No Food Left Behind

Part 1: Underutilized Produce Ripe for Alternative Markets

ACKNOWLEDGMENTS

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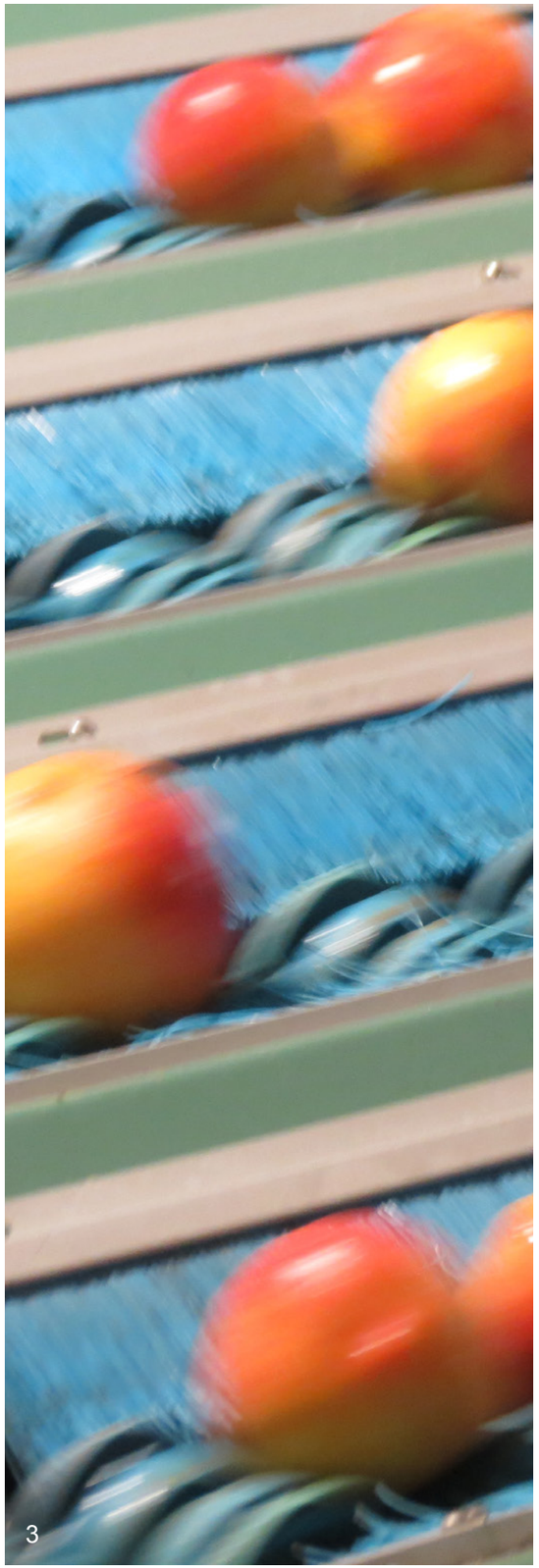


EXECUTIVE SUMMARY

The United States is a leading producer of agricultural products, including many of the specialty crops found at grocery stores across the country. Between 60-75% of fresh produce available in the US is produced domestically.[1] While the current system efficiently delivers a multitude of products to market 365 days a year both domestically and via imports, there is much room to improve the loss associated with this delivery along the supply chain, particularly at both endpoints – farms and retailers.[2] To begin to understand the magnitude of this opportunity, World Wildlife Fund (WWF) collected baseline primary data from farms on post-harvest losses of fresh and processing peaches, processing potatoes, fresh and processing tomatoes, and romaine lettuce.[3] WWF also supported Santa Clara University on their measurement of loss in over 10 specialty crops in California. Both quantitative and qualitative data were collected to show the amount of loss for each product during the selected seasons and timeframe of this study and to begin to illustrate a broader picture of why loss occurs at the farm-level. To translate these losses into environmental impacts in alignment with WWF's conservation mission, researchers performed life-cycle assessments to show the resource-use implications for each crop's production and what is lost when the crop does not make it past the farm-gate.

The results of this study show that specialty crop losses vary widely across crop types. Losses can also vary from year-to-year as market demands fluctuate and weather patterns change, therefore the results presented in this report only represent a snapshot in time (the 2017/2018 growing season) and space (only representative of the grower regions studied) and should not be considered representative of the annual national average of loss for that crop. Over the next one-two years, WWF is planning to investigate a variety of specialty crops to better understand loss across the entire fruit and vegetable market and will continue to track other research on this topic to provide robust annual assessments of post-harvest loss in the US fruit and vegetable market.

For the 2017-2018 growing season and only for the farms measured, the average measured loss for the four crops at harvest were: 40% of fresh tomatoes (processing tomatoes were not measured), 39% of fresh peaches (processing peaches were not measured), 2% of processing potatoes (fresh market potatoes were not measured) and 56% of fresh romaine lettuce. In terms of environmental impact, processing peaches require the most direct water use per kilogram (kg) of product produced, and they are tied with potatoes as the most carbon intensive crop to produce per kg.

Qualitative results showcase the hardships and economic losses that farmers are faced with when deciding whether to produce in excess of existing contracts, to rescue seconds or unmarketable produce, or to allow outside organizations or gleaners to rescue seconds. Farmers also face challenging market and labor dynamics and strict product quality standards that make it increasingly difficult to fully utilize all produce grown. In 2017, only 1 in 10 American adults consumed the recommended amounts of fruits and vegetables. If more Americans met those dietary recommendations, there would be a significant impact on the domestic specialty crop market.[4]

The results of this report found that there is potential in the US to increase availability of fruits and vegetables by better utilizing what is already being produced. Doing so could mitigate the need to increase land conversion, water use, and the use of other resources to increase supply, but more research is needed to validate this assumption. To achieve this ambitious goal, WWF recommends further exploration into improving transparency across supply chains, assessment of the potential benefits and challenges of whole-farm purchasing for specialty crops. Additionally, there is a need for research and experimentation into shifting consumer perceptions of ugly fruits and vegetables, frozen and canned fruits and vegetables, as well as realistic projections of demand.

