could be marketed to restaurants and institutional kitchens such as Sodexo at the University of Southern Maine.

Harvest and Glean

Using these platforms, the team successfully conducted three harvest-to-order sales, which utilized WCH's paid, trained student labor to pick and pack for a prearranged buyer, and three concurrent harvests that used local gleaning groups to rescue what remained after the harvest-to-order crops were picked. The two different crews worked concurrently in the same field, at opposite ends, to optimize the coordination time required with the farmers and to be the least costly to their operations. Having both crews concurrently harvest helped the farmers make extra income from the harvest-to-order sales and gain access to a tax deduction for the crop harvested by the gleaners for donation to local food banks. Previously, crops harvested for either channel were seen as having no value due to a lack of market security or tax incentive.

With the possibility of diverting food to businesses or restaurants, it was important that students still understood the proper techniques for harvesting different types of crops. Training alternative labor forces as an on-call mobile harvest crew, whether it's students, volunteers or another type of organized group, can increase a farm's capacity to solve for operational bottlenecks while meeting existing market demand. Following a similar model, WCH consulted for a pilot done by UpRoot Colorado on the Northern Front Range developing a Mobile Farm Workforce Cooperative that organized and trained veterans to harvest crops that would have likely been lost on farm.[15]

Distribute and Donate

Food that was salvaged from the farms during this pilot was distributed, donated, or processed to multiple end buyers or food banks. One of the harvest-to-orders went to Matriark Foods, a start-up value-add processing company, for use in their vegetable flavored umami[16] that use 90% surplus produce. Matriark Foods is actively developing national partnerships with schools, hospitals, and online marketplaces. The team also worked with Sodexo to harvest 368 pounds of surplus green beans, combine them with 1000 pounds from a second farm, lightly process them and distribute a resulting 800 pounds of frozen rescued green beans to five different University of Maine campuses that use Sodexo's dining services.

Challenges

While the WCH pilot was a success, it was not without its challenges. An ongoing challenge with this model is farmer adoption of online platforms that are specifically aimed at surplus produce and not entire operations. This is a necessary step to successfully make a farm-to-consumer or business-to-business connection, eventual sale, and plan for harvest. Farmers need a marketplace that is integrated with their existing platforms and a good market for this model to be successful. Lack of a market may block full utilization of surplus produce, oftentimes only yielding rescues of about 20% of what was measured in-field as edible and marketable. In a 2018 report put out by Salvation Farms of Vermont, farmers highlighted why managing surplus is a challenge: "It's tough, you know, it takes a lot of extra effort, and so I think that's often where the disconnect is, is when it takes extra effort to sell something that's blemished or second-quality or third-quality even, but we're getting a lesser price for it so it's really hard sometimes to justify the extra marketing effort to…connect to people."

Working with large distributors meant working with very large orders. Meeting their demand and finding regional processing facilities that could handle large industrial scale orders was a challenge that would need to be overcome if this regional model were to be scaled.

12 www.wholecrops.com/harvestpilot

13 Dunning, Rebecca D., et al (2019) Putting Dollars to Waste: Estimating the Value of On-Farm Food Loss. http://www.choicesmagazine.org/choices-magazine/theme-articles/examining-food-loss-and-food-waste-in-the-united-states/putting-dollars-to-waste-estimating-the-value-of-on-farm-food-loss

14 Johnson L.K., et al (2018). Estimating on-farm food loss at the field level: A methodology and applied case study on a North Carolina farm, Resources, Conservation and Recycling, Volume 137. https://doi.org/10.1016/j.resconrec.2018.05.017.

15 UpRoot Colorado. Mobile Farm Workforce Pilot_2018. https://drive.google.com/file/d/1YlB34neMw6eWMhmiMtivqwpgCyzI6F8l/view

16 Defined as a category of taste in food (besides sweet, sour, salt, and bitter, corresponding to the flavor of glutamates).

