

# Differentiated Cost of Production in the Northwest:

*An Analysis of Six Food Categories*

**STORAGE CROPS** / June 2016



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## Project Background

Consumers have demonstrated a willingness to pay a premium for food attributes such as “freerange,” “antibiotic-free,” “organic,” and “local.” However, when production systems designed to yield those attributes are authentically implemented on the ground, such methods also tend to bear higher production and processing costs in comparison to conventional production methods. As a result, higher retail prices do not always ensure a sufficient income to the producer, nor constitute a viable supply chain.

Further, institutions such as schools, hospitals, colleges, and jails are noticeably slower as a buyer segment (versus restaurants, retailers, and manufacturers) to respond to customer interest in differentiated products for a variety of reasons, including high price sensitivity. Such buyers are vital players in the quest to get fresh, nutrient-dense food to vulnerable populations, however, so creating frameworks that allow them to access minimally processed, regionally produced food at reasonable prices would serve farmer and eater alike.

Understanding the costs of differentiated production systems in comparison to conventional approaches is vital to identifying opportunities where efficiencies may be gleaned or market value harvested to support a viable regional food ecosystem.

Ecotrust is conducting cost of production analysis in six distinct food product categories, including this one on storage crops. In each category we define an “ag of the middle” scale and a “differentiated production system” for analysis purposes, meaning: a specific alternative production system (one that spawns product attributes about which consumers care, such as organic, pastured, or grassfed) will be defined at a particular scale of operation (big enough to participate meaningfully in an institutional supply chain), and be assessed relative to the conventional/commodity/industrial model of production for that category.

While there are certainly many variations of both production systems and scales of operation possible in a thriving regional food system, singling out a specific system allows us to create an economic model that facilitates sensitivity analyses and high level conclusions regarding which regional food sectors could make efficient and effective use of investment.

Note, this project builds on the foundation laid by the Oregon Food Infrastructure Gap Analysis report, released in May 2015. The full report and executive summary can be accessed here: <http://www.ecotrust.org/publication/regional-food-infrastructure/>, or a quick digital summary of highlights is available at <http://food-hub.org/intrepid>. The storage crops chapter from that report is included with this model/report as an addendum.

## Executive Summary / Introduction

Storage crops represent some of the Pacific Northwest's most economically important commodities: in Washington State alone, the potato industry accounts for \$4.6 billion in state income, as well as providing 23,500 jobs (Pihl 2012). From a global perspective, the U.S. also profits from storage crop exports, particularly with regard to processed products. In 2009, for example, the U.S. exported approximately 3 billion pounds of frozen French fries (fresh weight estimate) valued at \$635 million (Vegetables & Pulses: Potatoes 2016).



**Potatoes harvested on a farm in eastern Oregon.** Photo: Lynn Ketchum, Oregon State University

This narrative focuses on the three most economically important storage crops in the Pacific Northwest: potatoes, onions, and carrots. We focus on organic production of these three crops as the major alternative to conventional, industrial storage crop production.

Major findings from this study are as follows:

1. Production of organic potatoes and carrots is growing in the Northwest; production of organic onions is stagnant or declining.
2. Organic price premiums can be volatile, and tend to be higher for potatoes and carrots than for onions.
3. The regional consumer market for organic storage crops in the Pacific Northwest is still fairly small (as of 2012) due to low market penetration, but it may be growing.
4. As in most other crop categories, production of storage crops at the scale associated with "Agriculture of the Middle" is declining.
5. Crop rotation is an important aspect of both conventional and organic storage crop production; while the markets for some rotation crops are growing (e.g. silage corn), for other such crops the markets are declining (e.g. alfalfa, sugarbeets).
6. Demand for storage crops for frozen and processed foods (e.g. onion rings, French fries) is growing as a whole, and for organic crops specifically.
7. Locally grown storage crops are insufficiently branded.

## Overview: Comparing Industrial and Organic Storage Crops

### Industrial Storage Crop Production: Overview

Storage crops, of which the three most economically important in the Pacific Northwest are potatoes, carrots, and onions, are predominantly grown through chemically intensive production systems that we call “industrial storage crop production”. Industrial storage crop production operations are typically large in scale, highly mechanized, and grown with significant amounts of chemical fertilizers and pesticides. Crops grown using these methods are characterized by high volume production and uniform quality.

Storage crops are highly susceptible to pests and diseases, require crop rotation, and demand a fine balance between irrigation and well-drained soils. To mitigate these threats, industrial storage crop farmers rely heavily on the use of pesticides, herbicides, and fungicides to protect the quality and marketability of their products: in Washington State in 2005, over 19 million pounds of chemicals were applied to the state’s potato crops (Doughton 2010). While applied chemicals do succeed in managing pests and disease, they can also result in what’s known as the “pesticide treadmill” effect: where growers must apply increasingly greater amounts of chemicals as pests develop resistance, ultimately creating a harmful cycle that is costly and further degrades ecological health (Doughton 2010).

Industrial storage crop production also requires expensive mechanized infrastructure to reduce labor costs, streamline processing, and maintain quality control. To fulfill year-round demand, industrial growers must develop methods of preserving the quality of the crops (post-harvest) to prevent spoilage, often in the form of refrigerated, low humidity warehouses. Conventional farmers may also invest in packing technology, such as automatic “palletizing” machines that wrap pallets of bagged onions together to increase resilience during transport, especially overseas (Onion Warehouses 2016). The large infrastructure required for industrial farming operations has led to environmental pollution, particularly in the form of greenhouse gas emissions. In a 2014 report, the Washington State Department of Ecology released a list of top greenhouse gas emitters that included every commercial potato processing plant in the state (Department of Ecology 2014). The combination of heavy infrastructure, chemically-dependent monocrops, and economic (and ecological) pressure to produce high yields year-round has resulted in a powerful, yet destructive industrial storage crop production system.

Located principally in eastern Washington, the Columbia Basin serves as the agricultural hub for commercially produced storage crops in the U.S., especially potatoes. These crops were not always grown here, however: Maine, New York, and Pennsylvania were formerly the country’s major potato-producing states. As settlement expanded west in the late 19th century, Idaho, Washington, and Colorado took



the lead in national potato production (Vegetables & Pulses: Potatoes 2016). Fueled by the development of refrigerated rail transport and better irrigation systems, as well as the rise of chemical fertilizers and pesticides, western states quickly rose as the major producers of storage crops (Vegetables & Pulses: Potatoes 2016). In addition to these factors, agricultural productivity in the west was largely a credit to the nutrient-rich volcanic soils discovered in the Columbia Basin, which provided optimal conditions for storage crop as well as small grain production (Vegetables & Pulses: Potatoes 2016).

Today, the Columbia Basin hosts some of the largest food companies in the country (and the world), including ConAgra and the J.R. Simplot Company. ConAgra, which supplies to over 100 countries, has a particularly strong presence in the region: the highest concentration of ConAgra plants (7 out of 20 worldwide) is located in eastern Washington (Pihl 2012). Given the dominance of the Columbia Basin for potato production, it is not surprising that Washington State is one of the top storage crop producers in the country: providing 21% of U.S. potatoes (Pihl 2012), 33% of “processing” carrots (as opposed to fresh-market carrots) (Sorenson 2000), and ranked third in U.S. onion production (Pelter and Sorenson 2008).

### Organic Storage Crop Production: Overview

#### i. Comparison to Industrial Production

Organic storage crop farming differs sharply from industrial farming in its elimination of most pesticides and chemical fertilizers, and use of natural methods of pest control that include long crop rotations, cover cropping, crop residue management, and careful selection of field locations to minimize pest pressures. In general, organic farming has traditionally been a smaller-scale, more locally-focused subset of U.S. agriculture production. For example, less than 1% of Washington’s potatoes were organically-grown in 2010 (Doughton 2010). By raising crops without the use of synthetic fertilizers or chemicals to prevent pests, organic farmers typically experience more variability in yields and crop uniformity year to year, which can prevent them from meeting large-scale demand. In general, organic storage crops reap lower yields on average than their industrial counterparts.



Organically-raised potatoes at Local Roots Farm, a 10-acre family-run vegetable farm in Washington’s Skagit Valley. In the past, Local Roots has grown six types of potatoes, including purple, red, gold, and fingerling varieties. Photo: Jason Salvo

Organic storage crop production has some advantages over its industrial counterpart. Based on a 2010 study by Washington State University (WSU), organic farming methods can lead to larger sized potato plants than those produced using industrial methods. Based on the outcome in 42 potato plots, the study found that natural predators, such as insects and fungi, helped keep pests like the Colorado potato beetle under better control than pesticides (Doughton 2010). Overall, the WSU study found that potato plots with “the most balanced mix of insects, typical of organic fields, performed best” (Doughton 2010), with overall pest numbers decreasing by 20%, and potato plant size increasing by 30% (in general, potato plant size correlates with potato size and yield) (Doughton 2010). According to entomologist David Crowder, who led the study: “Though it’s not clear how the results would scale up, the study does suggest that farmers who reduce pesticide use might be able to rely on a mix of natural predators to take up the slack in controlling pests” (Doughton 2010). Finally, the study notes that natural pest control is cheaper than chemicals, in addition to inflicting less harm on human and ecological health (Doughton 2010).

#### ii. The Geography of Organic Production in Washington State

The geography of organic production in Washington State mirrors the geography of agriculture for the state as a whole: the Cascade Mountains essentially act as a dividing line between large and small-scale farming operations. Farms in the Columbia Basin (on the east side of the Cascades) tend to use industrial methods, have larger acreage, produce a higher volume of crops (specifically varieties used in processed products), require more infrastructure (including irrigation), and sell through larger market channels. The Eastside farms that are organic tend to be larger, and cultivate fewer crops for the commercial market, than do the Westside farms. By comparison, farms on the west side of the Cascades are typically organic, smaller in acreage, produce a lower volume, yet more diversified array of crops, require less infrastructure, and sell through either smaller market channels, or direct-to-consumer.

#### iii. The Rise of Big Organic

Early organic producers, during the infancy of the movement, tended to be smaller-scale and focused towards local and regional markets using relatively little infrastructure. However, as the market has grown and the USDA has developed a set of uniform organic standards for the nation, larger producers have captured an increasing share of organic markets. The rise of “Big Organic” has led to the acquisition of organic-oriented companies by major corporations. For instance, ConAgra, one of the largest producers in the Columbia Basin, has been making moves to increase its portfolio of organic frozen food producers, specifically through acquisitions of New York-based Alexia Foods in 2007 and New Hampshire-based Blake’s All-Natural Foods in 2015. According to Nasdaq.com, “by offering the newly acquired firm’s organic products, ConAgra would be able to cater to the demand for organic and natural frozen food products among the American consumers” (NASDAQ 2015). Additionally, “the Blake’s buyout would strengthen ConAgra’s frozen



foods business enabling it to tap the growing demand for natural and organic food products and boost revenues” (NASDAQ 2015).

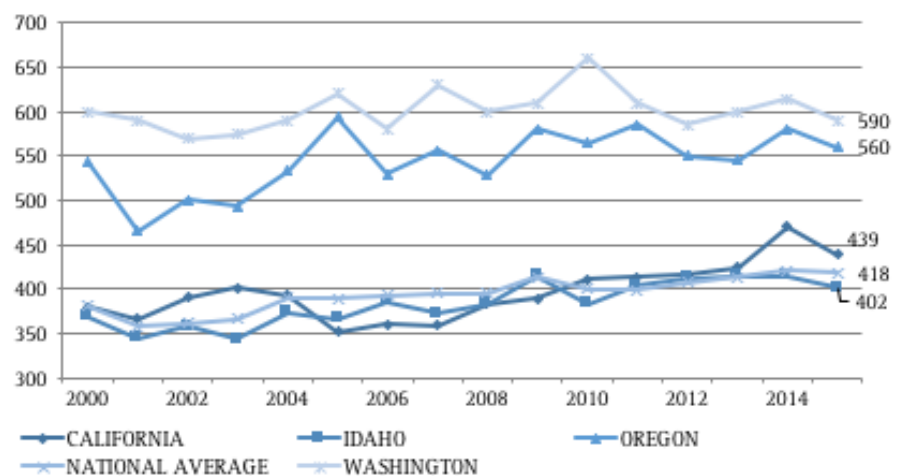
The rise of Big Organic has affected the market for carrots as well: over 14% of U.S. carrots are certified organic, making it the highest ranked vegetable in terms of percentage grown organically. Large-scale organic carrot producers are on the rise, particularly in California. Grimmway Farms acquired Cal-Organic in 2001, making it the largest organic grower in the U.S. with 26,000 acres dedicated to organic production (Eddy 2012).

The next three subsections provide a brief data profile of the top three storage crops in the Pacific Northwest: potatoes, onions, and carrots. For each crop, we present data on yields, total production and acreage, organic sales and acreage, conventional and organic market average prices, and conventional and organic average revenue per acre.

## Potatoes

### i. Yields

Idaho is the number one potato producing state in the nation, at 28% of total U.S. production. But Washington, second at 21% of the national total, has the world’s highest potato yields.<sup>1</sup> Figure 1 below provides data on market average potato yields by state between 2000 and 2015, for four states (California, Idaho, Oregon, and Washington), and the nation as a whole, measured in hundredweight per acre (cwt/ac). As of 2015, Washington potato yields are the highest in the nation with 590 cwt/ac, followed by Oregon with 560 cwt/ac. California yields slightly exceed the national average (439 vs. 418 cwt/ac), while Idaho yields are slightly below it (402 cwt/ac).



**Figure 1.** Potato Yields by State (cwt/ac), 2000–2015

<sup>1</sup> As of 2012, Washington State potato yields were almost double the national average (615 vs. 397 hundredweight per acre), with some farms yielding as much as 1,000 sacks per acre (Pihl 2012).

