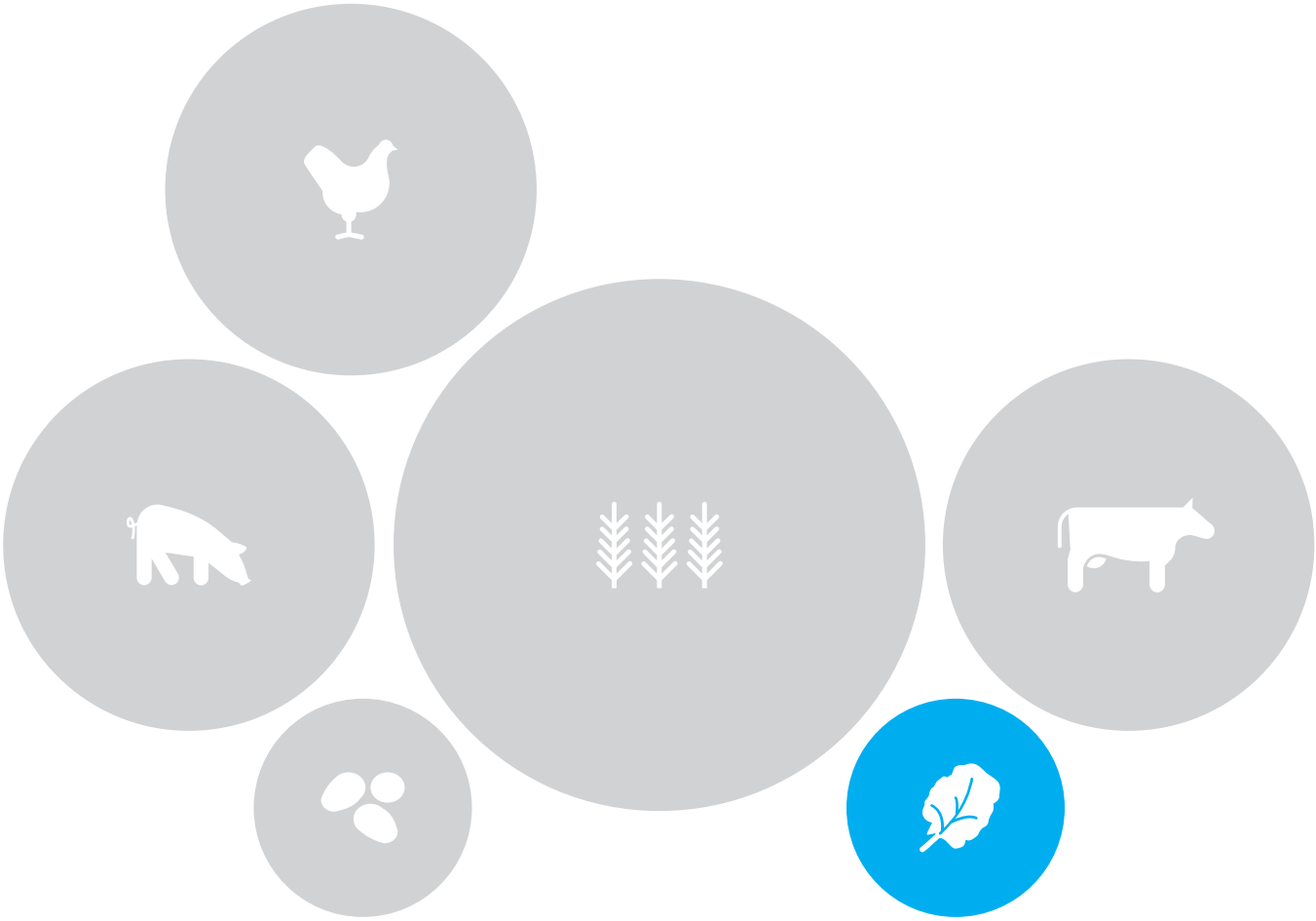

Differentiated Cost of Production in the Northwest:

An Analysis of Six Food Categories

LEAFY GREENS / June 2016

ecotrust

This research was commissioned by the Cascadia Foodshed Financing Project, a project of Philanthropy Northwest, and made possible by generous grants from JPMorgan Chase Foundation, the Greater Tacoma Community Foundation and the Thread Fund. Ecotrust appreciates the thoughtful support and partnership of these organizations to pursue reliable prosperity for all Oregonians and Washingtonians.