1 USDA, ERS Vegetable and Pulses: https://www.ers.usda.gov/data-products/vegetables-and-pulses-data/vegetables-and-pulses-yearbook-tables/#General. Fruit and Tree Nuts: https://www.ers.usda.gov/data-products/fruit-and-tree-nut-data/fruit-and-tree-nut-yearbook-tables/#Supply%20and%20Utilization

2 https://www.refed.com/?sort=economic-value-per-ton

3 The scope of reported losses includes in-field losses from the time a crop was ready to be harvested and post-harvest handling (e.g. grading and inspection, packaging), but the number of fields not harvested, also known as "walk-by" fields are not included. Pre-production data was gathered through comprehensive literature reviews (e.g. importance of crop, environmental conditions).

4 Lee-Kwan SH, 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.

INTRODUCTION

The business of global food production has the largest environmental impact of any human activity. Food production accounts for an estimated 70% of biodiversity loss,[5] 70% of freshwater use,[6] 25-35% of greenhouse gas emissions (GHGs),[7] and 50% of soil erosion.[8] We produce more than enough food to feed all people currently on the planet, but it is estimated that we waste one third of all calories produced globally. North America wastes more food than any other region, while in the United States more than 41 million people (including 13 million children) are food insecure.[9] [10] In the US, one estimate indicates that 16% of food waste occurs at the farm level, about 19 million tons annually; however, this number is based on limited field studies, and estimates vary considerably by region as well as quantification scope and method.[11] Increasing harvesting for commercial channels can create additional revenue along the supply chain, by creating value-added products from produce that can then be directed to alternative markets. Rescuing more edible, wholesome produce that is, for one reason or another initially unmarketable, represents an opportunity to support Americans living in food insecure households.

Ironically, farms represent a point in the supply chain where fresh, nutritious food may be most easily recovered and more fully utilized. But farms may also be where food loss is most "efficient" from a resource perspective; as food moves through the supply chain additional labor, refrigeration, transportation inputs and other energy resources are embedded in food products, and thus also in food products that go to waste.

World Wildlife Fund's (WWF) mission is to conserve nature and reduce the most pressing threats to the diversity of life on Earth - and to build a future in which humans live in harmony with nature. Given the environmental impacts of food production,[12] reducing food loss and waste is a critical strategy to fulfill this mission. We need to freeze the footprint of food and improve the resource use efficiency of our global food system. Currently, commodity crops make up most of the land under production in the US, with 215,754,000 acres under cultivation for crops such as corn, wheat, and soy. In contrast, specialty crops (i.e., vegetables, fruits, and tree nuts), which are the focus of this study, make up approximately 7,078,160 acres.[13] As we contemplate the impact that reducing specialty crop losses can have on preserving wildlife habitat, it is important to both understand how the current specialty crop footprint compares to commodity crops and how a move towards a diet that consumes more produce will shift these dynamics. This report, the first in a series on the issues surrounding food loss and waste of specialty crops at the farm level, provides an overview of our loss and waste research findings from the field and outlines potential paths forward for how to address the challenges with our current food system. In subsequent papers, WWF will look closely at these challenges and provide results from future research that test the validity of our proposed hypotheses.

5 Secretariat of the Convention on Biological Diversity (2014) Global Biodiversity Outlook 4. Montréal, 155 pages.

6 FAO (2016). AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO). Accessed on 03/21/2018.

7 Tubiello, F. N. et al (2014). Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks. Food and Agriculture Organization of the United Nations. Rome, Italy.

8 Yadav, S.K. and S. Kumar (2007). Soil Ecology. APH Publishing Corporation. 194 pp.

9 FAO (2016). FAOSTAT Database. Food and Agriculture Organization of the United Nations (FAO). Accessed at <http://www.fao.org/faostat/en/#data/EL>.

10 https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx

11 Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., ... & Cheng, S. (2017). Missing food, missing data? A critical review of global food losses and food waste data. Environmental Science & Technology, 51(12), 6618-6633.

12 For the purpose of this report we will describe any form of loss to be that of food meant for human consumption. This work builds upon studies including, but not limited to, Beyond Beauty: The Opportunities and Challenges of Cosmetically Imperfect Produce, Food Loss in Vermont, WRAPs studies on food loss and waste within supply chains, and Feedback Global's research and investigations into supply chain loss.

13 https://www.nass.usda.gov/Statistics_by_Subject

BACKGROUND

In October 2016, WWF, the Global Cold Chain Alliance (GCCA), and the University of California, Davis (UC-Davis) initiated a multi-year study to measure underutilization of four specialty crops: fresh and processing tomatoes,[14] fresh and processing peaches, processing potatoes, and leafy greens. These four crops were selected based on their land impact, distinctive growing and harvest characteristics, and consumer popularity and demand within the US food system. Additionally, the findings of a separate study started in 2016 by Santa Clara University (SCU) that analyzed 10 specialty crops in California between 2016 and 2017 are also included in this report. WWF is supporting additional field studies conducted by SCU in 2018. All three research teams gathered both quantitative and qualitative data on the amount of loss occurring and reasons for that loss. UC-Davis used a qualitative approach to collect data and primarily met with growers and farm managers in California. GCCA used a methodology that produced both quantitative and qualitative results and met with growers in four different states in the US.