Figure 2 below compares market average organic potato yields with market average yields for the potato industry as a whole, in Washington State between 2009 and 2012, with data from a recent study at WSU (Granatstein, Kirby and Brady 2015). The authors find that on average, organic potato yields in Washington State tend to range between 400-450 cwt/ac, while total market average yields range between 550 and 650 cwt/ac. Organic potato yields thus tend to range about 30-40% lower than market average yields.

**Figure 2.** Potatoes: Total and Organic Market Average Yields, WA, 2009-2012

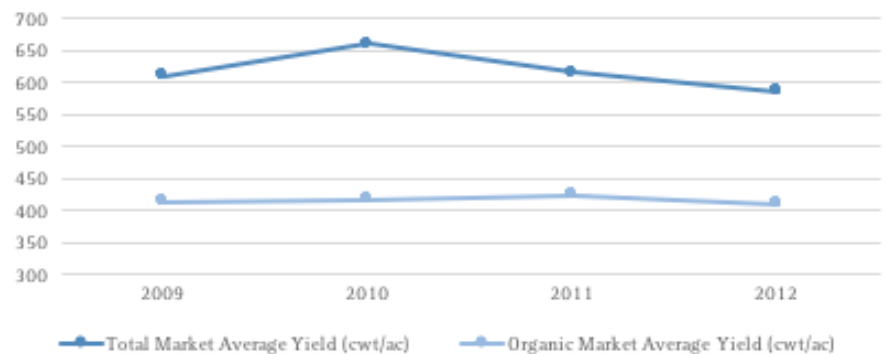


Figure 3 below shows production by value and acres harvested for potatoes in the Pacific Northwest (Oregon and Washington). While the number of acres of potatoes harvested has been fairly stable, the value of production has increased over time, stemming primarily from price increases. In 2014, Oregon and Washington produced a potato crop worth \$949.5 million.

**Figure 3.** Potatoes: Total Production and Acreage, U.S. Pacific Northwest (Oregon and Washington), 2000-2014

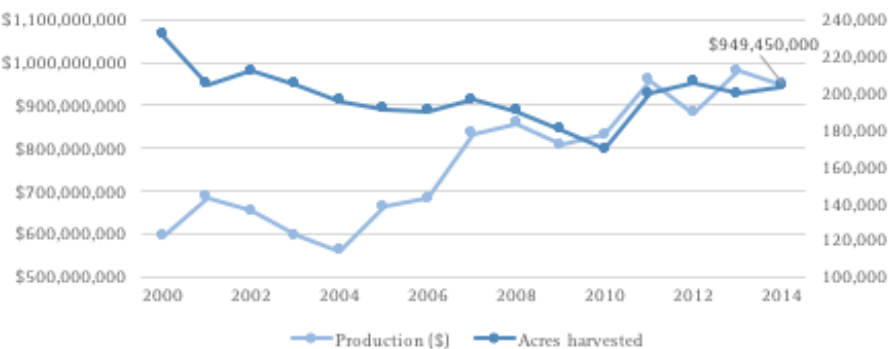
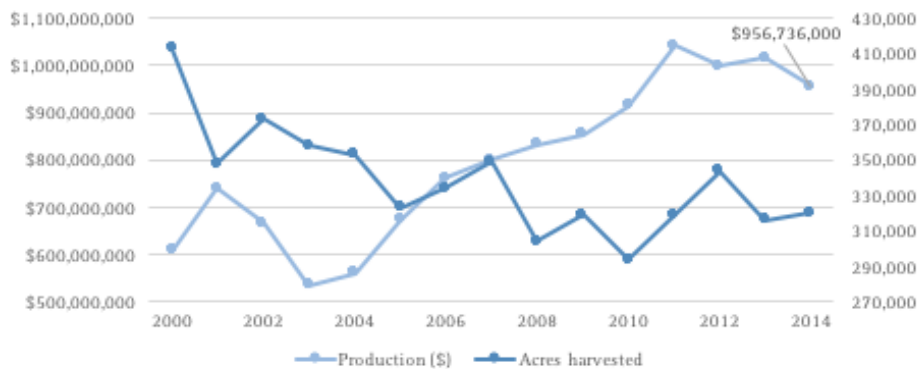
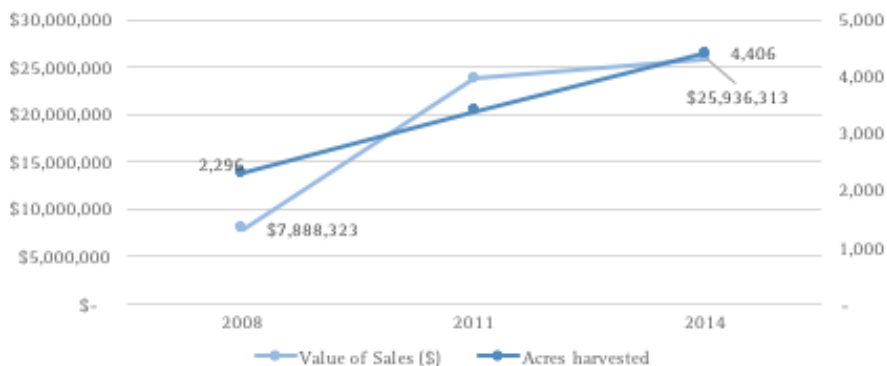


Figure 4 shows the corresponding figures for Idaho, which reveal a similar pattern: value of production has increased as acreage has declined. This trend is driven primarily by price increase, as yields have remained relatively constant over time. Idaho's potato crop in 2014 was worth \$956.7 million.



**Figure 4.** Potatoes: Total Production and Acreage, Idaho, 2000-2014

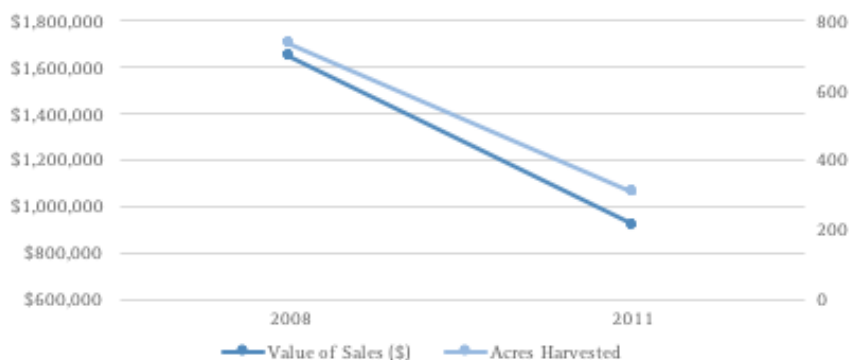
Figure 5 shows the value of sales and acres harvested for organic potatoes in the U.S. Pacific Northwest (Oregon and Washington), between the years of 2008 and 2014, the only years for which data is available. We see that both acres harvested and the value of sales have increased; however, the value of organic sales has increased more dramatically than acreage. As acres have approximately doubled (2,296 in 2008 to 4,406 in 2014), value of sales has increased over threefold (\$7.9 million in 2008 to \$25.9 million in 2014), as organic market prices have increased over time (see Figure 7 below).



**Figure 5.** Organic Potatoes: Value of Sales and Acreage, Oregon and Washington, 2008-2014

Figure 6 below presents the corresponding data for Idaho for comparison purposes, for the years 2008 and 2011 only (data from 2014 are not available). These data, limited as they are, reveal a downward trend in the Idaho organic potato market: acreage declined from 733 acres in 2008 to 305 acres in 2011. Whether this trend has continued into more recent years requires further research.

**Figure 6.** Organic Potatoes: Value of Sales and Acreage Harvested, Idaho, 2008-2011



### iii. Market Prices

Figure 7 below shows annual average market prices for potatoes between 2000 and 2015 in Oregon, Washington, Idaho, and the national average. All three Pacific Northwest states' (including Idaho) average potato prices lie below the national average; prices in all states and the nation as a whole have increased dramatically over the period 2000-2014. The proportional increase in average potato prices in the Northwest has increased faster than the CPI for food (urban consumers, American West) over this period: while the CPI for food has increased by 47% over this period, average potato prices have increased between 69% and 78% across the Northwest states, and 72% for the nation as a whole.

**Figure 7.** Potatoes: Annual Average Market Prices, \$/cwt, 2000-2015

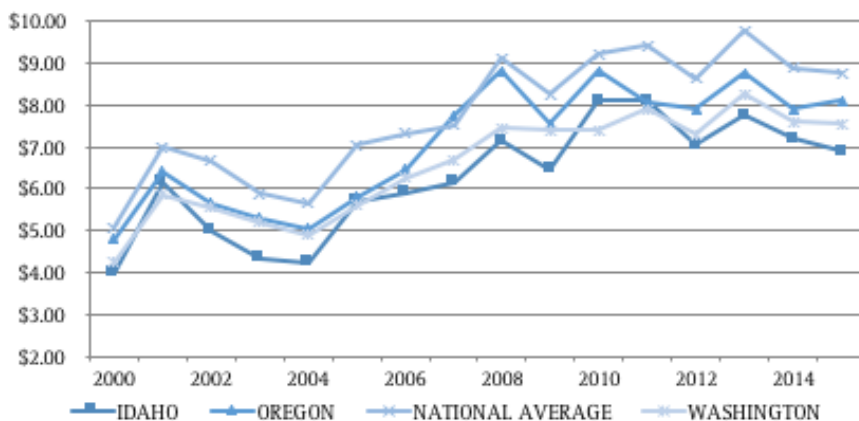
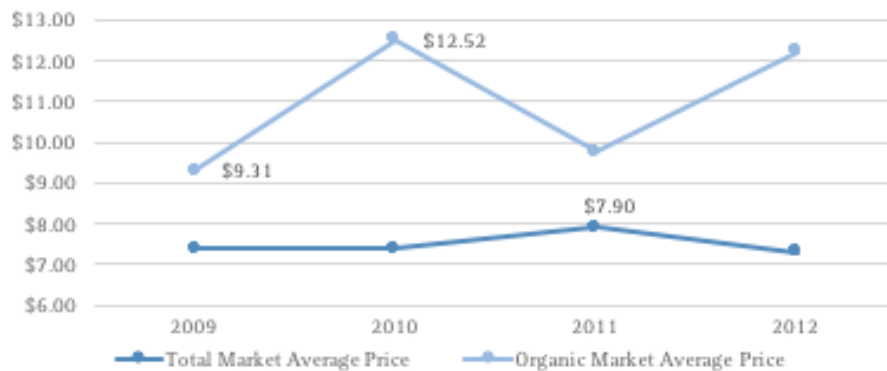


Figure 8 demonstrates the magnitude of organic price premiums for potatoes in the state of Washington, for which we have the highest-quality state-level data on organic production and prices (Granatstein, Kirby and Brady 2015). Between the years of 2009-2012, the market average price for organic potatoes fluctuated between \$9.31 and \$12.52 per hundredweight (cwt), while the corresponding average for the market as a whole never exceeded \$7.90/cwt. Organic price premiums ranged between \$1.87 (24%) in 2011 and \$5.12 (69%) in 2010.

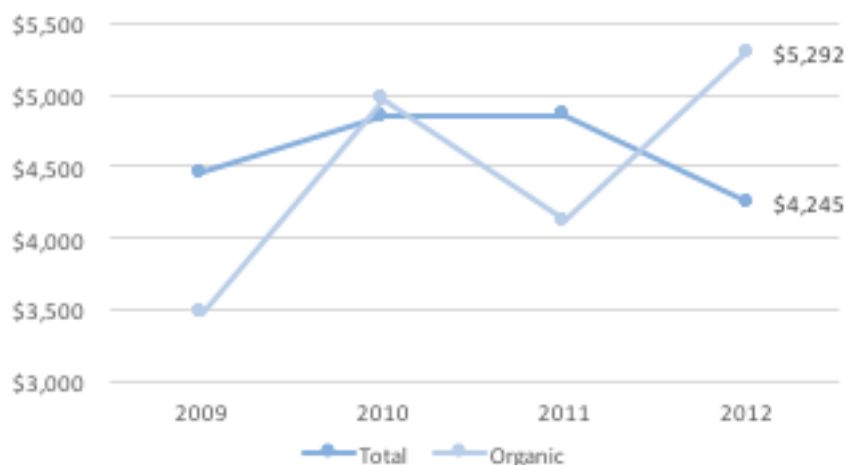
**Figure 8.** Potatoes: Total and Organic Market Average Prices, Washington, 2009-2012



#### iv. Revenue Per Acre

Due to price premium fluctuations, market average revenue per acre for organic potatoes sometimes exceeds the total market average, and sometimes falls beneath it. For example, Figure 9 below shows market average revenue/acre for organic potatoes alongside total market averages, between 2009 and 2012 (Granatstein, Kirby and Brady 2015). For two out of the four years studied, average organic potato revenue per acre exceeded the total market average. In 2012, organic revenue per acre was 25% higher than the total market average (\$5,292 vs. \$4,245).