17 Salvation Farms. Our Work. https://www.salvationfarms.org/wp-content/uploads/2019/04/Reducing-Food-Loss-Report_FINAL.pdf

SOWING THE SEEDS FOR CHANGE

Comparing the fresh and processing fruit and vegetable markets illuminates four key areas for additional study: (1) How can lessons learned from the differences in market structures including buyer power and the use of different contracting mechanisms or cooperatives be applied to the fresh market? (2) How can real-time measurement be improved to drive market innovation? (3) What does harvesting for the fresh market look like in the future to achieve full crop utilization (i.e., utilizing seasonal farmworkers for concurrent harvesting, mechanization, and/or supplementing seasonal farmworkers with other locally trained crews)? and (4) How can processed fruits and vegetables meet future demand while not exceeding the boundaries of our environment and depleting our world's natural resources?

Industry Structure

Results from the Midwest processing market showed that the vertical integration of the processing vegetable market and the blueberry cooperative model both allow for almost all product to be harvested and ensure that close to all harvested product is sold, including product that is not suitable for primary markets. Inferred from grower interviews, processing channels often have stringent contracting mechanisms between growers and buyers compared to fresh crop producers and buyers within the spot market. The relationship between buyers and sellers that was observed for the processing market may lend itself to higher-utilization levels by purchasing whole fields, or a whole product that is raised to maturity. While this purchasing model has potential to shift the loss to the processing stage, initial estimates indicate that this is unlikely and that if loss is shifted, it is still reduced overall. However, more quantitative research is needed to validate this initial hypothesis.

Food hubs are one potential model for the fresh market that mirrors the processing market structure but has not reached scale; they bring together producers, processors, marketers, and other value-add businesses under one roof. Food Works Group, a food produce strategy and consulting group, developed a concept that would establish a regional port or food hub in the Mid-Atlantic to support existing cooperatives in finding alternative, regional market channels for growers. This "port" would provide the physical infrastructure needed when there is a bottleneck in processing capacity for processed crops and a processing facility for rescued surplus that needs to be processed before being marketed using alternative channels.[18] While the model sounds promising, food hubs often struggle with their sales margins for moving and distributing surplus food from growers and processors and can also be seen to potentially crowd out sales for farmers' first-grade product.

Feeding America, the largest domestic hunger relief organization, currently operates regional mixing facilities, similar to food hubs, that aggregate and distribute farmer surplus to their food bank network. They are currently working on expanding this distribution system, which represents another potential distribution channel for fresh produce.[19] Given the economic challenges of food hubs, Feeding America's subsidized model may be more effective if it can continue to be subsidized. Further research should be conducted to determine whether food hubs could function for the fresh market as vertically integrated, multi-stakeholder cooperative models do for the processing market without cannibalizing farmers' highest quality produce. Another option is for farms to create their own processing capacity. The Value-Added Producer Grant Program (VAPG), recently reinstated in the 2018 Farm Bill, helps producers move into value-added agricultural enterprises, which could be another area of opportunity for growers to fully maximize their production and surplus when primary markets will not take cosmetically imperfect product or there is a bottleneck in processing. The model has worked for some producers in the past including Blue Ridge Food Ventures (BRFV), a shared-use, value-added food processing center that serves a range of food entrepreneurs throughout western North Carolina, and the Pacific Coast Producers (PCP), a processor of California fruits and tomatoes. BRFV used the funds to build additional capacity and equipment for multi-use processing from pulping to bottling. PCP used its grant to expand capacity of preparation-ready canned tomato products, including sandwich-ready sliced and salad- and taco-ready cuts that are marinated or seasoned, and for a marketing campaign to make canned produce competitive with fresh under the theme: "fresh as fresh can be."[20]

18 Food Works Groups. Assessment of the Mid-Atlantic Food Port Concept and Economic Impact on Rural Agribusiness. https://docsend.com/view/yq4caww
19 https://www.feedingamerica.org/about-us/press-room/produce-cooperatives
20 https://www.agmrc.org/business-development/strategy-and-analysis/analysis/pacific-coast-producers

Real-Time Measurement

Measurement as an enabler of market optimization and innovation continues to be a theme emerging from this research. Measuring crop loss is essential to understanding the regional and crop-specific differences of what is left in field, the opportunity this presents for alternative channels, such as food banks and animal feed, and the potential economic loss to growers. While measurement is essential to unlock the opportunity for full utilization of surplus produce, a grower's ability to measure has been limited to date. Simple and quick methodologies that a grower can easily adopt alongside their many other demands have been limited and the value of spending time on this effort has been questioned.