This project has set out to further inform baseline measurements for specialty crop loss by measuring and reporting the field data using the *Food Loss and Waste (FLW) Accounting and Reporting Standard*.[15] Additional objectives for the project included:

- understanding current information flow challenges within our food production systems from farm to retail,
- inventorying solutions for underutilized farm products that have the potential to increase revenue for growers, and
- seeding small-scale pilot projects that aim to address some of the causes of loss that emerged.

To ensure multiple perspectives were incorporated into this research and final report, WWF formed an advisory committee comprised of farmers, non-government organizations, private-sector, academic institutions, and technology innovators, to better guide and inform in-field research and strategize future paths and possible solutions to prototype. The advisory committee helped the research teams and WWF make necessary connections to appropriate stakeholders to scale efforts beyond the research stage; reviewed and provided comments on preliminary results from qualitative and quantitative surveys and data; and assisted in the selection of pilot projects.

The findings from this research showcase the uniqueness between qualitative and quantitative data results and the importance of both to tell a more complete story about what is happening with food loss and waste from the field to the farm-gate. Quantitative results show the raw potential for recovery given the unique context and market conditions of the timeframe being measured. Qualitative results show economic losses that farmers are faced with when deciding whether to rescue seconds, as well as the market dynamics and strict quality standards that make it difficult to harvest everything in-field. The qualitative results provide essential insights into what solutions are (and are not) practical. Finally, life-cycle assessments (LCAs) of the crops performed by UC-Davis quantify the resources that are lost when a crop does not make it to market, including water use, chemical inputs, GHGs, and energy use.[16]

What is clear from previous literature reviews and reports - and supported by the research conducted for this project – is that the burden of food recovery and food loss avoidance does not lie solely with growers.

In most circumstances, underutilization occurs because of a combination of market inefficiencies, poor information flows, cosmetic and quality standards, labor shortages and costs, and consumer expectations. It is imperative that innovators, researchers, and others are diligent, methodical, and patient as to how and when to approach growers on this topic and the language that is used. Building relationships and trust with growers is an essential component to continued execution of research and solution prototyping. The findings also suggest a need to understand elements of contract terms between buyers and growers and how these terms contribute to food loss and waste. WWF plans on investigating this topic further in the future. The following sections highlight key quantitative and qualitative results followed by a broader discussion of what this snapshot in time could be indicative of across our specialty crop production system and a few key levers that may put the system into a healthier balance for people and planet.

14 Botanically a fruit, but declared a vegetable in the Supreme Court case, Nix vs. Hedden

15 Details on the Food Loss and Waste Accounting and Reporting Standard can be found at www.flwprotocol.org

16 The scope of the LCA included upstream raw material extraction and processing of farm inputs, transportation of materials from manufacturer to farm, and all inputs (i.e. energy, fuel, water, etc.) required for planting to harvest.

RESEARCH RESULTS

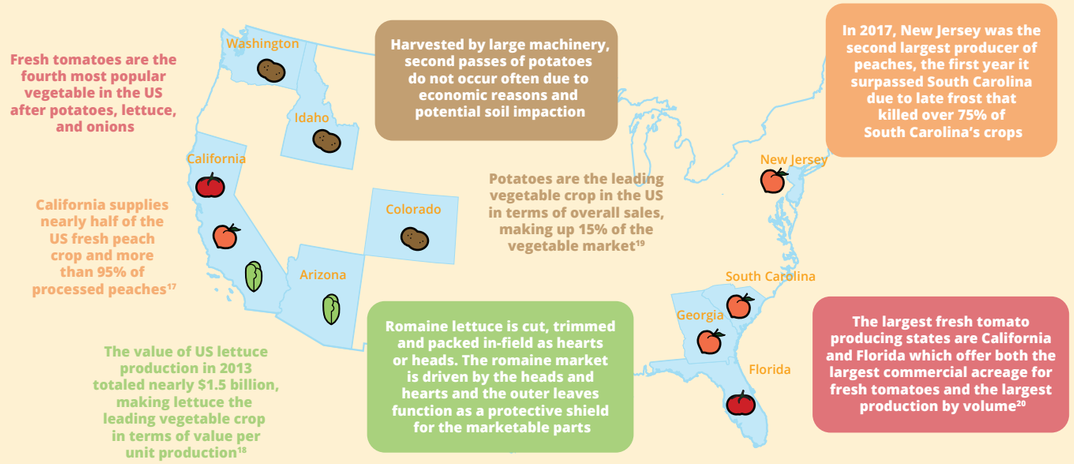
The following infographics highlight the key statistics and production methods for the four crops studied, which is followed by a high-level presentation of the methods used in this study, the loss results found, and how these results translate into environmental impacts. For more detailed information on all aspects of crop production, methods, and results, please refer to the in-depth technical report, which can be accessed at: worldwildlife.org/NoFoodLeftBehind_Technical.

BACKGROUND ON

Fruits & Vegetables Studied

The four crops included in this study have varying production volumes, methods, locations, and end markets. The information below highlights some of these key differences, which were some of the major drivers behind choosing the crops for this study as WWF aimed to gather data on loss rates across a variety of crop types.

Who are the leading producers?



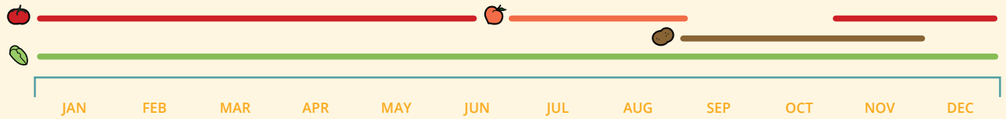
How and when are they harvested?