**Figure 9.** Potatoes, Market Revenue/Acre, Organic vs. Total, 2009-2012, WA



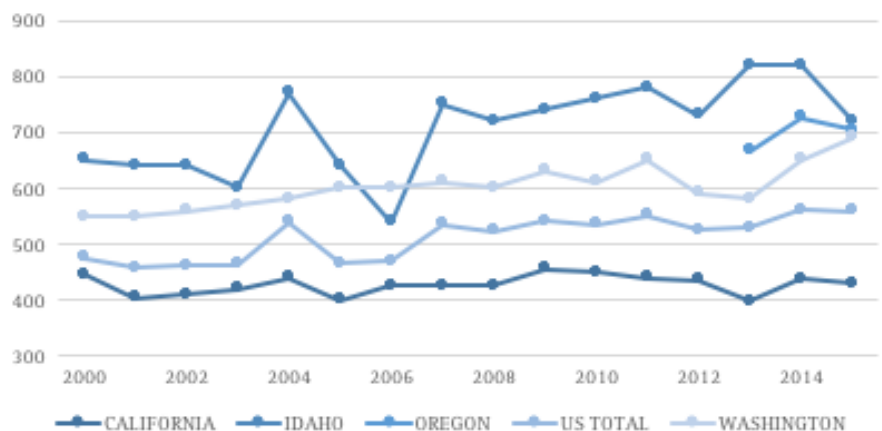
## Onions

According to the National Onion Association (NOA), Washington ranks first in national onion production, with most onions grown in the eastern part of the state in the Columbia Basin. Historically, Washington's onion industry began in Walla Walla in the 1800s, and has "expanded steadily since the early 1950s" in part due to the development of the Columbia Basin Irrigation Project (Pelter and Sorenson 2008). Onions are generally recognized as a difficult crop to grow, but also a high-value crop (Pelter and Sorenson 2008). Walla Walla onions, in particular, may be mono-cropped due to their high value as a specialty onion and grown on smaller acreages (Foundation n.d.).

The majority of the onions grown in the Pacific Northwest are dry summer onions of the storage type; dry, non-storage onions are a smaller, but significant type as well. Non-storage onions are those onions harvested in the spring and summer that tend to be sweeter than average onions, do not keep well, and are often eaten raw. Walla Walla and Vidalia are the two most well-known non-storage onion varieties. The figures for the Pacific Northwest that follow take their data exclusively from Washington; Oregon data series on summer onion acreage do not begin until 2013 and thus are not included here.

### i. Yields

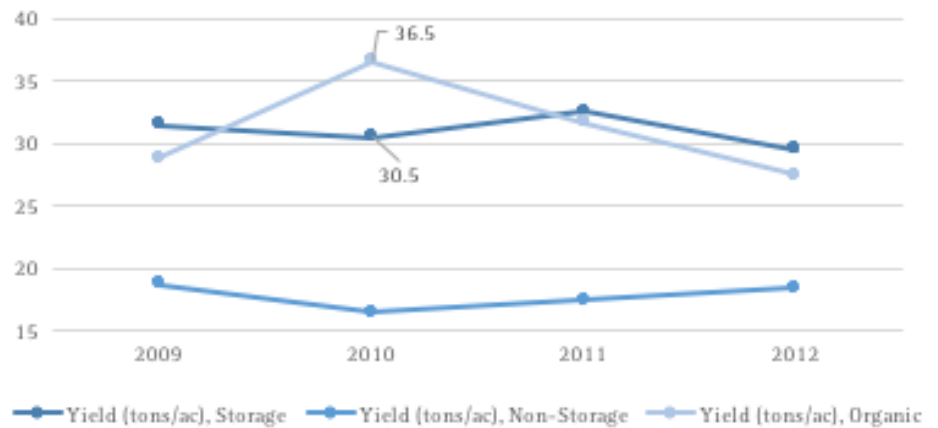
Figure 10 below displays yield data by state and national average for the top producers of dry summer storage onions. Idaho's yields are significantly above the national average, while California's are significantly below it. Washington's yields are between the national average and Idaho's. Data on Oregon yields is very limited, beginning in 2013; Oregon yields are between Washington's and Idaho's.



**Figure 10.** Dry Summer Storage Onions, Yields by State (cwt/ac), 2000-2015



Figure 11 below provides total market average and organic market average yield data for onions, measured in tons per acre, in Washington State between 2009 and 2012 (Granatstein, Kirby and Brady 2015). While total market average yields range between 29.5 and 32.5 tons/acre, organic yields were more volatile, ranging from 27.5 to 36.5 tons/acre. In 2010, market average yields for organic onions exceeded the total market average by about 20% (36.5 vs. 30.5). However, market average yields for organic onions were below total market average yields for three out of the four years studied.



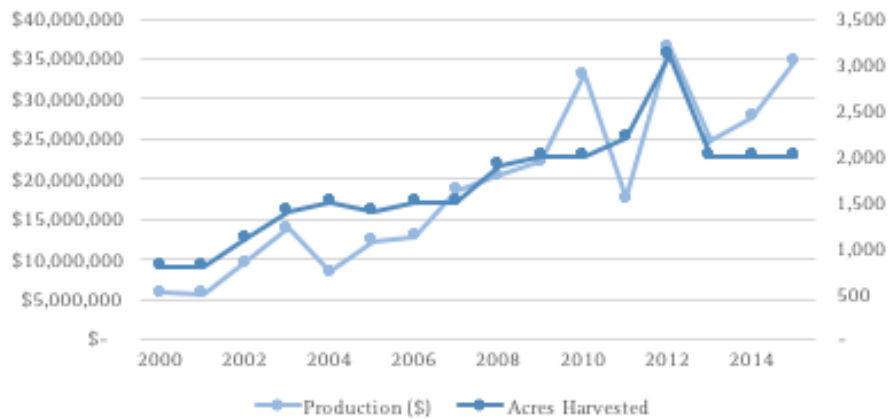
**Figure 11.** Onions: Total and Organic Market Average Yields, WA, 2009-2012

Figure 12 and Figure 13 below display data on production by value and acres harvested for dry summer storage and non-storage onions for the State of Washington between the years 2000 and 2015. The data reveal an upward trend in both acreage and value of production. In 2015, the State of Washington produced a storage onion crop worth \$177.7 million.



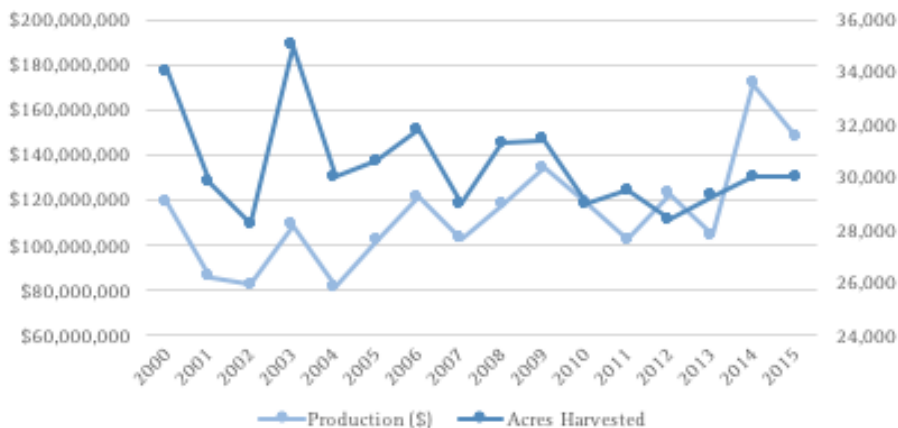
**Figure 12.** Dry Summer Storage Onions: Production (\$) and Acres Harvested, WA, 2000-2015

**Figure 13.** Dry Summer Non-Storage Onions: Production (\$) and Acres Harvested, WA, 2000-2015



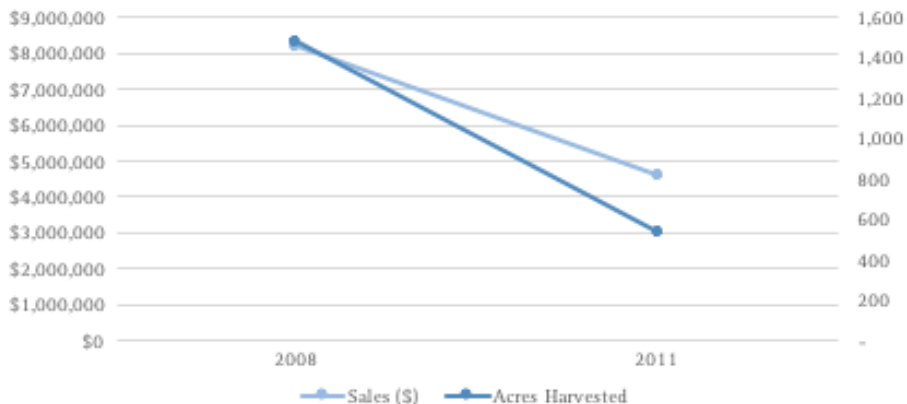
By way of comparison, Figure 14 below provides the corresponding acreage and production value figures for dry summer storage onions for California. Although California harvests about 150% (1.5 times) the number of acres of dry summer storage onions as Washington, the value of its summer storage onion production fluctuates within a dollar range comparable to that of Washington – due to significantly lower yields.

**Figure 14.** Dry Summer Storage Onions: Production (\$) and Acres Harvested, CA, 2000-2015

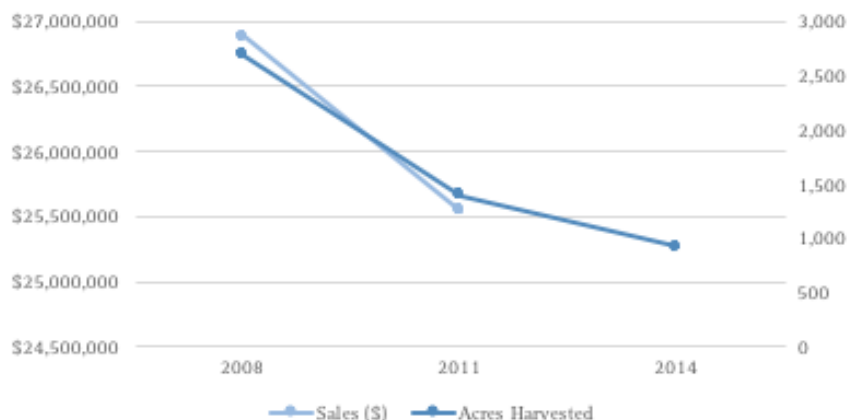


Organic onion markets in the Pacific Northwest appear to be stagnant. Figure 15 below displays acres harvested and value of sales for dry organic onions in Washington between the years 2008 and 2011 (data from 2014 are not even available). The data show a clear decline in both acreage and sales of organic onions.

**Figure 15.** Dry Organic Onions, Acres Harvested and Value of Sales, WA, 2008-2011

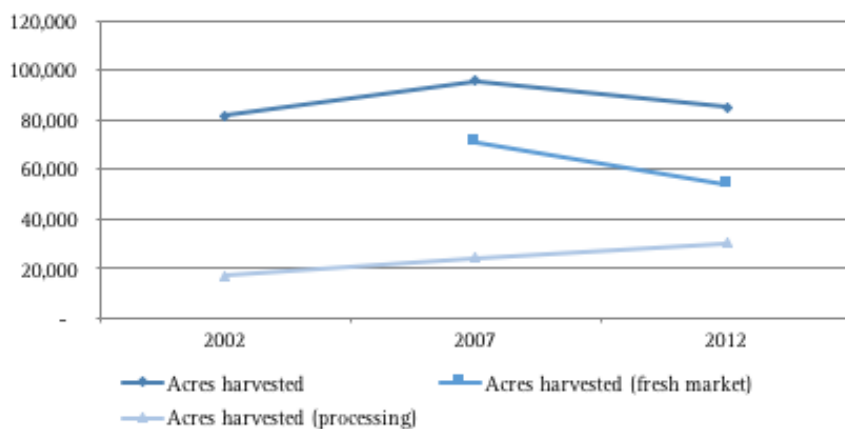


By way of comparison, Figure 16 displays acreage and value of sales data for dry organic onions in California over the same period. The trend is very similar: organic onion acreage and sales are on the decline. (2014 sales data for dry onions are missing for California.)



**Figure 16.** Dry Organic Onions, Acres Harvested and Value of Sales, CA, 2008-2011

Over the course of the 2000s, an increasing proportion of the onion crop in the Pacific Northwest has been grown for processing. Figure 17 below displays data from the USDA Census of Agriculture on the harvested acreage grown for fresh market and processing for all onion varieties in Oregon and Washington between 2002 and 2012. Between 2002 and 2012, the number of acres grown for processing increased by 76%, while between 2007 and 2012, the number grown for fresh market decreased by 23%. (Fresh market data from 2002 are not available.) It is likely that increased demand for processed products (such as frozen onion rings) is responsible for this increase in the proportion of the onion crop grown for processing.



**Figure 17.** Onions (All Varieties): Acres Harvested for Processing, Fresh Market, and Total, Oregon and Washington, 2002-2012

### iii. Market Prices

Onion market prices as a whole show no clear trend, but substantial volatility. Figure 18 below displays annual average market prices for dry summer storage onions for Washington, Idaho, California, and the national average. Dry summer storage onion prices in Washington (as well as Idaho) show substantial volatility, ranging from \$2.90 / cwt in 2004 to \$21.00 / cwt in 2006. California prices, by contrast, are

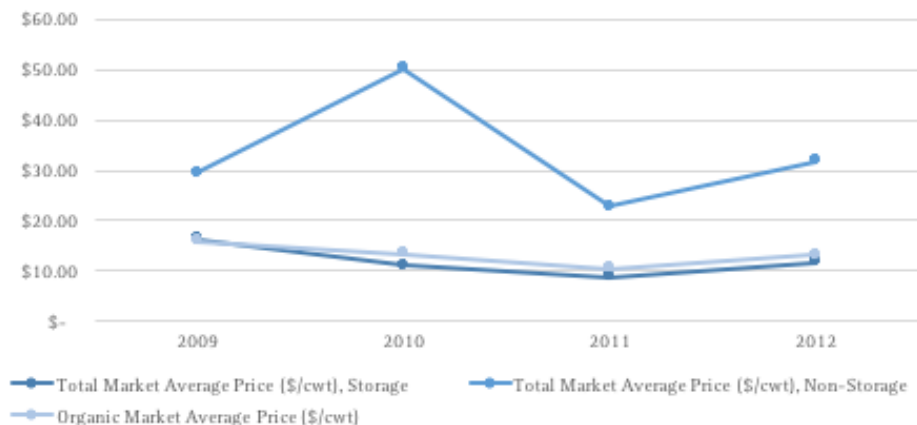
much less volatile, and do not fluctuate from year to year in the same dramatic fashion.