Cascadia Foodshed
Financing Project

JPMorgan Chase & Co.

thread fund

For more than twenty years, Ecotrust has converted $80 million in grants into more than $800 million in assets for local people, businesses, and organizations from Alaska to California. Ecotrust's many innovations include cofounding an environmental bank, starting the world's first ecosystem investment fund, creating programs in fisheries, forestry, food, farms, and social finance, and developing new tools to improve social, economic, and environmental decision-making. Ecotrust honors and supports the wisdom of Native and First Nation leadership in its work. Learn more at www.ecotrust.org

TABLE OF CONTENTS

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 leafy greens. In each category we define an "ag of the middle"[1] 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 greens chapter from that report is included with this model/report as an addendum.

1 "Agriculture of the Middle" is defined in this narrative on page 8.

Executive Summary / Introduction

Leafy green vegetables are an important source of nutrition, and thus form a vital part of the food system for any region. In this narrative, we examine the drivers of supply and demand for organic leafy greens. The Pacific Northwest, while not a major producer of leafy greens nationally, nonetheless possesses a thriving diversified organic farm sector, predominantly on the West side of the Cascades. These farms produce leafy greens in combination with an array of storage crops, brassicas, and other vegetables.

This study documents emerging trends in organic greens farming in the Pacific Northwest. The study finds that in general, leafy greens produced in the Pacific Northwest are not competitive commercially with those produced in California, whether conventional or certified organic. The crop category of mixed vegetables is a more significant category of farming in the Pacific Northwest than leafy greens alone. In mixed vegetable farming, producers can combine leafy greens (e.g. lettuce, spinach) with root crops, alliums (e.g. onions), brassicas (e.g. broccoli), herbs, and other crops.

Drivers of Supply

The drivers of supply for organic leafy green vegetables are as follows:

1. Production costs. Organic leaf lettuce production costs per acre are similar to those of conventional, though yields are lower. Due to price premiums however, organic leaf lettuce production can provide farmers with net returns per acre that are competitive with conventional.
2. Crop diversity. Mixed vegetable farming can provide producers with diverse revenue streams, and consumers with a diverse array of products. Rotating mixed vegetables with forage for livestock can restore soil quality while expanding the range of products beyond vegetables to meat, eggs, and dairy.
3. Alternative production systems, such as indoor hydroponics, are emerging as an alternative to field-based agriculture, which may play a growing role in the market for leafy greens in the years to come. Not all of these systems are certified organic.
4. Alternative distribution systems, such as home delivery, can provide consumers with a diverse selection of organically grown vegetables sourced from a variety of farms.
5. Environmental changes, including the California drought and ongoing climate change, are already changing cropping patterns in California and, to some extent, the Pacific Northwest. These changes have the potential to become far more dramatic in the years to come; however, it is not clear whether the leafy greens sector in the Pacific Northwest is best positioned to capitalize on them.

Drivers of Demand

The drivers of demand for organic leafy green vegetables are as follows:

1. Consumer Trends. Leafy greens have tended in recent years to go through fads: kale is the primary example.
2. Environmental and social values. Consumers, in general, have revealed positive willingness to pay premiums for product attributes including environmentally friendly production methods, local varieties, and socially equitable business practices.
3. The rise of mass market organic. The increased availability of organic products through mainstream retailers has stimulated consumer awareness and led to increased demand; a significant proportion of this demand has been met by imports from other countries.

Investment Recommendations

The complexity, uncertainty, and poor data quality that characterizes the organic leafy greens sector (see section B.2 below) means that we cannot recommend specific areas to invest, but we can offer some guiding principles for those seeking to make catalytic investments in organic leafy greens and related mixed vegetable crops. The most important thing to remember for a prospective impact investor seeking to move the market in organic leafy greens – or organic vegetables in general is: pay attention. There is no clear, dominant trend in organic leafy green vegetable agriculture; sustained attention to the details of the market, including emerging crops, new production systems, and alternative methods of distribution, is essential for identifying future profitable opportunities.