Fresh tomatoes are harvested ***by hand***, while processed tomatoes are harvested ***mechanically***

Peaches in California are harvested *by hand*, then mechanically by year five. In New Jersey, all peaches are harvested by hand

Roughly *90%* of US potatoes are planted in the spring and harvested mechanically *in the fall*

Almost all lettuce is *hand-harvested* and *field-packed* for bulk sale or sent to a processing facility



Where do they go?

About ***90%*** of the domestic tomato market is sent for ***processing*** into tomato sauce, paste, and other value added products while the remaining ***10%*** is eaten fresh at ***home*** (70% of market) and at restaurants and other food service outlets (30%).[21]

About *50%* of domestic peach production enters *fresh market* while the remaining *50%* is sent for canning (75% of market), freezing (21%), or dehydration (<5%).[22]

Nearly 60% of potato sales are to *processors* for French fries, chips, dehydrated potatoes and other potato products.

All lettuce is marketed as a *fresh product*.

17 https://www.agmrc.org/commodities-products/fruits/peaches/
18 https://www.agmrc.org/commodities-products/vegetables/lettuce
19 https://www.ers.usda.gov/topics/crops/vegetables-pulses/potatoes.aspx
20 https://www.ers.usda.gov/topics/crops/vegetables-pulses/tomatoes.aspx
21 https://www.ers.usda.gov/topics/crops/vegetables-pulses/tomatoes.aspx
22 http://usda.mannlib.cornell.edu/usda/current/noncfruinu/noncfruinu-06-27-2017.pdf

Fruit & Vegetable Losses

Methods

To determine an estimate for post-harvest loss of potatoes, tomatoes, leafy greens and peaches for the 2017-2018 growing season, researchers gathered samples from 35 farms and 20 packinghouses, which volunteered land and time. Measurements for each crop include farms in a single state, with a total of four states participating across the four crops. Given these parameters, the loss numbers presented below should not be considered representative of the entire US nor of an average year. The data is a snapshot in time that adds to the growing research in this space. For more details, please see the technical report at worldwildlife.org/NoFoodLeftBehind_Technical.

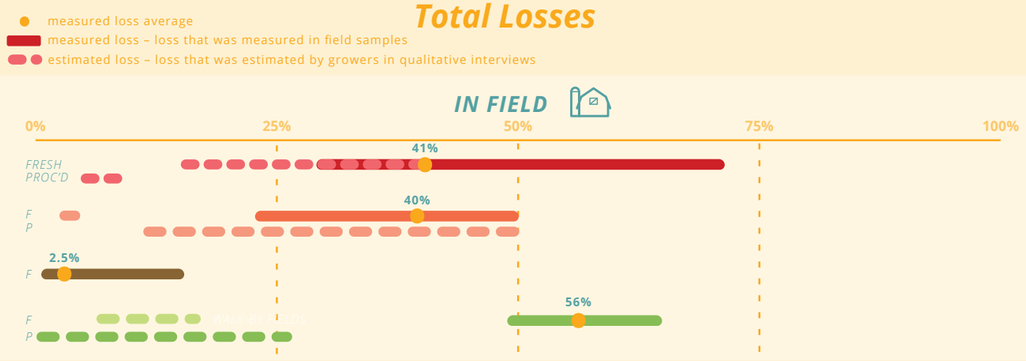
Quantitative data were collected from six (6) farms and six (6) packinghouses in two (2) counties in April of 2017. Qualitative data were collected through ten (10) grower interviews for processing and fresh tomatoes from March to October 2017.

Quantitative data were collected in August 2017 from ten (10) farms and ten (10) packinghouses in three (3) different counties. Qualitative data were collected through ten (10) interviews for processing and fresh peaches in March to October 2017.

Quantitative data were collected from ten (10) farms in one (1) county in January 2018. Qualitative data were collected though nine (9) grower interviews from March to October 2017.

Quantitative data were collected from nine (9) potato farms in five (5) different counties in September 2017. No qualitative interviews were performed.

Total Losses

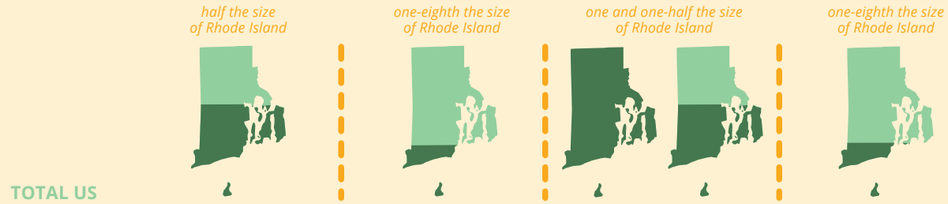


This figure illustrates the variance in loss rates across crops, between crops grown for fresh versus processed markets, and the differences between estimated and measured values of loss. Loss rates are highest for romaine lettuce and lowest for processing potatoes. On average, crops grown for processing have lower loss rates than those grown for fresh markets. This data also shows that farmer estimates for on farm loss are consistently lower than what is measured in the field.

Average loss data from the packinghouses is much smaller than loss on farm since this step is just a further culling of produce that looks damaged, diseased, or off spec. Tomatoes showed the highest levels of losses at the packinghouse.

Production Statistics[23]

The statistics below highlight the 2016/2017 total US production footprint for each crop included in this study, specifically the total land under cultivation and the total annual harvest. These statistics are included to show the relative impact the crops have on land use and their relative size in terms of volumes produced. This data, in combination with the LCA results discussed in the study, was used to estimate the environmental impacts of in-field losses.