**Figure 18.** Dry Summer Storage Onions, Annual Average Market Prices, \$/cwt, 2000–2015



Organic onion price premiums tend to be small, which may explain the decline in organic onion acreage: premiums may be insufficient to cover increased unit costs of production. Figure 19 below presents data on organic onion prices, as well as onion prices as a whole, for Washington State between 2009 and 2012 (Granatstein, Kirby and Brady 2015). The data show that the average market price of non-storage onions far exceeds that of storage onions and organic onions as a whole. Organic onion prices usually exceed total market averages for storage onions, but not by much: dollar price premiums range from a high of \$2.15/cwt (19%) in 2010 to a low of  $-\$0.40/\text{cwt}$  (-2%) in 2009. The prospect of low to negative organic price premiums may be driving producers from the organic onion market.

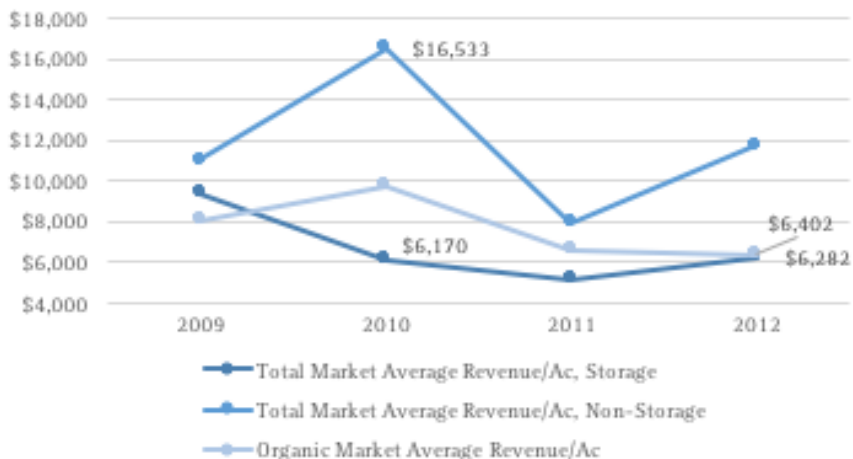
**Figure 19.** Storage and Non-Storage Onions: Total and Organic Market Average Prices, \$/cwt, Washington, 2009–2012



#### iv. Revenue Per Acre

Figure 20 below provides market average revenue per acre data for organic, all storage, and all non-storage onions (Granatstein, Kirby and Brady 2015). In the case of onions, organic market average revenue per acre exceeded the total market average for storage onions three out of the four years studied. The market average revenue for non-storage

onions exceeded both organic and total storage onion market average revenue in all four years: in 2010, non-storage onions' market average revenue per acre was 168% higher than storage onions' per-acre revenue (\$16,533 vs. \$6,170).



**Figure 20.** Onions, Market Average Revenue/Acre, Organic vs. Total, 2009-2012, WA



Organically-raised carrots from Local Roots Farm. Storage crops like these carrots are grown in the Skagit Valley and distributed within a 45 minute drive distance from the farm, including a number of Seattle-based farmer's markets.

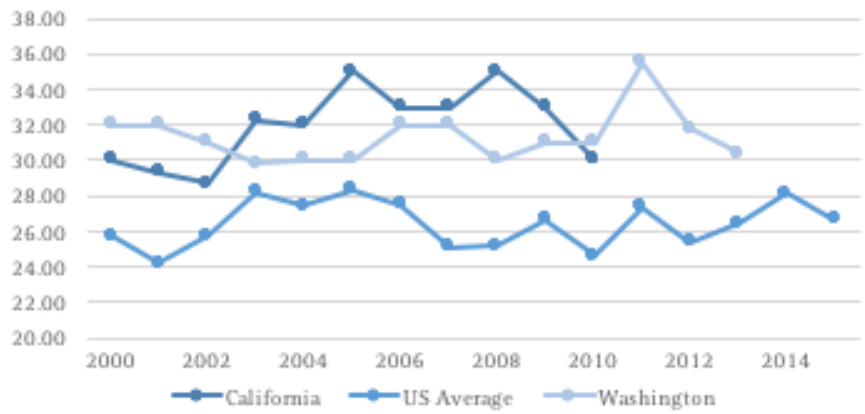
Photo: Jason Salvo

## Carrots

### i. Yields

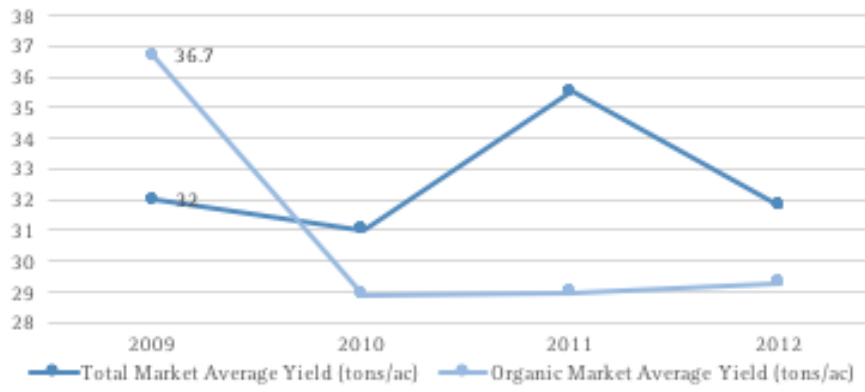
The Pacific Northwest is an important producer of carrots grown for processing, much more so than for the fresh market. Figure 21 below provides yield data on carrots grown for processing in California, Washington, and the national average between 2000 and 2015. (Time series data on fresh market carrot yields is not available for either Pacific Northwest state.) Both California and Washington yields exceeded the national average, with Washington yields overtaking those of California in 2010.

**Figure 21.** Processing Carrots: Yield Per Acre (tons/ ac), 2000-2015



Organic carrot yields tend to be smaller than industrial yields on average, though the actual yield gap depends on numerous factors. Figure 22 shows market average yield data for organic carrots, as well as carrots as a whole (Granatstein, Kirby and Brady 2015). Similarly to onions, organic yields are lower than conventional yields for three out of the four years studied; however, in 2009, organic carrot yields exceeded total market averages by 18% (36.7 vs. 32).

**Figure 22.** Carrots: Total and Organic Market Average Yields, WA, 2009-2012





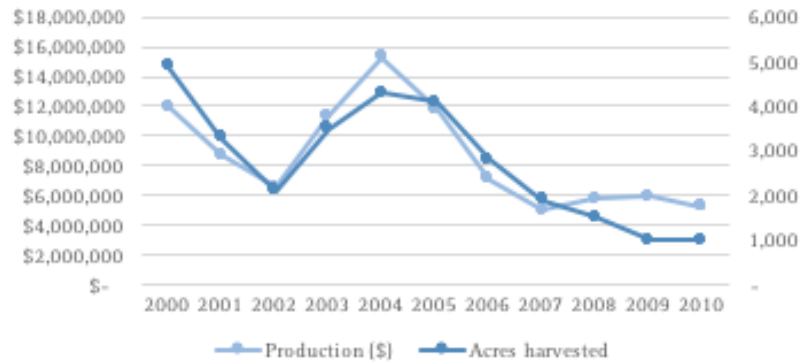
## ii. Production and Acreage

Figure 23 and Figure 24 below show acreage and value of production of processing carrots between 2000 and 2013 in the Northwest (Oregon and Washington) and California, respectively. Over the course of the 2000s, processing carrot production in the Northwest has overtaken that of California. However, as shown in Figure 25, fresh market carrot production in California dwarfs processing carrot production in both California and the Northwest.<sup>2</sup>

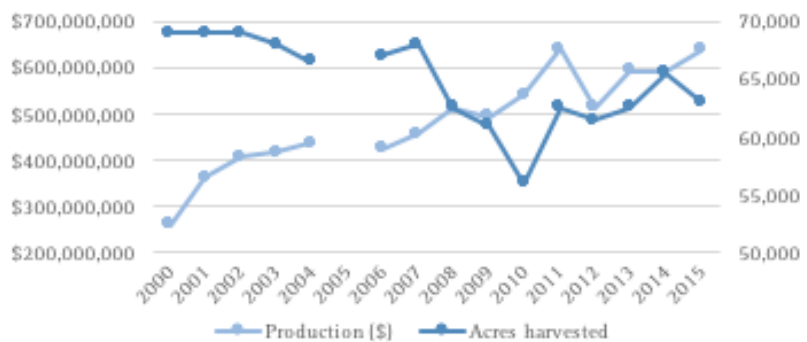
**Figure 23.** Carrots Grown for Processing: Production (\$) and Acreage, Oregon and Washington, 2000-2013



**Figure 24.** Carrots Grown for Processing: Production and Acres Harvested, California, 2000-2010



**Figure 25.** Carrots Grown for Fresh Market: Production (\$) and Acres Harvested, CA, 2000-2015

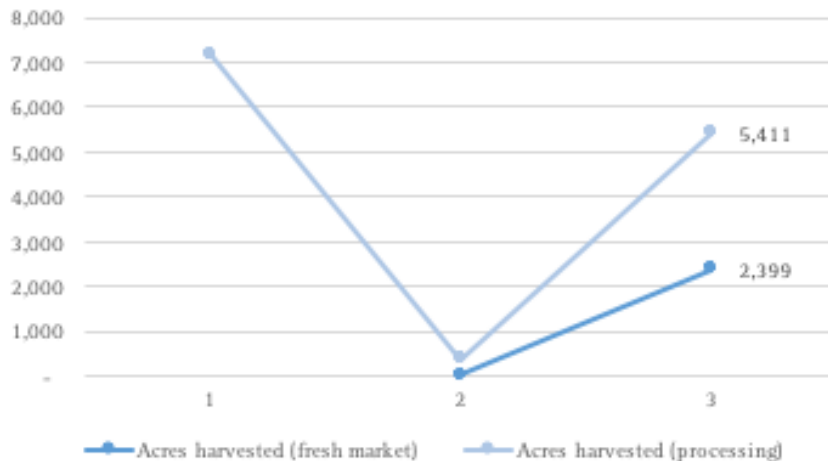


2

There is a gap in the data in Figure 25 due to missing data from 2005.

Figure 26 below compares carrot acreage grown for the fresh market to acreage grown for processing, using data from the Census of Agriculture for Washington State only. (Data on carrot acreage in Oregon was insufficient to be displayed.) Carrot growers in Washington grew almost twice as many acres for processing as for the fresh market (5,411 vs. 2,399).

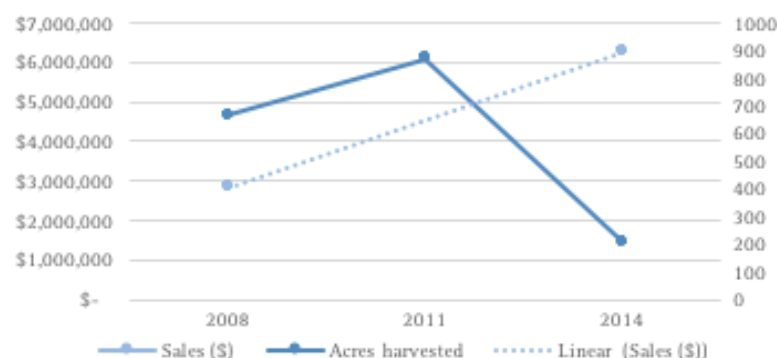
**Figure 26.** Carrots: Fresh Market and Processing Acreage, WA, 2002–2012



### iii. Market Prices

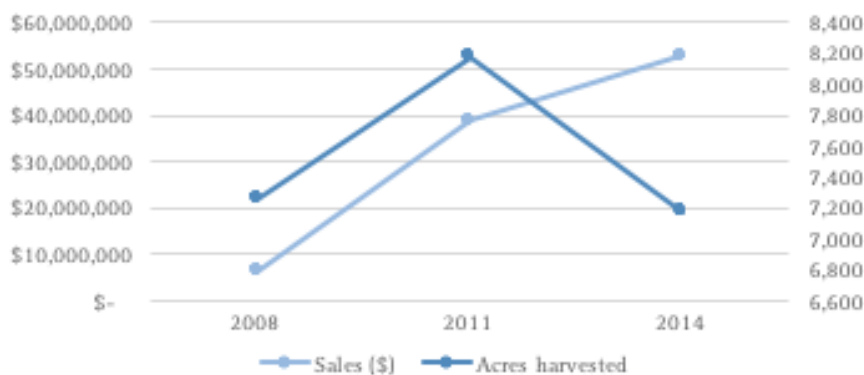
While acreage devoted to organic carrots in the Northwest declined between 2008 and 2014, the value of organic carrot sales has increased due to higher organic prices. This pattern holds true in both the Pacific Northwest and California, as shown in Figure 27 and Figure 28 below. Figure 27. Organic Carrots: Value of Sales and Acres Harvested, Oregon and Washington, 2008–2014<sup>3</sup>

**Figure 27.** Organic Carrots: Value of Sales and Acres Harvested, Oregon and Washington, 2008–2014<sup>3</sup>



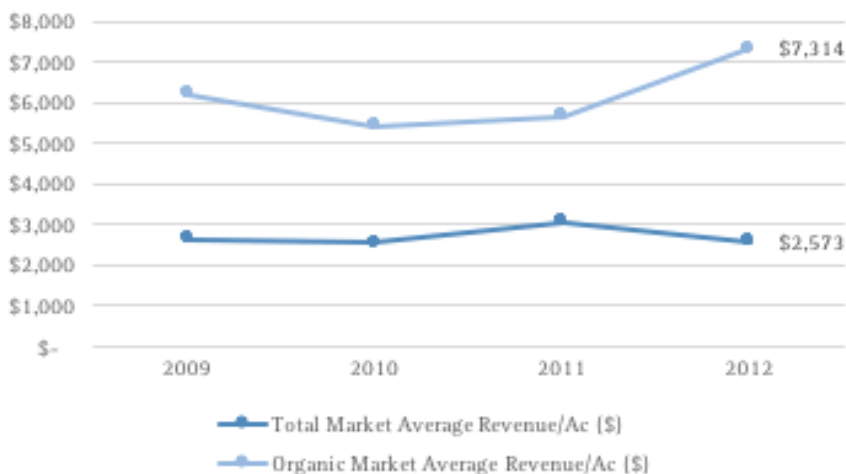
<sup>3</sup> Due to missing data from 2011, Figure 27 displays the linear trend between 2008 and 2014, which simply draws a straight line between the two data points.