We elaborate on this fundamental point by identifying seven areas in which the sustained attention of prospective impact investors may bring positive results:

1. Yields matter. The yield gap is one of the reasons behind the higher production cost of organic food. But organic yields are competitive in some regions, for some crops, and under conditions of drought and environmental stress.
2. The land market matters. Supply of organic farmland still lags behind growth in the demand for organic food (Barrett 2012). In the next decade, millions of acres of farmland will change hands, as the current generation of farmers retires. This large-scale transition may offer opportunities for conversion to organic production methods (Bradford 2016).
3. Organic imports and exports are both increasing. The growth of the mass market for organic food means a lot more organic produce is crossing borders than ever before (Economic Research Service 2014).
4. California is the elephant in the room. And in the face of ongoing drought and climate change it's not clear which direction the elephant is going to fall; most of the evidence says it will fall southward towards Mexico. Still, there is evidence of northward shifts in cropping patterns: for instance, increased commercial

plantings of blueberries and hazelnuts (Bradford 2016).

5. Indoor farming is emerging and may become more important as arable land near urban areas becomes scarce. Indoor production systems and crops are internally diverse, but the most common crop type is microgreens. Hydroponic greenhouses are an emerging production system that merits attention (Knaus 2016).
6. Distribution systems matter. Organic agriculture contains a variety of distribution channels, including organics-focused distributors, community-supported agriculture (CSA), and home delivery (Stout 2016). Expanding organic farmers' access to a wider array of distribution channels through supply chain coordination and networking may play a role in shaping the future market (Murray 2016).
7. Vegetables grown for processing are as important as those grown for the fresh market. Related to the growth of a mass market for organic foods, vegetables grown specifically for processing into pre-packaged and frozen foods have emerged as a profitable alternative for organic farmers, to meet consumer demand for pre-packaged frozen vegetables and other convenience food products (Bradford 2016).

Organic mixed leaf lettuce starts at Boistfort Valley Farm in Curtis, WA

Organic Agriculture: An Alternative Approach

Brief Introduction to Organic Agriculture

Organic agriculture is an ecosystem-based approach to farming that reduces the negative impact of agriculture on ecosystems. The organic approach can play an important role in restoring the fertility of farmland and improving related ecosystem functions, including soil nutrient cycling and provision of clean water. Conventional agriculture is associated with numerous negative environmental impacts such as soil erosion, nutrient and chemical runoff leading to water pollution, overuse of irrigation water, and depletion of soil nutrients and soil organic carbon. Chemically intensive conventional agriculture is also

associated with negative human health impacts, most consistently with the health of agricultural workers. Though some studies have found that crops grown under chemically intensive farming practices are less nutritious than those grown under organic practices, the evidence so far is inconclusive (von der Groeben 2012).

The FAO defines organic agriculture as "a system that relies on ecosystem management rather than external agricultural inputs; (it) eliminates the use of synthetic inputs, such as synthetic fertilizers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and irradiation. These are replaced with site-specific management practices that maintain and increase long-term soil fertility and prevent pest and diseases" (FAO 2016).

Organic agriculture can be considered an approach more than a single system; it encompasses a very wide range of practices including cover cropping, crop rotation, composting, natural methods of pest control, and selective use of organic fertilizers and soil amendments. In the case of vegetables, the biggest differences between organic and conventional agriculture are the following:

1. Weed Management. Whereas conventional systems use herbicides, organic systems make more intensive use of labor and cultivation using equipment and hand tools.
2. Soil Health Management. Whereas conventional systems use chemical fertilizers that include synthetic nitrogen, organic systems use compost and other organic soil amendments. Organic systems also make use of cover cropping, which entails planting a nitrogen-fixing crop (such as clover) during fallow seasons.
3. Pest and Disease Management. Whereas conventional systems use pesticides and herbicides to control pests and plant diseases, organic systems use crop rotations, soil health management techniques, row covers such as black plastic, and some organic pesticide sprays.