	TOMATOES	PEACHES	POTATOES	ROMAINE
TOTAL US LAND USE (acres)	322,100	99,000	1,000,000	100,000
ANNUAL PRODUCTION VOLUME (metric tons)	12,481,052	666,719	22,418,396	1,562,100

Environmental Impacts[24, 25, 26, 27]

The following metrics highlight the relative environmental impacts of the four (4) crops researched in this study using the results from the LCAs for each crop along with supplementary data for potatoes, which were not included in the original LCAs. The first number represents the impact for the total volume produced in the US, followed by the total number scaled for in-field losses, and finally the per unit production value to easily compare impacts by the same unit of production. The green to red scale quickly identifies the highest and lowest values within each metric category. For more details on the methods used to generate the impact data, please refer to the technical report, which can be found at worldwildlife.org/NoFoodLeftBehind_Technical.

	TOMATOES	PEACHES	POTATOES	ROMAINE
TOTAL H_2O USE (acre-feet)	3,500,000	677,000	2,200,000	532,000
LOSS RATES INCLUDED	3,700,000	711,000	2,300,000	830,000
PER UNIT ACRE-FT/KG	0.000287	0.00102	0.000102	0.000341
TOTAL GREENHOUSE GAS EMISSIONS (tons co_2)	600,000	93,000	2,900,000	164,000
LOSS RATES INCLUDED	630,000	98,000	3,000,000	255,000
PER UNIT KG/KG	0.0486	0.14	0.1324	0.105

Potatoes and tomatoes have the largest overall environmental footprints, which in both cases is primarily driven by the volume produced. When looking at the per unit production values, peaches have the biggest water and carbon footprint.

23 Scaled up for production
24 Potato impact data was pulled from: https://fieldtomarket.org/national-indicators-report-2016/report-downloads/
25 https://www.nass.usda.gov/Statistics_by_State/index.php
26 Maximizing Farm Resources and Edible Food Rescue, WWF's final technical report based on in-field studies
27 Qualitative and Life-Cycle Assessment work received IRB approval

SANTA CLARA UNIVERSITY ON-FARM RESEARCH IN CALIFORNIA

In addition to the crops studied by WWF's funded research teams, parallel efforts to quantify on-farm loss were performed by SCU's Food and Agribusiness Institute (FAI), looking at a range of specialty crops in California. SCU's study was largely driven by local area food banks, including The Second Harvest Food Bank of Santa Clara County and the Second Harvest Food Bank of San Mateo County (SHFB).

SCU identified three distinct harvest systems in their data collection: hand harvest field packing, hand harvest shed sorting, and mechanical harvest shed sorting of which in-field sorting predominated for specialty crops.

Unlike the WWF field work, SCU's researchers developed field survey protocols on a crop-by-crop basis to account for the differences in how the crops were grown and harvested. At the end of their surveying period they had collected data on approximately 6-8 fields for 10 different crops. Similar loss results were found by research teams at SCU and WWF's in-field research team. SCU's summarized results can be found in Table 1.

TABLE 1
POST-HARVEST LOSS, CROPS ASSESSED IN 2016 - 2017 GROWING SEASONS

CROP	TOTAL % LOSS AVERAGE UNHARVESTED WEIGHT AS A PERCENT OF TOTAL YIELD	PLANTED ACRES CALIFORNIA, 2017
Round Tomato	3.7%	254,800
Artichoke	4.3%	7,200
Cantaloupe	25.9%	29,700
Sweet Corn	8.4%	37,000
Broccoli	16.2%	120,000
Celery	23.5%	23,700
Bunch Spinach	12.6%	33,500
Strawberry	0.8%	39,000
Cauliflower	2.8%	37,800
Romaine Heart	38.1%	72,100 HEADS AND HEARTS

*This data is preliminary and will be adjusted when Santa Clara University has published final results.

QUALITATIVE RESULTS

To gather qualitative answers to questions about loss, a total of 33 growers, nine grower intermediaries, and 23 UC Cooperative Extension (CE) agents were interviewed. Interviews with CE agents were used as preliminary background data for the research. The results from the grower interviews coalesced around five key themes, which are outlined below.

1. What is considered edible?

Growers generally estimate that a high percentage of what is lost is edible, but not marketable. Growers were all equally skeptical of using one definition for edible and had many questions about how one would define this term. For example, although a crop might be "edible," could it be sold as food for humans? Would anyone want it? Also, the concept of "edible now" versus "edible when it reaches the consumer" was brought up by a few growers. One peach grower commented, *"But if it's imperfect because it's got a flaw, it might be minor at the field level when they're looking at it, but it might be a ball of mush by the time it gets to the consumer level."* As another example, a leafy greens grower noted, *"The outer leaves are left behind, that is the workhorse of this plant, not waste…You wouldn't go out into a tomato field and see all of those vines and go, "Oh, what a waste!" It's not waste. It's what we needed to grow the vegetable."*

2. Is it really "loss"?

Virtually all produce loss on farm is tilled back into the soil, dumped on farm (e.g. for use as a soil amendment[28]), or used as animal feed. Therefore, growers reported rarely sending food to landfill or other destinations where there is less opportunity for some value or nutrient to be captured. For example, an organic tomato farmer made the point that, *"When people say that food is being wasted, maybe it's just not going through the traditional distribution system. Everything that we grow in some way makes it back into the natural system of recycling nutrients."*

A second theme brought up by several of the growers interviewed was the benefit of food being left on farm, instead of "pushing the problem" somewhere further down the supply chain where its chances of being sent to landfill are much higher due to a blemish, cosmetic imperfection, or rapid spoilage. This not only wastes the product, but also the energy and other resource inputs required throughout its journey along the value chain. As one leafy greens grower pointed out, *"If you're going to have waste, better to have it here at this level. Rather than ship something of questionable quality."*

That said, growers interviewed in this study made it clear they prefer to sell as much of these specialty crops as possible.