**Figure 28.** Organic Carrots: Acres Harvested and Value of Sales, CA, 2008–2014



#### iv. Revenue Per Acre

Comparison of market average revenue per acre between organic carrots and the market as a whole is displayed in Figure 29 below (Granatstein, Kirby and Brady 2015). In this case, the market average revenue per acre for organic carrots dramatically exceeds the total market average revenue per acre in all four years studied. In 2012, organic market average revenue per acre exceeded the corresponding average for the total market by 184% (\$7,314 vs. \$2,573). Though these results cannot be generalized to other years and states, it is clear that between 2009 and 2012, organic carrots in Washington State earned much more in gross sales per acre than did conventional carrots.



**Figure 29.** Carrots, Market Average Revenue/Acre, Organic vs. Total, 2009–2012, WA

#### Regional Consumer Market Size for Organic Storage Crops

In this section, we estimate regional consumer market size at the retail and farmgate levels, for organic varieties of the top three storage crops in the Pacific Northwest: potatoes, onions, and carrots. The results of this exercise demonstrate that the size of the market for organic storage crops in the Northwest is still very small relative to the total market. To increase organic market size, the organic share of local and regional consumption of storage crops must increase as a percentage of the total market for these crops.

## i. Potatoes

The assumptions for our estimation of the size of the consumer market for organic potatoes in the Pacific Northwest are as follows. We follow the Oregon Food Infrastructure Gap Analysis (Ecotrust 2015) in assuming a 63% retail share for potatoes, and assume that the retail share is identical across organic and conventional. We follow the USDA in assuming a 17% farmgate share of the retail price for both organic and conventional potatoes, and draw on USDA data presented above in assuming a 2.7% market penetration for organic potatoes, reflecting regional production by value. We quote the certified organic retail price from New Seasons quoted in the Infrastructure Gap Analysis (Ecotrust 2015), and the regional average conventional retail price from The Packer website, also quoted by the Gap Analysis (Ecotrust 2015). Finally, we use national per capita consumption data from the USDA Economic Research Service for the most recent year from which it is available (2013), to estimate the total market size for consumption of organic and conventional potatoes, given the current size of the populations of Washington and Oregon. Assumptions are listed below in Table 1.

**Table 1.** Potatoes: Regional Organic Consumer Market Size Assumptions

Population (OR) (million)	4.01
Population (WA) (million)	7.06
Retail share of consumption	63%
Farm Share of Final Retail Price	17%
Organic market penetration	2.7%
Organic retail price (\$/lb)	\$1.49
Conventional retail price (\$/lb)	\$0.61

Table 2 presents the results of the analysis based on these assumptions. The total local / regional market size for organic potatoes in the Pacific Northwest at the retail level is \$9.3 million; at the farmgate level it is \$2.6 million. After taking into account the low market penetration and relatively low farmgate and retail prices of potatoes, these markets are not particularly large. By contrast, the total retail and farmgate opportunity for potatoes as a whole in the region is \$141.7 million and \$39.7 million, respectively. In order to become a significant local and regional market, organic potato production in the Pacific Northwest will need to increase market penetration.

**Table 2.** Potatoes: Estimated Regional Organic Consumer Market Size

	Farmgate	Retail
Estimated per capita annual consumption (lbs)	34.6	33.3
Estimated regional annual consumption (million lbs)	383.0	232.2
Estimated regional annual organic consumption (million lbs)	10.3	6.3
Regional Organic Market Size (million USD)	\$2.6	\$9.3
Total Regional Market Size (million USD)	\$39.7	\$141.7

## ii. Onions

The assumptions for our estimation of the size of the consumer market for organic onions in the Pacific Northwest are as follows. We follow the Oregon Food Infrastructure Gap Analysis (Ecotrust 2015) in assuming a 67% retail share for potatoes, and assume that the retail share is identical across organic and conventional varieties. We follow the USDA in assuming a 27% farmgate share of the retail price for both organic and conventional onions<sup>4</sup>, and use USDA data on regional organic and conventional production by value from 2011 to estimate a 7.6% market penetration for organic onions.<sup>5</sup> We quote the certified organic retail price from New Seasons quoted in the Infrastructure Gap Analysis (Ecotrust 2015), and the regional average conventional retail price from The Packer website, as published by the Gap Analysis (Ecotrust 2015). Finally, we use national per capita consumption data from the USDA Economic Research Service for the most recent year from which it is available (2013), to estimate the total market size for consumption of organic and conventional onions, given the current size of the populations of Washington and Oregon. These assumptions are listed below in Table 3.

**Table 3.** Onions: Regional Organic Consumer Market Size Assumptions

Retail share of consumption	67%
Farm Share of Final Retail Price	27%
Organic market penetration	7.6%
Organic retail price (\$/lb)	\$1.49
Conventional retail price (\$/lb)	\$1.02

Table 4 presents the results of the analysis based on these assumptions. The total local / regional market size for organic onions in the Pacific Northwest at the retail level is \$14.7 million; at the farmgate level it is \$6.3 million. The decline in organic onion acreage, apparent in Figure 13 above, suggests that these are upper-bound estimates. By contrast, the total retail and farmgate opportunity for onions as a whole in the region is \$132.4 million and \$56.7 million, respectively.

**Table 4.** Onions: Estimated Regional Organic Consumer Market Size

	Farmgate	Retail
Estimated per capita annual consumption (lbs)	18.6	17.5
Estimated regional annual consumption (million lbs)	205.9	129.8
Estimated regional annual organic consumption (million lbs)	15.6	9.9
Regional Organic Market Size (million USD)	\$6.3	\$14.7
Total Regional Market Size (million USD)	\$56.7	\$132.4

<sup>4</sup> There is no separate estimate of the farmgate share of the retail price for onions; the 27% figure reflects the catch-all category "Fresh Vegetables Basket".

<sup>5</sup> This estimate may be overstated; a recent study in Washington State alone estimated a state organic market share of 2.9% in 2011, and only 1.7% in 2012.

iii. Carrots

The assumptions for our estimation of the size of the consumer market for organic carrots in the Pacific Northwest are as follows. We follow the Oregon Food Infrastructure Gap Analysis (Ecotrust 2015) in assuming a 67% retail share for carrots, and assume that the retail share is identical across organic and conventional varieties. We follow the USDA in assuming a 27% farmgate share of the retail price for both organic and conventional carrots.<sup>6</sup> Since the USDA data presented above is insufficient for estimating market penetration, we use the national average of 14% market penetration for organic carrots. We quote the certified organic retail price from New Seasons quoted in the Infrastructure Gap Analysis (Ecotrust 2015), and the regional average conventional retail price from The Packer website, also quoted by the Gap Analysis (Ecotrust 2015). Finally, we use national per capita consumption data from the USDA Economic Research Service for the most recent year from which it is available (2013), to estimate the total market size for consumption of organic and conventional carrots, given the current size of the populations of Washington and Oregon. These assumptions are listed below in Table 5.

**Table 5.** Carrots: Regional Organic Consumer Market Size Assumptions

Retail share of consumption	67%
Farm Share of Final Retail Price	27%
Organic market penetration	14%
Organic retail price (\$/lb)	\$1.49
Conventional retail price (\$/lb)	\$0.69

Table 6 presents the results of the analysis based on these assumptions. The total local / regional market size for organic carrots in the Pacific Northwest at the retail level is \$14.4 million; at the farmgate level it is \$4.9 million. The total retail and farmgate opportunity for carrots as a whole in the region is \$47.7 million and \$16.1 million, respectively. Proportionately, in relation to conventional markets, the organic carrot market appears to be healthier than either the organic potato or onion markets in the Pacific Northwest.

**Table 6.** Carrots: Estimated Regional Organic Consumer Market Size

	Farmgate	Retail
Estimated per capita annual consumption (lbs)	8.0	7.8
Estimated regional annual consumption (million lbs)	86.3	69.1
Estimated regional annual organic consumption (million lbs)	12.1	9.7
Regional Organic Market Size (million USD)	\$4.9	\$14.4
Total Regional Market Size (million USD)	\$16.1	\$47.7

<sup>6</sup> There is no separate estimate of the farmgate share of the retail price for onions; the 27% figure reflects the catch-all category “Fresh Vegetables Basket”.



## Defining Agriculture of the Middle in Storage Crops

This section defines briefly the scale of acreage necessary that is definable as Agriculture of the Middle. We use the rule of thumb of \$250,000 - \$500,000 in gross sales as a proxy for Agriculture of the Middle (McAdams 2015). Given the wide range in revenue per acre listed in the graphs above, these sales figures translate into a wide range of acreage figures. Table 7 below estimates the acreage ranges necessary to fall into the Agriculture of the Middle category, based on 4-year market average revenue per acre (2009-2012), for the three major storage crops grown in the region: potatoes, onions, and carrots. For potatoes as a whole, the range of acres that falls under Agriculture of the Middle is 54-109 acres, and for organic potatoes, it is 56 - 112 acres. Since the market average revenue per acre is similar across organic and conventional potatoes, the acreage required to reach Agriculture of the Middle is very similar between organic potatoes and for potatoes as a whole. Similar calculations are performed for onions and carrots.

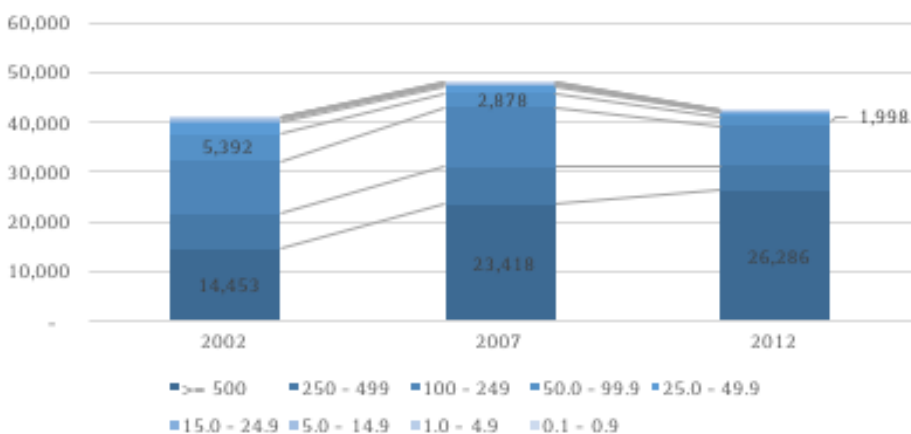
		AOTM Calculation	
		Min # Ac (\$250K)	Max # Ac (\$500K)
Potatoes	\$ 4,601	54	109
Potatoes (Organic)	\$ 4,463	56	112
Onions, Storage	\$ 6,764	37	74
Onions, Non-Storage	\$ 11,836	21	42
Onions (Organic)	\$ 7,713	32	65
Carrots	\$ 2,701	93	185
Carrots (Organic)	\$ 6,150	41	81

**Table 7.** Market Average Revenue/Ac and Agriculture of the Middle Acreage Ranges, Major Storage Crops

Data from USDA suggest that similarly to other crop categories, Agriculture of the Middle may be in decline in the case of storage crops. Over the last decade, the storage crop industry has become increasingly consolidated, reflecting a larger trend within the U.S. food system as a whole (Hauter 2012). In the potato industry alone, the number of farms decreased by 70% between 1974 and 2007 (Vegetables & Pulses: Potatoes 2016). As farming operations have grown in scale, large capital investments in equipment and storage facilities have enabled growers to maximize production (Vegetables & Pulses: Potatoes 2016), ultimately out-competing smaller-scale farms. Conventional growers face a concentrated market situation, with many producers and few buyers, as well as an increasingly narrow margin for profitable production (Dufour, Hinman and Schahczenski 2009). In this way, more and more acreage is required to maintain income (Dufour, Hinman and Schahczenski 2009), thus further encouraging the rise of large-scale agriculture. At the same time, the number of producers at the smallest end of the distribution has also increased somewhat, due to the growing popularity of direct-to-consumer marketing arrangements such as community-supported agriculture (CSA) and farmers' markets.