Dunning et al. (2019) illustrated the value of farm-level loss measurements by showing how they can enable profit and loss calculations of harvesting and selling produce left in-field to secondary markets or food banks.[21] Building from this business case, WWF, in collaboration with the Stewardship Index for Specialty Crops (SISC), is developing a simple tool that allows growers to measure their loss and make management decisions based on their findings. WWF is a member of SISC, which is a multi-stakeholder collaborative of growers, grower groups, buyers and environmental NGOs focused on building science-based, data-driven metrics for measuring sustainability across specialty crop supply chains. This food loss measurement tool is currently undergoing pilot tests with the intent of adding it to SISC's suite of metrics. This tool and outcome-focused metric will enable producers to benchmark themselves against the industry and make decisions to improve their performance.[22]

Whole Crops (see Box 1 for case study)[23] found that using measurement to accurately market excess product via online platforms was a successful way to sell small and large quantities of marketable and edible produce that would have traditionally gone unharvested. Adopting this highly coordinated, regionally specific model, growers avoided speculative and potentially superfluous marketing, harvesting and distribution efforts by securing sales for non-contract product prior to going back in-field. Without in-field measurement of surplus, the model would have encountered higher risks of overselling or underselling produce. This model presents an opportunity to rescue produce when it is left in field for cosmetic quality reasons, when infrastructure does not exist between grower and alternative marketing channel, or when there are bottlenecks in processing.

Addressing Harvesting Labor Challenges

In addition to challenges with the structure of the fresh market, limited labor and its rising costs is another area requiring further research and exploration into alternative harvesting models that can work. The Whole Crops Harvest model is one example of a regional pilot that was able to utilize trained, albeit more expensive, labor and online marketing channels to successfully harvest fresh crops as fresh and for secondary market channels in a processed form. While this model is regional and currently only tested on small scale farms, its basic premise of utilizing data, technology platforms, and on-demand local labor to make the needed market connections holds potential in regional markets all while strengthening the local food system. The pilot proved that measurement informed marketing coupled with concurrent harvest crews can achieve higher utilization rates, though this practice requires investment in professionally training alternative labor crews, which may not work at scale.

The processing market relies on mechanical harvesting; cultivars are bred to reach peak maturity at roughly the same time interval allowing for a single harvesting pass to be made. Mechanical harvesting is currently not ideal for more delicate fruits and vegetables sold to the fresh market, but it does address the challenge of a shrinking and increasingly expensive labor force. The mechanical harvesting technologies under development that can harvest the most delicate of crops such as berries could be a game-changing technology for the industry that allows for full utilization of the crops. For example, the Agrobot, a robotic strawberry harvester, has the capability to grip and cut the stem without contacting the fruit itself and uses graphic processing units to determine the fruit's ripeness allowing for only the optimal fruit to be picked.[24] This has the potential to improve harvesting efficiencies while also addressing the seasonal labor crunch. Although this harvester and its competitors are still undergoing trials, growers and industry representatives are investing in these technologies as a solution to labor shortages for large scale farms.

A one size fits all solution to the labor challenge across all farm sizes and types is unrealistic. The future of harvesting fresh produce will involve multiple solutions that come at a range of costs and the producer's decisions will be based on what is best for their business, which may be switching to robotic technology, continuing to work with seasonal labor, or a combination. This is an area of study that needs further exploration to see what the optimal solution is for workers, producers, and the environment.