28 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5970559/

3. What drives loss?

Food loss on farms is primarily driven by weather, labor and market conditions. Market prices, grading standards, and retailers' views of consumer preferences guide quality standards and influence how much a producer will harvest or leave in the field. The market price determines how cost effective it is to employ labor to harvest a crop with questionable value in the field. As a leafy greens grower put it, *"[Loss] varies based on what the marketplace is, and it's all about oversupply. So last winter, we left like 200 acres of lettuce through the course of the whole season…. And there were other seasons that we didn't leave any walk-bys at all…. We track that very closely because it impacts the bottom line. It's really hard to predict what that's going to be."*

Growers also commented that consumer preferences, and thus retail specifications, lead to significant waste. In one peach grower's eyes, *"We throw away, daily, a quarter of a million pounds…Maybe it's overripe, maybe it's misshapen, maybe it's a split pit…I could take you to a packing shed and you'd watch the cull line and you'd go, why are you throwing that away? But that's how particular the market is."*

Unpredictable weather patterns impact loss as well, usually by causing cosmetic damage to the product or ripening of the product at a less than ideal market time. Per one leafy greens grower, *"There is a lot of effort that goes into figuring out the right variety for the right time of the year for climates and soil. And anyone will tell you, it's an art. I will never forget having this really humid storm in September. And all of the lettuce right after the storm didn't have any life to it… When it got to the East Coast, it was all blotchy and looked terrible. It was all because of this environmental event that occurred."*

A less obvious issue is that weather also changes consumption patterns. Ask any grocery merchandising team, and they know weather has a direct impact on the food people buy. Abnormal weather patterns can have big impacts on growing regions. In the extreme, preparations for a storm in the Northeast can leave grocery store shelves barren one day, and lack of distribution and demand in the subsequent weeks can leave fresh produce stockpiled and lost on farm. In these situations, WWF hypothesizes that improving information flows to increase quantities that can be rescued or gleaned by food-rescue organizations will be critical if we are to reduce food loss.

Finally, an insufficient and unpredictable labor supply and increasing cost of labor can have a big impact on losses. Many growers in California are feeling the pressure; as one processing tomato grower put it, *"It's getting harder. And, of course, with minimum wage going up it's getting more expensive, so we're getting priced out of a lot of the fresh market business in California."*

4. How is food currently recovered?

Growers reported two ways in which food is generally recovered, 1) diversion of fresh produce culls into processing options such as juicing, drying, freezing, or some other value-added product; 2) donation of product to food banks. Some growers mentioned that they do utilize available tax credits from donations but noted that credits don't always cover the extra costs incurred through the donation process. Per one fresh peach grower, *"There's no better way to reward a farmer than tax incentives. That helped us greatly. If we could get some sort of a write-off for donating, that will offset the cost of our box and our labor and our pallet in the handling. In their heart, every farmer would like to help."*
The opinion is further confirmed by a leafy greens grower, *"You need someone to cover that variable cost, or why else would you capture it in the first place? But the other point is that there is a channel of commerce that it can go into. So, you need an organization that wants that product, that will pay for the marginal cost of harvest and then have the logistics to handle it. To get it to whoever the end users are going to be."* Another issue for growers, besides feeling that the hassle of paperwork just wasn't worth it, is the concern of "double-dipping"- - a feeling that since some production costs were already deducted, that it might be risky to file for donation credits.

Growers repeatedly mentioned the USDA Farm to School efforts, formalized by the Healthy Hunger-Free Kids Act of 2010, as very effective and beneficial for farmers and consumers. That program intended to better connect local foods to school breakfast and lunch programs. For example, funds from the program supported frozen peaches from California for school lunches.

5. What are the biggest challenges for reducing loss?

Growers elucidated that the specialty crop production system currently in place is meant to deliver cosmetically appealing produce at the lowest cost to consumers. Growers attributed most loss to unpredictable events, which happen at low frequency, but with high volume impact. Creating a production system that can react to such unpredictability would require a heightened level of transparency and information sharing, while avoiding incentives for additional over-production. One processing tomato farmer captured this quandary: *"In the best conditions, your investment [on a recovery system] is going to get a zero return…. There's just nothing to be recovered. So, in the conditions that are ideal, there's no use for it. It's only when things are less than ideal that there's a use for it. But there's no reason to set up something for less-than-ideal conditions, because that's not the condition that's normal, you understand."*

DISCUSSION

The results of the field studies and qualitative interviews highlight potential opportunities for improving utilization that could lead to economic benefits for growers, buyers, and consumers while also minimizing the environmental impacts of fresh fruit and vegetable production per unit, but further research is still needed to test these hypotheses. Moreover, every specialty crop is different, and therefore opportunities will need to be highly tailored to the planting schedules, growing regions, harvest methods, and overall demand patterns for specialty crops. For example, loss reduction solutions for highly perishable foods like leafy greens and peaches may require more regional production or mobile and adaptable value-added processing to avoid longer journeys, otherwise it may be most efficient to leave in-field. On the other hand, solutions for hardier crops with lower loss rates, like potatoes, may need to focus on genetics that can make those 1-2% of potatoes left in-field larger and therefore more economically worthwhile to harvest.