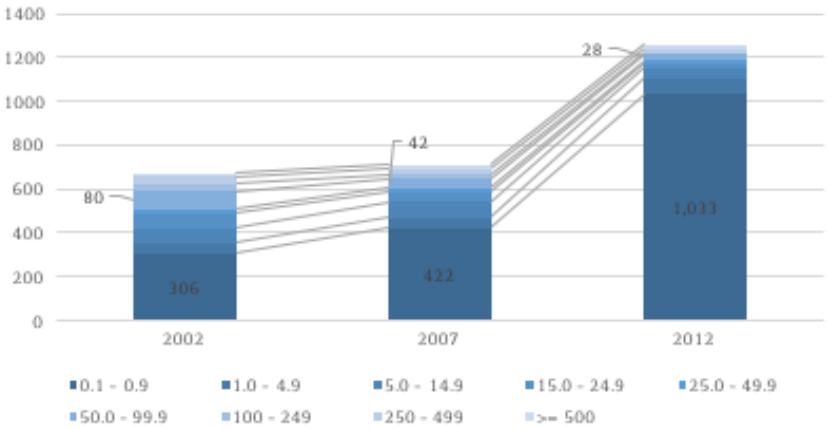
Storage crop acreage in the Pacific Northwest over the last decade appears to be trending towards a bimodal distribution: an increasing number of farms operating at the smallest scale, combined with a concentration of acreage at the largest scale of operation, and a corresponding decline of the middle. Figure 30 through Figure 33 below demonstrates this trend in the case of onions. Figure 30 shows the distribution of onion acreage in Oregon and Washington based on farm size class between 2002 and 2012. Over that decade, the acreage harvested by farms in the largest size class (over 500 acres) increased by 82%, from 14,453 to 26,286 total acres. Meanwhile, the acreage harvested by farms in the most significant size class containing Agriculture of the Middle producers (50 – 99.9 acres) declined by 63%, from 5,392 to 1,998 total acres. At the same time, the total number of small-scale farms in the Pacific Northwest that cultivate onions has increased dramatically. Figure 30 displays the number of farms that cultivate dry onions in the Pacific Northwest by farm size class between 2002 and 2012. Over that decade, the number of farms in the smallest size class (0.1 – 0.9 acres) increased by 237%, from 206 to 1,033 total farms, as the number of farms in the most significant Agriculture of the Middle size class (50 – 99.9 acres) declined by 65%, from 80 to 28 total farms. Figure 32 and Figure 33 demonstrate similar trends in the case of potatoes, which can be summarized as follows:

1. A dramatic increase in the number of farms cultivating at the smallest scale range;
2. A dramatic increase in the acreage being cultivated at the largest scale range;
3. A dramatic decline in both the number of producers and acreage being cultivated at the scale most closely associated with Agriculture of the Middle.

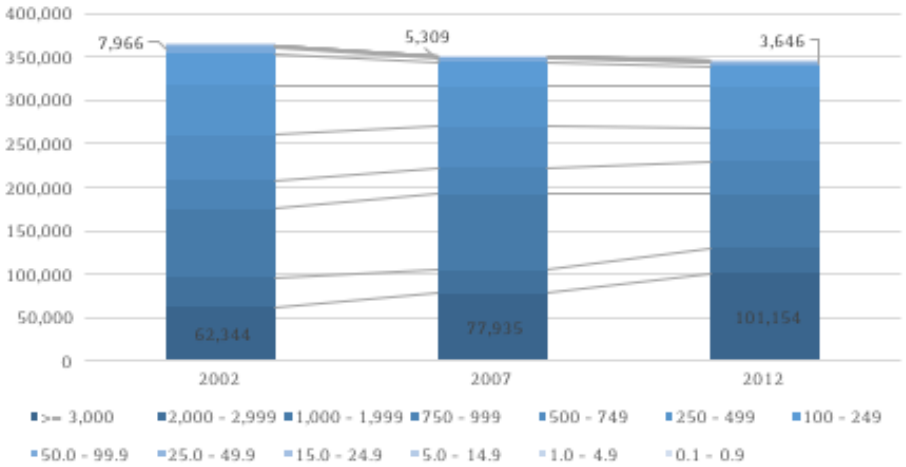


**Figure 30.** Onions: Total Acreage by Farm Size Class, Oregon and Washington, 2002-2012

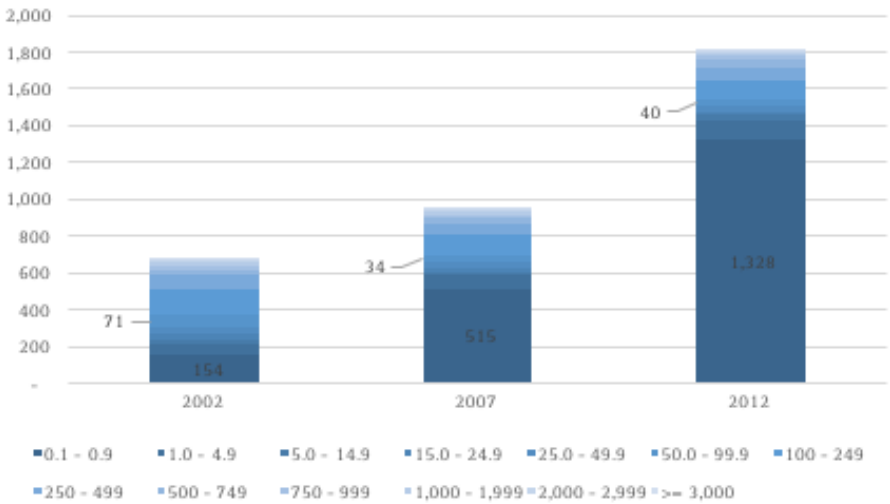
**Figure 31.**  
Onions: Number of Farm Operations  
by Farm Size Class, Oregon and  
Washington, 2002-2012



**Figure 32.**  
Potatoes: Total Acreage by Farm  
Size Class, Oregon and Washington,  
2002-2012



**Figure 33.**  
Potatoes: Number of Farm  
Operations by Size Class, Oregon and  
Washington, 2002-2012



## Drivers of Supply of Organic Storage Crops

### Production Costs

Organic and conventional storage crops differ systematically in their cost breakdowns. This section focuses on the production cost for organic potatoes. We chose potatoes as the product focus because they are the most economically important storage crop in the Pacific Northwest (Oregon and Washington) as well as Idaho.

Existing evidence indicates that organic potatoes are generally competitive with their conventional counterparts on production costs, though there are significant differences in yields across space and time for both production systems. Table 8 below compares an organic and a conventional potato enterprise budget. All cost estimates are given in per-acre units. Organic data are from Painter et al (2009). The original cost data were given in current dollars (2009 USD), which we inflate to 2014 USD using the Producer Price Index (PPI) for Russet potatoes. The purchase price data were also given in constant dollars; we inflate these data to 2014 USD using the Consumer Price Index (CPI) for fresh fruits and vegetables, for all U.S. cities. The budget data on conventional production are from Patterson (2014), and refer to farm budgets for Southcentral Idaho. The budget data reflect a weighted average between fumigated and non-fumigated acres, with calculations performed by Patterson (2014).

These budgets are modified to ensure that the same cost categories are being counted, and land costs are equalized by assumptions. Land costs differed significantly across the original budgets: \$600/ac in the conventional production budget, and \$250/acre from the organic budget. We assume that land costs are equal at \$500/acre. The conventional production budget also included an implied management fee of \$150/acre, which we eliminated to make the two budgets count the same categories. We also eliminated the costs of overhead and sorting from the conventional budget. Hence, the cost estimates in Table 8 are lower than the average costs reported across enterprise budgets, as we demonstrate below in Table 9. The purpose of Table 8 is primarily to provide a sense of the different cost breakdown between conventional and organic potatoes, not to provide definitive data on production costs.

To summarize the results briefly: the production of conventional potatoes involves much greater reliance on chemical inputs, including fertilizers, pesticides, and fumigation, than does the production of organic potatoes. Organic potato production involves greater reliance on seed and irrigation. In this budget comparison, it appears that organic production costs per acre are lower than conventional; however, this is probably an artifact of the different methods of data collection across the two budget studies. We cannot guarantee that organic production costs are below those of conventional production.

	Organic		Conventional	
Cost Category	2014\$	% Cost	2014\$	% Cost
Seed	\$402	19%	\$331	13%
Fertilizers, Pesticides, and Custom/Consultants	\$276	13%	\$796	32%
Irrigation	\$382	18%	\$109	4%
Machinery-Total Costs	\$222	10%	\$404	16%
Labor	\$129	6%	\$171	7%
Other Variable Costs	\$159	8%	\$137	5%
Operating Interest and Land Rent	\$550	26%	\$556	22%
TOTAL COST PER ACRE	\$2,120		\$2,503	
Yield (cwt/ac)	375		420	
Price (\$/cwt)	\$9		\$7	
TOTAL REVENUE	\$3,190		\$3,045	
Net Income	\$1,070		\$542	

**Table 8.** Comparison of Cost Breakdowns, Organic and Conventional Potatoes

Table 9 below shows point estimates for conventional potato production costs and yields compiled by Patterson (2015) from enterprise budget data for Washington and Idaho. All potatoes are Russet Burbank variety and are grown for processing. All data is from studies conducted in 2014.

Operating costs refer to all variable costs including seed, fertilizers, pesticides, irrigation, labor, machinery variable costs including fuel and maintenance, and interest on operating capital. Ownership costs refer to all fixed costs plus land rent, management fees, overhead, and taxes. Total economic cost equals operating costs plus ownership costs. Finally, the table distinguishes between potatoes grown with a fumigation treatment, and those without. The table below reveals fairly significant differences in total economic costs per acre, ranging from a low of \$2,869 in Southeast Idaho to \$4,241 in Washington.

Location	Washington	Idaho – Southwest	Idaho – Southcentral	Idaho– Southeast	Idaho– Southcentral
Treatment	Fumigated	Fumigated	Fumigated	Fumigated	Non-Fumigated
Operating Cost/ac	\$2,964	\$2,457	\$2,192	\$1,951	\$1,817
Ownership Cost/ac	\$1,277	\$1,223	\$1,040	\$918	\$1,030
Total Economic Cost/ac	\$4,241	\$3,680	\$3,232	\$2,869	\$2,847
Yield (cwt/ac)	580	499	437	394	399

**Table 9.** Cost Comparisons of Conventional Potatoes

## Technology / Mechanization

Mechanization of storage crop production has given rise to land consolidation for both organic and conventional production systems. Lack of machinery appropriate to the smaller scale of many diversified organic farms may be a factor in this process. A recent analysis pointed out: “Higher costs and higher price premiums may be due to the lack of appropriate-scale machinery to replace high labor costs associated with small- to medium-scale organic potato production ... It may be that the processing and packing facilities available to organic potato producers are inadequate, forcing organic producers to invest more in packing equipment than conventional growers” (Dufour, Hinman and Schahczenski 2009).

## Crop Rotation

Crop rotation is an important tool to reduce losses from pests, weeds, and fungi in storage crop production. It is arguably the most important step in successful, high-yield production of storage crops, particularly for organic farmers. Of the three most profitable crops (potatoes, carrots, onions), each have distinct rotation times: onions are generally grown in 3-4 year rotations (Adam 2006); carrot rotation should be at least 1 year (Sorenson 2000); and potato rotation can be as high as 4-7 years (Dufour, Hinman and Schahczenski 2009).

Rotation crop choices and rotation times are very specific to individual agricultural plots, soil types, and micro-climatic zones: each zone can support multiple possible combinations of crops that can lead to healthy, nutrient-rich soil and robust yields. There is no predetermined formula for successful crop rotation. Farmers must therefore determine the best rotation schedule based on their soil makeup, capacity, and desired crops. Based on feedback from smaller-scale organic growers in Washington, cover crops are not typically sold for profit, but instead tilled into the ground (Salvo 2016). In some cases, greens like chard or kale are grown in the rotation, and sold through local supply chains (DeVries 2016). Below, each major storage crop is described in terms of its most common rotational crops, production challenges, and whether a market exists for the rotational crops themselves.

### i. Potatoes and Alfalfa

This section focuses on the market for alfalfa, the most economically important crop that consistently rotates with potatoes. Alfalfa is far from the only rotation crop for potatoes: depending on market demand, row crops can include dry beans, squash, or field corn (Dufour, Hinman and Schahczenski 2009). According to the National Sustainable Agriculture Information Service (ATTRA), “the most important step in organic potato production is planning a scheme that allows for a few years between potato crops on the same land” (Dufour, Hinman and Schahczenski 2009). For potatoes, ensuring a longer rotation acts like a form of “crop insurance” because it can “help prevent plant pathogens in the soil from building up to economically damaging levels” (Dufour, Hinman and Schahczenski 2009). In the Pacific Northwest,



the recommended potato rotation lasts seven years, and includes the following crops: Year 1-3: Alfalfa; Year 4: Row Crop; Year 5: Grain; Year 6: Row Crop; Year 7: Grain.

Rotations may also include cover crops or green manures – crop parts left in a field, typically used for mulch or tilled into the soil. Cover crops and green manures provide an advantage by adding organic matter and nitrogen to the soil, which “generally will reduce input costs over time” (Dufour, Hinman and Schahczenski 2009). Typical cover crops in a potato rotation include legumes, sudangrass, and mustards; with mustards shown to improve soil pest management (Dufour, Hinman and Schahczenski 2009).

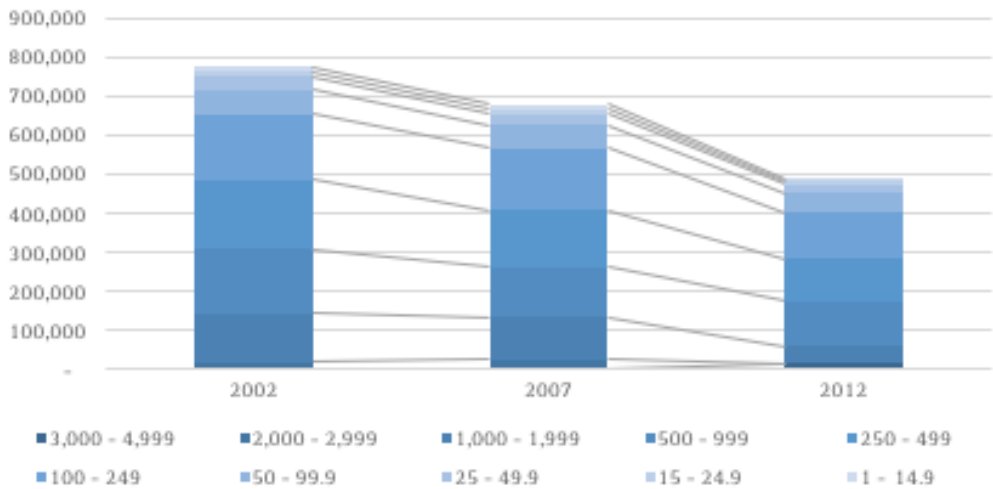
Potatoes generally struggle with insect pests (such as the Colorado potato beetle, or CPB), competition from weeds, blight, and certain plant pathogens. For weed management, cover crops such as red clover, buckwheat, and sorghum sudangrass have been shown to compete with weeds and add organic matter to soil. In response to insect pests, “straw mulch of wheat or rye in potato fields may reduce the CPB’s ability to locate potato fields and alter the microenvironment in favor of CPB predators” (Dufour, Hinman and Schahczenski 2009). Finally, with regard to soilborne pests, “recent studies in Washington show that mustard green manures may offer farmers an equally effective but less expensive alternative to fumigants” (Dufour, Hinman and Schahczenski 2009). In general, ATTRA recommends “crop rotation to nonhost crops such as cereals for at least two years [to] reduce disease incidence” (Dufour, Hinman and Schahczenski 2009).