Though organic farming methods, in general, lead to superior soil and water quality than conventional practices, these methods also tend to produce lower average yields, and thus entail higher average production costs per unit of output. A recent article in Nature, based on a meta-analysis of crop yield studies, noted that "yield differences are highly contextual, depending on system and site characteristics, and range from 5% ... to 34% lower yields." The article concluded that "with good management practices, (and) particular crop types and growing conditions ... organic systems can thus nearly match conventional yields, whereas under others it at present cannot." (Seufert, Ramankutty and Foley 2012).

It is widely accepted that organic farming methods are more resilient to environmental stresses, from drought to extreme temperatures, than

conventional methods. According to a recent study published in the journal Nature Plants, "organic crops are better suited for farmlands subjected to drought conditions" (Ahearn 2015). Washington State University professor and organics expert John Reganold asserts that "the key to withstanding the effects of climate change, while feeding a growing global population, lies in building healthy soil" (Ahearn 2015). Organic farmers, who enrich their soil using compost or manure rather than chemical fertilizers, help to establish soil that can hold both more water, and more nutrients, than under conventional farming practices. Under drought conditions, organic soils "can produce the same amount [as conventional farms] and sometimes more, because of the water being held in the soil" (Ahearn 2015). The Rodale Institute, the leading research organization in the United States devoted to organic farming, has found in its experimental studies (called the Farming Systems Trial) that during droughts and times of environmental stress, organic yields are competitive with conventional (Rodale Institute 2016).

Data Issues in Organic Agriculture

There are significant gaps in the data on organic vegetables, which present barriers to a full understanding of the intricacies of the sector in the Pacific Northwest. The data gaps create difficulties in identifying potentially profitable investment opportunities in this sector without sustained attention.

For example, a researcher at national certifier Oregon Tilth recently attempted to quantify supply shortages of organic crops, in order to assist farmers in planning and scaling up production. The effort has led to inconclusive results due to poor data (Murray and Chambers 2015). The author of the study concluded: "Between the limited information publicly available about how organic crops are marketed, and the proprietary nature of most company purchasing data, this analysis is too incomplete to be used to draw meaningful conclusions about supply gaps... Buyers' perspectives are too unique to individual companies to make generalizations about supply gaps for specific crops" (Murray and Chambers 2015).

The principal barriers to a robust statistical profile of organic vegetable agriculture in the Pacific Northwest are as follows:

1. The sector is extremely internally diverse. Pacific Northwest small- to mid-sized producers of organic certified vegetables predominantly fall into the crop category of mixed vegetables (see section B, paragraph 2 below). Mixed vegetable farming encompasses leafy greens, herbs, brassicas (e.g. broccoli, cauliflower), storage crops (e.g. beets, squash), berries, nuts, and other related products including small livestock (such as chickens). There are dozens, if not hundreds of crops that fit into the category of mixed vegetable farming, and there are thus thousands (if not millions) of possible combinations of cropping patterns and rotations that jointly determine the farmer's total and variable costs of production. Similarly, there are thousands of possible combinations of diverse revenue streams that jointly determine the

farmer's income or gross sales in a given year. There is no single alternative production system that does justice to the complexity of potential crop combinations in this sector. Finally, the production technologies are internally diverse: field-based fruit and vegetable agriculture involves a completely different set of tools than urban, indoor hydroponic agriculture. For this and related reasons, most farmers practicing diversified vegetable farming do not know their own production costs (Murray 2016). Studying a single crop or alternative production system is insufficient to understand this highly complex, rapidly evolving, and fragmented market.

2. Public data on the organic vegetable sector goes back very few years, and is very incomplete. There exist multiple publicly available datasets that provide partial glimpses into farming operations, acreage, yield, production, prices, revenue, cost of production, and other important variables that determine the economic well-being of organic greens growers in the Pacific Northwest. None of them are good enough to identify clear trends or make robust predictions (Murray and Chambers 2015). The USDA Organic Survey dataset provides data on organic acreage and sales, beginning in 2008 and collected every three years; however, it is riddled with missing data points. The 2014 Farm Act has budgeted an additional $5 million to upgrade the database and technology systems of the National Organic Program (Greene 2015).

   Most of the up-to-date information about organic market trends is located in proprietary datasets. The leading proprietary organic dataset, the Organic Industry Survey, is available for purchase from the Organic Trade Association. This dataset focuses on retail sales by major organic food companies. Prices for non-members range from $1495 for a single user to $1995 for a corporate package (Organic Trade Association 2016).