While every crop is unique, and opportunities may vary, field examination of all perishable products in this study did share similar themes for rejection or culling. These similarities include:

- Decay: due to lack of market, lack of affordable technology to help mechanically harvest, and/or insufficient labor to harvest plants at ideal ripeness for the market. Markets take produce before it is ripe because products often travel days or weeks to reach market. If product is too ripe when it begins the journey there is a risk that retailers may reject it when it reaches their distribution center.
- Damage: from pest issues, unpredictable weather events, and over-ripeness. Markets do not accept produce that cannot handle long transportation hauls or have cosmetic defects.
- Size: Fruits and vegetables that are too small, too large, or misshapen may not meet retailer standards or quality grades for sale to consumers as intact, whole fruit and vegetables.

Table 2 further breaks out the drivers of loss as identified through our research and pairs them alongside external efforts that are currently being piloted that might help to address each challenge. The possible solutions are based on the synthesis of this research and additional workshops with a variety of stakeholders from across the supply chain. To note, the Solutions in Prototype are not directly affiliated with this study. Ideas for improvement of the current system and potential next steps will be discussed further in the final section of the report.

TABLE 2 KEY INSIGHTS AND NEXT STEPS

REASONS FOR LOSS	POSSIBLE SOLUTIONS	POSSIBLE SOLUTIONS
Does not meet quality or retail standards	• Omnichannel (e.g., retail, food service, value-added processing, donation, secondary surplus markets) solutions to deal w/varying ripeness and size issues • Behavior change: consumer awareness/ campaign for “bronzed” items • Retail merchandising prototypes • New products, i.e. canned soup for romaine leaves	**Imperfect Can Work Perfectly:** Several companies in the US are capturing food that is out of grade and rejected at the farm or distribution center by buyers and selling the product at lower prices to food service operators who do not need perfect produce. Food banks are also acting as secondary beneficiaries in this process, when the out of grade produce cannot be sold but can be donated safely.
Too ripe	• Send to local food banks • Send to regional retail outlets • Diverting to the frozen, value-added, or canned supply chain	**Extending Shelf Life:** Innovative companies are developing food-grade coatings, to cover produce items, locking water in and oxygen out, slowing the ripening cycle and doubling the lifespan of fruits and vegetables without refrigeration or a controlled atmosphere.
Labor shortages and cost of labor leading to unharvested fields	• Mechanization • Increase availability of reliable labor force to harvest fruits and vegetables	**Supplemental Labor:** Innovative companies are working on both technology and improved business models to address this challenge. Tech companies are developing highly efficient mechanical harvesters to enhance the labor force and start-ups are prototyping improved business models that professionalize in-field food rescue currently done by volunteers.
Market dynamics & the Grower/Buyer relationship	• Cooperative competition to improve supply/demand dynamics that reduce prices • Financially viable alternative markets including value-added processing & food banks • Whole field/farm purchasing • Using stranded assets to grow greens closer to population centers • Genetic enhancements to improve edibility of outer leaves	**Optimizing food recovery:** Many companies, and even food banks are developing technologies to improve gleaning, delivery efficiency, and payments to farmers **Improving transparency:** Many innovators are developing online platforms to market & distribute excess produce, increasing transparency of what is available and allowing markets to react

SOWING THE SEEDS FOR CHANGE

Farmers are some of our country's most important land stewards. Qualitative studies illustrate that farmers do not want to see the food they produce wasted. Though more work is needed, the results from this research begin to indicate that it could be possible for the US food system to increase availability of fruits and vegetables without increasing land, fertilizer, and other resource use by utilizing the surplus that is left in-field—if the price is right, standards are relaxed, and the market demands that supply. However, surplus production from farms will continue to vary from year to year. Recovering additional surplus requires timely distribution interventions and is further improved if farmers are able to predict edible quantities available. It will also require having smart infrastructure investments and logistic incentives that show return on investment (ROI) during both lean and heavy surplus years. While some programs are already in place, there is an opportunity for more government, private-sector, and non-profit investments that bring to market nutritious food surplus. This effort would need to be closely linked to hunger relief efforts already underway by organizations like Feeding America and Food Forward.

Through improvements in real-time measurement and reporting, organizations may be able to plan for regional surplus and find cost effective interventions and markets that return reasonable profits to farmers, help pay for labor, while also incentivizing distributors and third party logistic companies. At the same time, we must provide disincentives for land use expansion into native habitats, e.g. forests, native grasslands, wetlands, water-intensive deserts, etc.[29] The primary driving force for achieving higher utilization levels and reducing loss is to create markets that allow farmers to do this profitably or create favorable conditions in which recovery systems can take advantage of surplus production in financially beneficial ways.

To test some of the solutions and hypotheses identified through this report, WWF recommends more research and discussions with food system stakeholders in the following areas:

1. Encouraging Transparency

A 20-acre spinach field tilled under and left unharvested as a "walk-by field" must become an unacceptable option for our food system. It is possible that by actively reporting underutilization and making farm loss visible, it may be possible to accelerate more effective responses. This transparency does not come without added risk and a cost to farmers. As previously discussed, sometimes loss on farms is the optimal place for loss to occur both from an environmental and economic perspective.Food Forward piloted this theory of increased transparency and access to information in Los Angeles. The organization used backhauling to transport excess produce from the Los Angeles Wholesale Produce Market to local food banks. Transparency was key—what was going to waste at the market and who needed it. Adding transparency into the market dynamics and improving information flows across all players in the delivery chain facilitated 6 runs during this pilot, which ultimately rescued 233,111 pounds of fresh produce that otherwise would have been lost and sent to landfill.[30] See Figure 1 for more details.