Alfalfa is a major rotation crop with potatoes. In both Washington and Idaho, there appears to be a downward trend in alfalfa production with regard to acres harvested and pounds produced.<sup>7</sup> In general, the market outlook for alfalfa was less positive in 2015, but appears to be strong in the long-term (Merlo 2015). According to Ag Web, “sky-high alfalfa prices [in 2015] sent dairy producers looking for feed replacements, causing demand for alfalfa hay to decline” (Merlo 2015). In general, Ag Web notes that “California dairies are typically the largest market for the West’s alfalfa hay” but due to high prices, many dairies are “feeding the more economical wheat straw” (Merlo 2015). Another reason for declining alfalfa production may be “due to the drought and uncertainty of water supplies” (Merlo 2015).

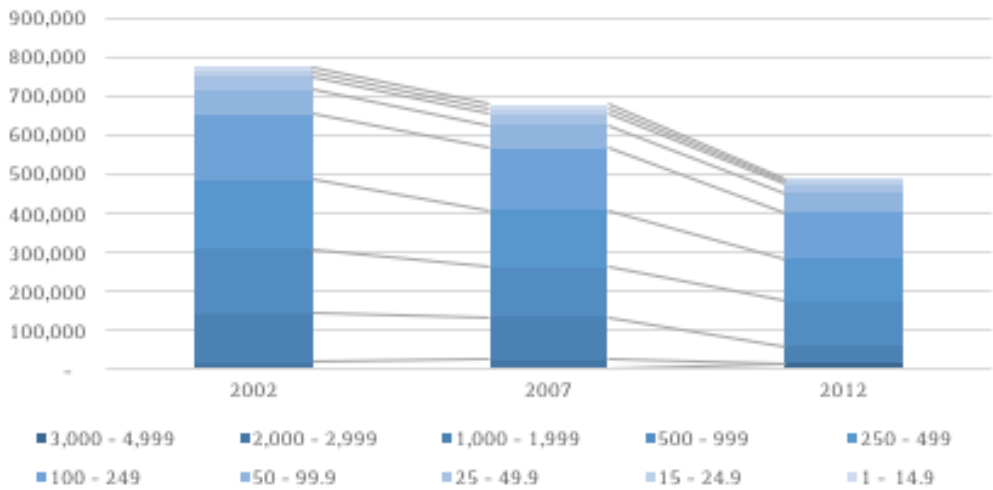
Figure 34 through Figure 36 below present acres of alfalfa harvested in Oregon and Washington, Idaho, and California over the period 2002 – 2012, sorted by farm size class. In Oregon and Washington, total acreage has declined consistently across farm size classes over the ten-year period. In Idaho, acreage increased slightly from 2002 – 2007 and then declined from 2007 – 2012. The trend in California is more similar to that of Oregon and Washington.

<sup>7</sup> Significant data for other probable rotational crops, like buckwheat, sorghum, wheat, rye, and mustards, do not show up within the USDA Census.

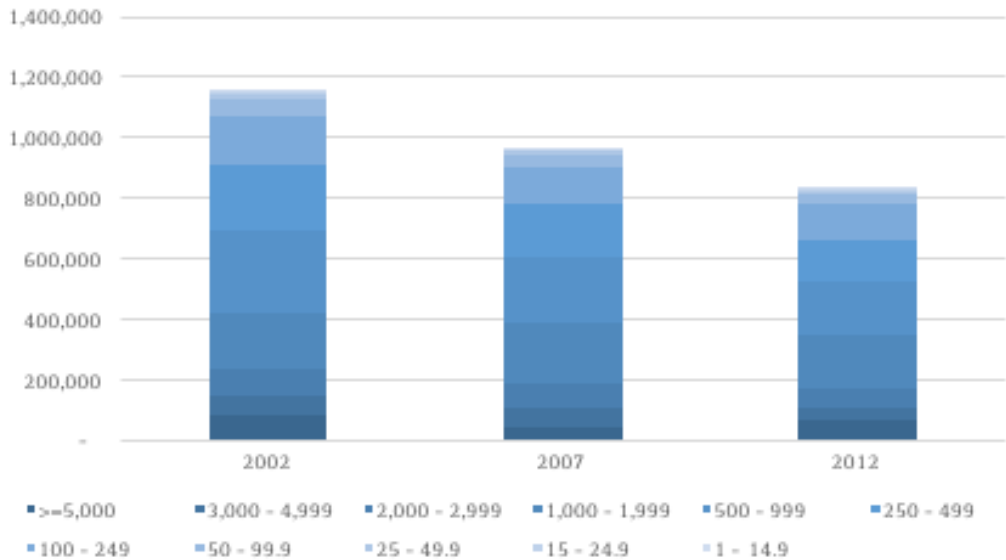
**Figure 34.**  
Alfalfa: Acres Harvested by Farm  
Size Class, Oregon and Washington,  
2002-2012



**Figure 35.**  
Alfalfa: Acres Harvested by Farm Size  
Class, Idaho, 2002-2012



**Figure 36.**  
Alfalfa: Acres Harvested by Farm Size  
Class, California, 2002-2012



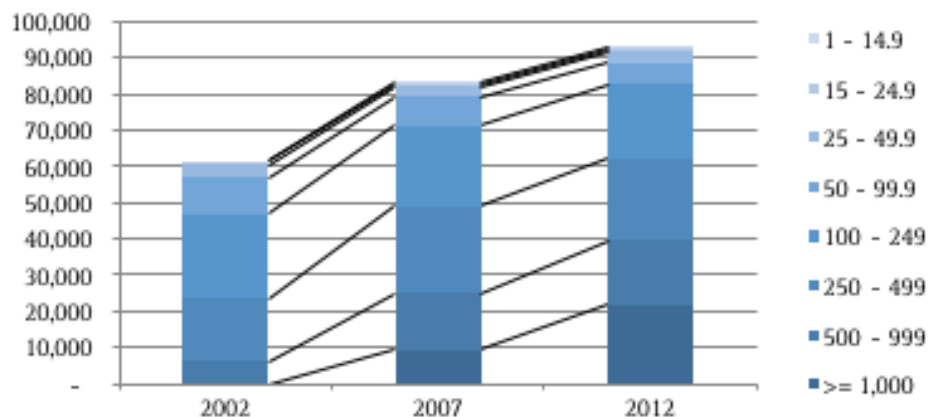
## ii. Carrots and Silage Corn

This section focuses on silage corn, a common rotation crop for carrots. Silage corn refers to corn that is raised for animal feed.

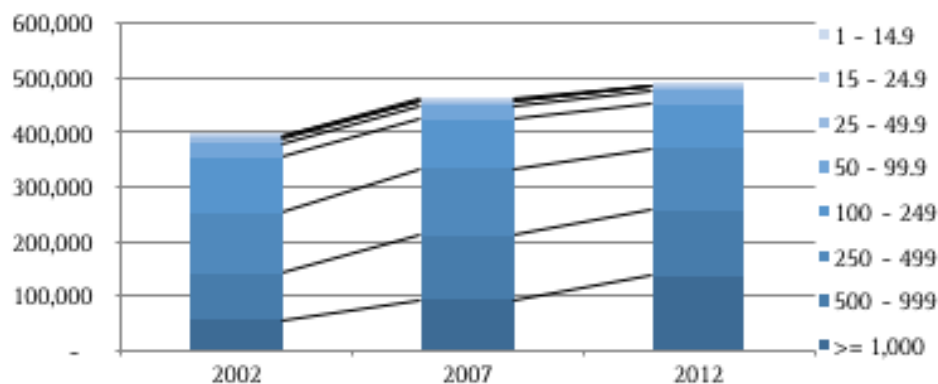
California and Washington are the largest carrot-producing states in the U.S., with Washington ranking first with regard to production of “processing” carrots. In general, carrots are known as “heavy feeders,” meaning that the soil must have enough nutrients to support the crop, especially when it comes to large-scale production (Sorenson 2000). Similar to potatoes, high chemical use is common among conventional carrot farmers to prevent crop losses. Preventing the spread of fungi is a particular challenge for carrot farmers, but crop rotation can help minimize damage in all areas (including pests, nematodes, and mold/mildew). According to the Crop Profile for Carrots in Washington State, “crop rotation to non-host crops for at least one year and turning under residue following carrot harvest can help reduce losses” (Sorenson 2000). Common non-host crops include oats, corn (silage), or alfalfa. Additionally, carrots are common rotational partners with potatoes, usually planted following a potato crop. In this way, the potato and carrot markets are connected.

Silage corn appears to have a strong market in California and Washington based on acres harvested. Figure 37 and Figure 38 below demonstrate increases in total silage corn acreage between 2002 and 2012 in Washington and California.

**Figure 37.** Silage Corn: Acres Harvested by Farm Size Class, Washington, 2002–2012



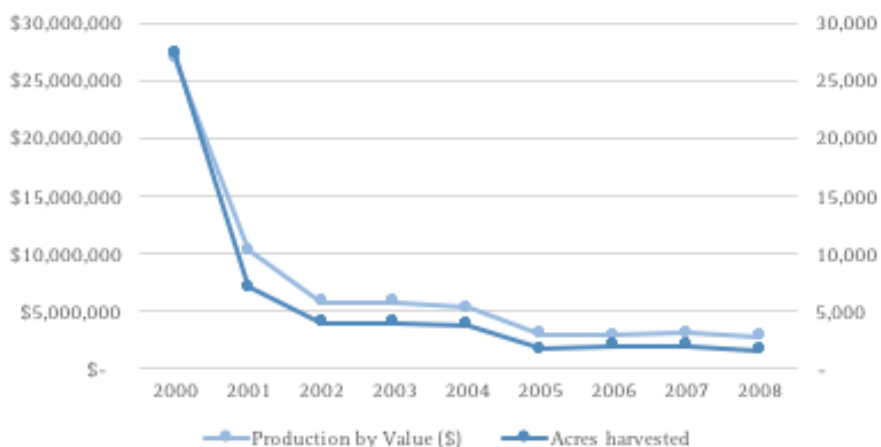
**Figure 38.** Silage Corn: Acres Harvested by Farm Size Class, California, 2002–2012



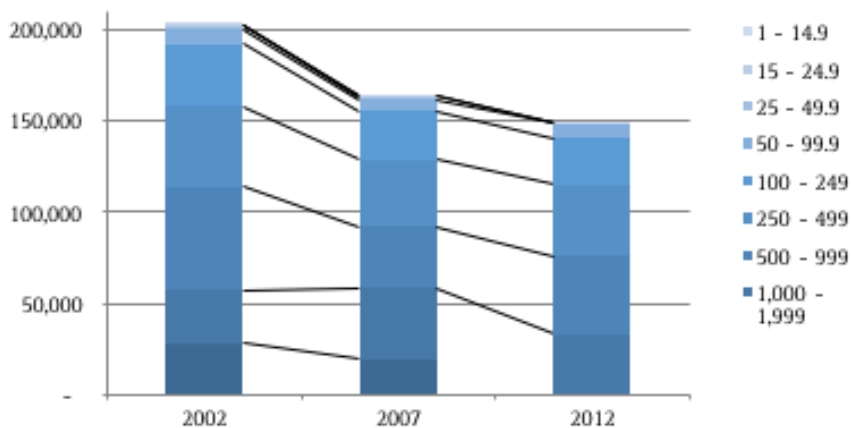
### iii. Onions and Sugarbeets

This section focuses on the market for sugarbeets, a rotation crop that commonly follows onions. Onions rotate with a wide variety of crops. According to the Crop Profile for Onions in Washington, onions in the Columbia Basin are generally grown in “3-4 year rotations with carrots, sweet corn, cereals, and potatoes, where potatoes sometimes follow onions” (Pelter and Sorenson 2008). Potatoes should be grown two crop years away from onions, since volunteer potatoes can be a serious weed. Other onion rotation partners are field corn, wheat, peas, beans, and sometimes alfalfa (Pelter and Sorenson 2008). Based on the Crop Profile for Onions in Washington, “nitrogen movement below the rooting zone is an important factor when managing an onion crop, and therefore many growers rotate with a crop like wheat or corn following onions to capture any residual nitrogen” (Pelter and Sorenson 2008). Similarly, according to a 2001 study by Oregon State University, “crop rotations that include a deep-rooted crop following onions (alfalfa, sugarbeets, or cereals) can assist in recovering some of the nitrate-N from below the onion root zone” (Sullivan, et al. 2001).