21 Dunning, Rebecca D., et al (2019) Putting Dollars to Waste: Estimating the Value of On-Farm Food Loss. Choices: Agricultural and Applied Economics Association. http://www.choicesmagazine.org/choices-magazine/theme-articles/examining-food-loss-and-food-waste-in-the-united-states/putting-dollars-to-waste-estimating-the-value-of-on-farm-food-loss

22 The Stewardship Index for Specialty Crops. https://www.stewardshipindex.org/

23 https://www.wholecrops.com/harvestpilot

24 http://agrobot.com/

The Future of Processed Fruits and Vegetables

Although processor feedback alluded to a decrease in demand of processed fruits and vegetables, market research shows that the US canned foods industry is expected to grow at an estimated compound annual growth rate of 3.9% over the period of 2017-2025, highlighting a potential area for additional research to truly understand where this growth is occurring and who is benefiting.[25] The study attributed the increase in consumption of both canned and other processed fruits and vegetables to improved processing techniques and packaging (canning liners), and a rise in awareness among people regarding the nutritional value of these products. These products have the potential not only to limit loss within production and distribution, but also might be able to dramatically reduce food loss in homes because of their longer shelf life and reduced trimmings resulting from pre-cut preparations.

Reimagining this product category to increase its appeal is desperately needed. Relying solely on fresh produce to meet the future population's demand for fruits and vegetables could have significant land use, water, and resource implications. However, satisfying this demand with processed products requiring refrigeration also has its environmental costs. More studies are needed that consider in-field and supply chain losses to understand the full life cycle costs and benefits of these different product types.

25 *25 Grand View Research. US Canned Foods Market Size, Share, & Trends Analysis Report, By Type) Seafood, Vegetables, Meat Products, Fruits, Ready Meals), Competitive Landscape, And Segment Forecasts, 2018-2025. https://www.grandviewresearch.com/industry-analysis/us-canned-foods-market*

CONCLUSION

Research for Part II added supporting evidence that post-harvest loss varies significantly based on the crop type, its use (fresh market versus processing market) and its production location. There is qualitative evidence that suggests there is less food loss on farms in processing channels because there are fewer cosmetic standards and grading constraints during harvest. However, there is also evidence to suggest loss in processing channels is shifting further along the chain and can be higher at the packinghouses or processing centers than in the fresh market. While research does not yet definitively show that cumulative loss is higher or lower, initial estimates point to the processing market being more efficient overall. While loss at processing facilities is still not optimal, moving surplus to these facilities centralizes the produce, creating an opportunity to more efficiently redistribute it to alternative markets and donation centers.

Initial pilots confirmed that where there is measurement or estimates undertaken, opportunity follows. When quantification and real-time reporting of surplus can be communicated to the marketplace, there is potential to create additional revenue and donation opportunities, especially when concurrent harvesting of product for alternative and donation channels is part of a planned harvest strategy (and not a reactive harvest strategy). The need for real-time measurement and market information flows is critical. While more prototyping and piloting of information technology is needed, great potential exists for full utilization of crops if real-time measurement of surplus crop availability could be better integrated into existing or future market communications platforms.

The No Food Left Behind platform will continue to probe this topic through the release of future reports that 1) report post-harvest loss data for additional specialty and commodity crop losses; 2) highlight pathways to a future where as much as possible of what is grown is utilized; and 3) report on results from prototyping and pilot efforts in-field and across the supply chain.

WWF is calling upon stakeholders across the supply chain to think about how they can measure their food loss and waste in real-time, transparently report it, and work with other market actors to minimize or prevent it in an effort to freeze the footprint of food in the US and minimize agriculture's expansion in critical geographies globally. In a world of finite resources where population, global wealth and inequality are on the rise, food production and consumption are humankind's most pressing challenges. Production systems are faced with changing growing cycles, increasingly unpredictable weather patterns, unusual temperature swings, growing water scarcity and declining soil health. It is imperative we ensure that what is produced on farms and what leaves the farm-gate is fully utilized so we can both feed people and limit agriculture's encroachment on wildlife habitat and degradation of natural resources.