It is critical that there is heightened transparency and better real-time mapping of where food is being produced and an understanding for how that food can be efficiently distributed without simply moving the waste further downstream. Creating a real-time reporting framework (such as blockchain, for example) for regionally underutilized farm products can help organize more efforts toward alternative markets and recovery. This could also include a direct line of communication between buyer and grower for immediate, urgent changes in demand from consumers (such as extreme weather events) that allow farmers to redistribute product that the buyer no longer wants, or delay harvesting. Without these information flows, in addition to providing incentives to farmers for making this information transparent, innovation will likely remain stagnant. While results might not be immediate and could take multiple growing seasons, eventually regional, mobile and opportunistic entrepreneurs could take advantage of surplus fruits and vegetables and inject them into new markets.

Figure 1

29 As part of WWF's work, a future report will explore how the American model for agriculture intensification, food recovery and distribution could be applied in developing countries to leapfrog the US's production pathway.
30 Using a commercial food vehicle to make minor detours to existing routes to deliver other products that can fit in open space on their truck or utilizing an "empty" return route after delivering a full load of product.
31 Regmi, A. Changing Structure of Global Food Consumption and Trade. Ed. Market and Trade Economics Division, Economic Research Service, US Dept of Agriculture, Agriculture and Trade Report.
32 https://www.fmi.org/docs/default-source/default-document-library/top-trends-in-fresh_pov-iri2017.pdf?sfvrsn=4ad97c6e_2

2. **It's Not All About "Fresh"** Between the mid-70's and late 90's, consumers significantly increased their consumption of both fresh and frozen fruits, 26% and 36% respectively, and vegetables, 33% and 44% respectively, at a ratio of 3 to 1 in terms of overall consumption levels, while canned produce saw significant declines.[31] Even with these consumption increases, Americans are still not consuming close to their daily recommended fruits and vegetables. According to more recent studies by the Food Marketing Institute, fresh food is the fastest growing segment of the modern grocery store[32]. Demand for more healthy food choices leads to an increase in "fresh" product displays and product diversity. Demand for fresh forces retailers to constantly differentiate fresh in-store perimeters and push for customer loyalty and sales in an extremely competitive landscape. Trends in fresh are pushed even further by customers who want unprecedented convenience and availability. Accommodating, much less predicting, production and consumption trends on a planet where climate and food production are rapidly changing will become increasingly difficult. The notion that all nutritious food entering markets must be "fresh" will not help our food system fully utilize everything that is produced. We need to contemplate building capacity for both macro and regional value-added processing to deliver fruit and vegetable nutrients in a variety of shelf-stable, refrigerated, and frozen product offerings. Crops grown for fresh markets could reach fuller potential by delivering the nutrients in many forms, not just as fresh whole fruits and vegetables that have grown in trend. This shift, however, would need the proper demand and infrastructure in place to succeed. The very notion of "fresh" must be re-imagined. This is about increasing per-capita fruit and vegetable consumption, in whatever form, with our existing domestic production footprint. Retailers and brands have an opportunity to change consumer perception and decision-making by revamping their frozen and shelf-stable food aisles, highlighting regional fresh produce as seasonal and promoting domestic foods that are shelf-stable and frozen as "preserving the harvest" at peak taste and ripeness. With a little culinary creativity these foods can be prepared as well if not better than their fresh counterparts. This change in perception and preference could contribute to maximizing what is produced and has the added benefit of building profitability and food system resiliency.

3. **Establishing a New Buyer/Seller Landscape** Potato processors have a relatively efficient value chain, due to potato's unique characteristics, contract mechanisms in place between buyers and growers, and American consumption preferences. If full utilization is to become a priority and a shared value across the supply chain, this model must be expanded to other specialty crops. Buyers and sellers must collaborate to create efficient contracting systems where both parties take responsibility to see that food is recovered to the highest utilization levels possible. The goal would be to establish loss levels that are tolerable from an environmental outcome and take into consideration the economic cost of expanded recovery (labor, transportation, etc.). With continued measurement and transparency of product utilization at farm-level and active engagement from buyers, both short and long-term contracts have the potential to benefit buyers and growers. When buyers take interest in seeing that whole farms and/or fields are utilized, it could potentially lead to improved forecasting and planning between growers and buyers and increase crop harvest, especially if this new collaboration is linked to consumer awareness campaigns. Initiatives like Kroger's Zero Hunger | Zero Waste[33] plan and Walmart's Project Gigaton[34] can help provide a framework for this work on-farm and can lead to constructive deal-making with institutional buyers. This framework is not to be confused with a call for vertical integration. In addition, there must be mutual incentives established for farmers and buyers. The ideal crops for this solution will be crops that have ready outlets and markets for different produce grades. For example, potatoes and other root vegetables can cascade from the fresh market that takes the top two grades, to a processed market that accepts more imperfections, finally to a dehydrated or animal feed market.

This synthesis is the first in a series of WWF-authored reports that will collect and report data across a variety of specialty and commodity crop losses; highlight pathways to a future where as much as possible of what is grown is utilized; and report on results from pilot efforts in the field and suggested in the analysis included in this report. Through this report, and over the course of this series, we call upon stakeholders across the supply chain to re-assess their practices and partner with farmers in their network to maximize efficiency in their supply chain. In a resource-limited world where population, global wealth - and also inequality - are on the rise, food production and consumption will be our most pressing challenge. Production systems are faced with changing growing cycles, weather, temperature, water scarcity, and degrading 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.

33 Read more about Kroger's Zero Hunger | Zero Waste goals here
34 Read more about Walmart's Project Gigaton here