Figure 39 and Figure 40 below show a general decline in sugarbeet acres harvested in Washington and Idaho. According to Capital Press, an agriculture publication focusing on the western U.S., market outlook for sugarbeets in Idaho, traditionally a large producing state, has been weak in the past few years: “Idaho’s sugarbeet growers suffered a tough year in 2013, with the price for their crop falling 21% to \$40 a ton – lowest since 2007” (Dumas 2013). The weak market for sugarbeets may be due primarily to low world market prices for sugar. Paul Patterson, agricultural economist for the University of Idaho, says: “With a global sugar supply glut caused by large sugar cane crops in Asia and Brazil this year, growers can expect low prices to linger in the near term” (Dumas 2013). In addition, Patterson notes that “U.S. sugar producers can’t compete against sugar cane produced in countries that aren’t subject to the cost of U.S. labor and environmental regulations or against subsidized sugar dumped on the world market” (Dumas 2013). For example, sugar imports from Mexico increased 98% in 2012, which contributed to a decrease in U.S. market prices (Dumas 2013). The market may be looking up, however, with Patterson predicting “a possible slight improvement in the 2014/2015 marketing year” (Dumas 2013).



**Figure 39.** Sugarbeets: Acres Harvested and Production by Value (\$), Washington, 2000-2008



**Figure 40.** Sugarbeets: Acres Harvested by Farm Size Class, Idaho, 2002-2012

### Environmental Changes: Threat or Opportunity?

The recent California drought, combined with ongoing climate change, suggest that the geography of agricultural production in the Western United States may be shifting. However, it is too early to assess the extent to which these changes will affect the cropping patterns for storage crops. As the California drought continues, the importance of the Columbia Basin may increase for all irrigated crops. Changes in the timing of growing seasons, due to climate change, may lead some irrigated crops to move from California's agricultural regions, particularly the hot, dry San Joaquin Valley, to the Columbia (Granatstein 2016). These include permanent crops such as cherries, for which California's agricultural environments are becoming overly hot and dry. Protected cultivation systems, such as plastic netting systems, have begun to be used on tree crops including apples and cherries. It is not clear to what extent storage crop cultivation will be affected by these environmental changes, nor to what extent the new cultivation practices will be applicable.

## Drivers of Demand for Organic Storage Crops

### Environmental Values

In general, research on consumer demand indicates that consumers are willing to pay premiums to purchase organic foods, though data specific to storage crops is scarce. Consumer preferences for organic are driven in part by concern for the environment, though human health and support for local economies are two other significant concerns. According to a 2011 Thomson Reuters-NPR Health Poll, 58% of consumers prefer organic food to conventional food. Among respondents that prefer organic food, 17% say their primary reason is "environmental health"; the most popular primary reason was "supporting local farms" (36%), followed by "avoiding toxins" (34%). The results of this survey suggest that concepts of local and organic food are intertwined. (Huffington Post 2011). Younger, and more educated consumers have a stronger preference than older and less educated. Income level did not strongly influence preference for organic food.

Differentiated varieties of organic storage crops such as specialty potatoes are increasingly of interest to consumers. Photo: Taylor Schefstrom

## Health

The section on environmental values above noted that concern for health, specifically “avoiding toxins,” was a primary motivation for consumers to purchase organic. This section elaborates on the health issues associated with industrial storage crop production, and the ways in which organic production methods can alleviate these issues.

### i. Pesticides and Health

One of the most alarming aspects of high chemical use in large-scale production of storage crops relates to their susceptibility to absorbing harmful chemicals. According to Organic Nation, “root vegetables... absorb almost anything in the soil, so heavily-sprayed crops will often have pesticides make their way into the plant itself” (Dirty Dozen: Why to Always Buy Organic Potatoes 2015). Along these lines, a 2006 USDA study found that 81% of potatoes tested still contained traces of pesticides after being washed and peeled (Parker-Pope 2007). In 2006, a study by the Environmental Working Group (EWG) found that potatoes had one of the highest pesticide contents out of 43 fruits and vegetables tested (Parker-Pope 2007); ten years later, potatoes still have the highest pesticide content of all the storage crops on the EWG’s high pesticide list (Environmental Working Group 2016).

Conventionally-grown potatoes receive three chemical applications: fungicides and herbicides are commonly applied pre-harvest and during the growing season; then, post-harvest, potatoes are treated again to prevent sprouting (Dirty Dozen: Why to Always Buy Organic Potatoes 2015). Particularly for large-scale, conventional farmers, chemical application is seen as indispensable to producing high yield, uniform crops: the Washington State Carrot Crop Profile noted that if all herbicides were lost, impact on carrot yields would be an estimated 60% statewide (Sorenson 2000). Similarly, the crop profile estimated that the state could expect a 40% decrease in carrot yields without nematicides, and a 30% decrease if fungicides/insecticides were unavailable (Sorenson 2000).

Organically grown potatoes and carrots demonstrate that the levels of chemicals frequently used on these crops may not be necessary: one organic grower we spoke with noted that they can grow potatoes and carrots adequately without the use of chemicals (DeVries 2016). Due to pesticide risk, consumers must ask themselves, “why buy conventional?” —especially when organic potatoes are not much more expensive (Dirty Dozen: Why to Always Buy Organic Potatoes 2015). By choosing to purchase organic potatoes, consumers can improve their health at a low cost and make the most impact for their dollar (Parker-Pope 2007).

Compared to potatoes and carrots, conventional onions are significantly less risky from a health standpoint. Due to their “thick exterior skin,” which most consumers remove before eating, onions pose less risk to those seeking to avoid pesticide exposure.

## ii. Genetically Modified Crops (GMO) and Health

Genetically modified (GMO) crops are a controversial trend in commercial agriculture. According to The Guardian, “the potato is one of a new wave of genetically modified crops that aim to provide benefits to consumers, not just to farmers as the widely grown biotech crops like herbicide-tolerant soybeans and corn do” (Pollack 2014). Large companies like Simplot and Monsanto have each introduced genetically-engineered (GE) potato varieties in the last 20 years. Most recently, Simplot revealed what it refers to as the “innate potato” – a GE varietal designed to satisfy both consumers and farmers. Approved by the USDA and FDA in 2014, a major selling point of the “innate potato” is that it “resists bruising, a characteristic long sought by potato growers and processors for financial reasons” since “potatoes bruised during harvesting, shipping or storage can lose value or become unusable” (Pollack 2014). The “innate potato” is also marketed to mainstream consumers, as Simplot’s scientists claim that it contains lower levels of a naturally-occurring amino acid called asparagine. When heated to high temperatures, as in frying frozen french fry products, asparagine reacts with sugars in potatoes and produces acrylamide, which has been recognized as a “probable human carcinogen” by the International Agency for Research on Cancer. In reality, no definitive opinion exists with regard to the human harm caused by acrylamide: the federal National Cancer Institute says that “more research is necessary... the effect of dietary intake [of acrylamide] is not fully understood” (Glenza 2014).

Scientists and food experts question Simplot’s “innate potato” because the technology used to engineer it is as yet unproven and could have unexpected, adverse effects. To create the “innate potato,” Simplot used what’s known as RNA-interference: a process that essentially “silences” a potato’s own genes, like those that would cause a potato to brown or bruise, for example (Gunther 2013). The downside, according to Doug Gurian-Sherman, a senior scientist and plant pathologist at the Center for Food Safety, is that this process is “not well understood” (Pollack 2014). Groups opposed to the “innate potato” stress that “altering levels of plant enzymes can have unexpected effects,” including potentially suppressing genes that are important for a plant’s “proper use of nitrogen and... protection from pests” (Pollack 2014). Gurian-Sherman also notes that USDA and FDA approval of Simplot’s RNA-interference technology is “premature” and “not being adequately regulated” (Pollack 2014) – a potential nod to the large influence big companies like Simplot have within the potato industry. While opposition groups like Food and Water Watch have urged groups like McDonald’s not to source the “innate potato,” the National Potato Council (which represents potato farmers) only “expressed concern that exports could



be disrupted if genetically engineered varieties inadvertently end up in shipments bound for countries that have not yet approved the potatoes” (Pollack 2014).

Historically, genetically-modified potatoes have not fared well in the larger potato market. In 1995, Monsanto introduced its NewLeaf potato variety, designed to be resistant to common pest, the Colorado potato beetle. However, fueled by fear of consumer resistance, the market collapsed after large potato processors (like Simplot) encouraged farmers not to grow the beetle-resistant strain (Pollack 2014). Overall, the history of introducing GE crops “points to the importance of consumer acceptance when introducing any ‘innate’ crops and products into the market,” writes Pete Clark, Simplot’s regulatory affairs manager (Glenza 2014).

### iii. Breeding Healthier Carrots

Current research has found that carrot colors are indicators of abundance for specific nutrients. Lead researcher Phillip J. Simon, plant geneticist for the Agricultural Research Service (ARS), is running a five-year study on Carrot Improvement for Organic Agriculture (CIOA) with the goal of “helping breeders develop carrots that are tastier, more nutritious, and better equipped to combat weeds, diseases, and pathogens” (O’Brien 2016). With regard to human health, Simon’s research has found that different colors often correspond to different health benefits. According to Simon, “organic growers... are more interested than conventional growers in producing carrots with novel shapes and colors—purple, red and yellow—that will attract organic consumers” (O’Brien 2016). The following health benefits are associated with different carrot colors: high levels of vitamin A (orange); antioxidants (purple); lycopene, which can reduce the risk of certain cancers (red); and lutein, which can reduce the risk of macular degeneration (yellow) (O’Brien 2016). Similarly, superior nutritional results have been found for ancient varieties of potatoes, corn, and apples, as well as wild greens such as dandelions (Robinson 2013).

### **Marketing and Branding / Packaging**

Marketing and branding of local and organic varieties of storage crops is an area in which further research and business development can take place. In the case of storage crops, the cost of packaging can actually exceed the cost of the product itself (Ecotrust 2015). The Oregon Infrastructure Gap Analysis Report states: “Grower-shippers of retail-packed onions and potatoes would likely benefit from a stronger and more prominent statement of origin to distinguish their products.” (Ecotrust 2015) Given that 87% of consumers nationally regard the availability of locally grown foods as “Very Important” or “Somewhat Important” (Ecotrust 2015), a marketing and branding campaign for local storage crops, with a focus on differentiated and/or organic products, may prove a boost to local production.

### **The Rise of Processed Foods**

Since 1940, demand for processed food products has steadily increased, especially within the potato industry; this trend has affected the trajectory of organic production and marketing. As of 2012, an estimated 87% of Washington's total potato crop was sold to processors to be transformed into either frozen, dried (chips), dehydrated, or canned products (Pihl 2012). In addition, over 50% of U.S. potato sales go to processors of potato products, with the rest of sales going to "fresh market" potatoes (Vegetables & Pulses: Potatoes 2016). Looking at global demand, frozen potato products are the most valuable potato export, representing two thirds of total U.S. potato export sales (Vegetables & Pulses: Potatoes 2016).

Demand for processed products extends to other storage crops beyond potatoes. For example, what many consumers recognize as "baby carrots" are actually mature carrots, peeled through steel cylinders and cut at 2" lengths so as to appear smaller (Sorenson 2000). While these carrots are consumed fresh, they are still considered "manufactured" or "processed" carrots. Overall, "baby carrots" account for half of all fresh carrots consumed in the U.S. (O'Brien 2016), and are largely responsible for the fact that carrot production has grown by 33% since the 1990s (Nelson 2006).

Similarly, a significant market exists for processed onion products, with approximately 49.4 billion pounds of frozen onions produced annually (Adam 2006). Across the board, high demand for processed products (e.g. frozen, dehydrated, etc.) has only increased the need for larger processing plants and the development of state-of-the-art storage facilities to allow for year-round supply.

The rise of processed organic storage crops has accompanied the rise of Big Organic production. A new market is emerging for processed organic potatoes by nationally-branded manufacturers such as Cascadian Farm, Kettle Chips, and Amy's Kitchen (Dufour, Hinman and Schahczenski 2009). Cascadian Farm, located in Washington's Skagit Valley, offers a full line of frozen organic products, among other specialty food items. Out of their extensive line of frozen food products, Cascadian Farm offers frozen potatoes (including fries), peas & carrots, multi-colored carrots, and most recently, frozen beets – a unique product in the organic frozen vegetable market. Kettle Chips offers an organic line of chips, as well as a bagged line of frozen, ready-to-bake "home fries" – a nod to the profitable frozen potato market, though Kettle Chip "home fries" are not labeled as organic. Amy's Kitchen focuses more on complete dishes, whether entrees, sides, soups, etc. Amy's Kitchen products are made from organic ingredients, though they do not specify "100% organic". Amy's Kitchen is also a founding member of the "Just Label It" campaign to promote labeling all foods made with GMO ingredients. Organic Valley, a farmer-owned organic cooperative founded in 1988, sources from farms around the U.S. to supply regional market channels with organic products, including vegetables (Organic Valley 2016). Organic Valley has also spoken out against GMOs and promotes labeling GMO products.

## Conclusion and Recommendations

Our recommendations in this area are as follows:

Focus on market growth for organic potatoes and carrots, over and above organic storage onions, for which market demand appears to be stagnant.

Seek opportunities to invest in branding and marketing initiatives for local and regional organic storage crops, focusing on key attributes such as nutrition/health, flavor, and uniqueness.

Seek companies that grow and process differentiated varieties of storage crops, such as multi-colored carrot varieties, specialty potatoes such as fingerlings, non-storage onions including Walla Walla, Vidalia, and scallions / green onions.

Look for opportunities to invest in organic storage crops grown for the processing market, in order to meet increasing demand for organic ingredients among producers of frozen and processed foods.

Seek opportunities to invest in packing facilities for small- to mid-size organic potato production.

Continue to conduct research into trends in the markets for rotational crops; look for ongoing fluctuations, or indicators of recovery, in the markets for alfalfa and sugarbeets, and seek additional rotation crops with robust markets which can accompany potatoes.

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