3. Existing literature on this topic by USDA analysts, academics, journalists, and other authors is lengthy, complex, nuanced, and not regionally targeted. There is a vast academic, popular, and public report literature on alternative food systems, much of it treating directly with organic and related production systems (e.g. agroecology). Much of this literature is thematic (e.g. women in agriculture; issues of corporate control of the food supply; urban farming in African American communities). Very little of this literature targets the Pacific Northwest specifically. Much of the popular literature is impressionistic, anecdotal, editorial, partisan, and non-scientific. The bulk of the public report literature comes from USDA, which treats the country as a whole and does not tend to analyze data from specific regions, nor explore regional differences beyond broad generalities. The bulk of the academic literature focuses on either technical issues such as methods of weed and pest control; or broader socio-political questions about the nature and trajectory of organic farming in general (Guthman 2014).

In summary, it is difficult to make clear predictions or identify clear trends in organic agriculture simply by looking at the data. The sector requires sustained attention, including participation in organic trade events and networking with producers, distributors, and purchasers, in order to identify profitable and catalytic investment opportunities.

Despite the problems accessing publicly available datasets, we can derive rough, ballpark estimates of the market size for specific organic crops using category-level data.[2] We derive these estimates in the next section.

Organic spinach field on Farmland LP land in Philomath, OR

Estimates of Organic Market Size

Our investigation of market size begins by looking at national-level data for the top-level category of fruits and vegetables as a whole. The U.S. organic food industry in total has grown from $13.3 billion in 2005 to an estimated $35 billion in 2014 (Economic Research Service 2014). The dollar value of organic fruits and vegetables has also grown consistently over the period, from $5.4 billion in 2005 to an estimated $15.1 billion in 2014; the size of the total organic fruit and vegetable market has also grown slightly relative to the organic food industry as a whole, from 40.3% in 2005 to an estimated 43.3% of the market in 2014. Figure 1 below shows total sales of organic fruits and vegetables, and the share of fruits and vegetables in the total organic food market, over the period 2005-2014 (Economic Research Service 2014). The data demonstrate that organic fruits and vegetables are increasing in importance, both in absolute terms and relative to other food product categories.

2 The most recent publicly available data varies by dataset; hence the estimate below is meant to be very approximate.

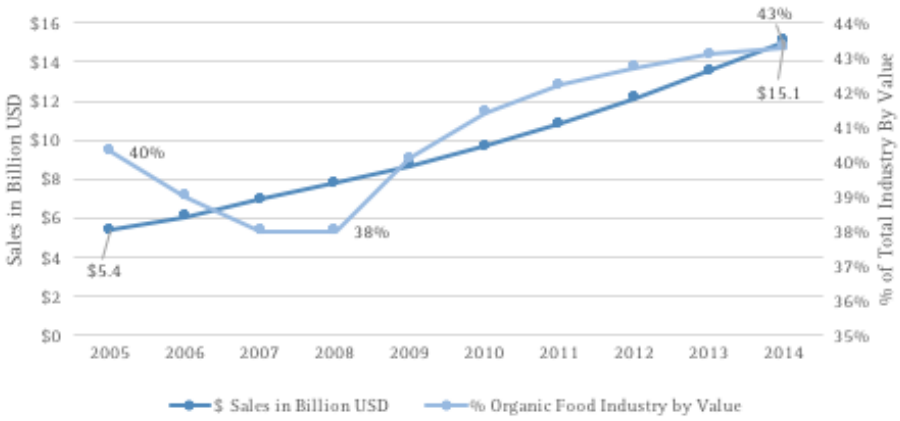

Figure 1. Organic Certified Fruits and Vegetables: Total Sales and Share of Organic Food Industry, U.S., 2005-2014

Our product focus, described in greater detail below, is organic leaf and romaine lettuce. We use data on national food consumption by category to estimate the approximate size of the organic leaf and romaine lettuce market in the Pacific Northwest.[3] Nationwide consumption data from the USDA Economic Research Service indicate that total per capita consumption of leaf and romaine lettuce (conventional plus organic) was 10.6 lbs. in 2013, the latest year for which data is available (Economic Research Service 2015). The most recent Organic Industry Survey, a proprietary dataset published by the Organic Trade Association, indicated that the market penetration for organic fruits and vegetables, as a top-level category, was about 12% as of 2014 (Murray and Chambers 2015).[4] Assuming that the market penetration for leaf and romaine lettuce is equal to the category average, per capita consumption of organic leaf and romaine lettuce is thus about 1.27 lbs. on average, nationwide, for our latest available data.

Recent examination of retail prices for organic leaf lettuce indicate prices of $1.99/head as of 2015, with frequent season and year-on-year fluctuations (Ecotrust 2015). The average weight of a head of leaf lettuce is estimated by the USDA as 0.83 lbs. (Agricultural Marketing Service 2012). The most recent population estimates for Oregon and Washington are 4.01 million and 7.06 million, respectively (Suo and Population Research Center 2015, Office of Financial Management 2015). Given these estimates, the total market size (retail opportunity) for organic leaf and romaine lettuce in the U.S. Pacific Northwest is approximately $33.6 million annually. Currently, the vast majority of such lettuce is sourced from California.

3 The USDA collects data on consumption of these two varieties of lettuce together as a single category.

4 We could not find publicly available data on organic market penetration for our crop of interest, leaf lettuce.

Product Focus: Organic Leaf and Romaine Lettuce

We choose to focus on leaf lettuce as an illustrative example of organic leafy greens production in the Pacific Northwest. Lettuce is an example of a crop for which demand in the Pacific Northwest is high, but supply has not been sufficient to meet demand. In the USDA Census of Agriculture, lettuce is divided into three major categories: head, leaf, and romaine.[5] In 2012, total (conventional plus organic) leaf and romaine lettuce supply in Oregon was sufficient to meet an estimated 13.3% of final consumer demand, based on comparisons between consumption data collected by the national Consumer Expenditure Survey, lettuce acreage data collected by the USDA, and yield estimates from Oregon State University enterprise budgets (Ecotrust 2015).

To derive an equivalent figure for Washington State, start by noting that Washington alone cultivated 153 acres of leaf and romaine lettuce in 2012 (NASS 2015). Assuming identical yields in Washington to those derived for Oregon by the Ecotrust study (Ecotrust 2015), these acres are expected to yield 3.55 million pounds of lettuce. Using the (2013) average leaf and romaine lettuce consumption of 10.6 lbs / person / year (Economic Research Service 2015), and Washington State's approximate population of 7.06 million, we estimate that total demand for leaf and romaine lettuce in Washington is 74.83 million pounds per year. Given those estimates, Washington State produces about 4.7% of its final consumer demand for leaf and romaine lettuce.

Figure 2 below presents total acres of lettuce harvested in Oregon and Washington over the period 1997-2012. The figure demonstrates that overall, since 1997, total acreage planted in lettuce of all varieties, using all production systems (conventional plus organic), has fallen across the Pacific Northwest. From a total acreage of 1,440 in 1997 across all varieties, Pacific Northwest lettuce production fell to 461 total acres in 2012 (NASS 2015). The biggest drop occurred between 1997 and 2002; unfortunately, we do not have data on the breakdown of this period of decline by lettuce variety (head, leaf, or romaine).

Figure 3 provides the corresponding acreage totals for California. The first thing to notice is that the total area cultivated in lettuce for California is about 150 times larger than the corresponding area for Oregon and Washington combined. As of the most recent Agricultural Census, lettuce production in California was not in decline. Over the period 1997-2012, total lettuce acreage in California increased slightly; however, the mix of varieties has changed, as leaf and romaine lettuce gained acreage at the expense of head lettuce. Lettuce plantings have declined in more recent years in California as a result of the drought; data on this decline is not yet publicly available. It is too early to tell whether this decline is part of a longer-term trend, and it is not clear whether the Pacific Northwest is best positioned to capitalize on such a trend if it does exist. For a more detailed discussion of this issue, please see section C, paragraph 5 below.

5 For organic production data, however, in many cases the data is not broken out by variety and the aggregate across all lettuce varieties is reported. For the lettuce market as a whole, the sector tends to be divided into two top-level categories: leaf and romaine comprising a single category, and head lettuce comprising the other.

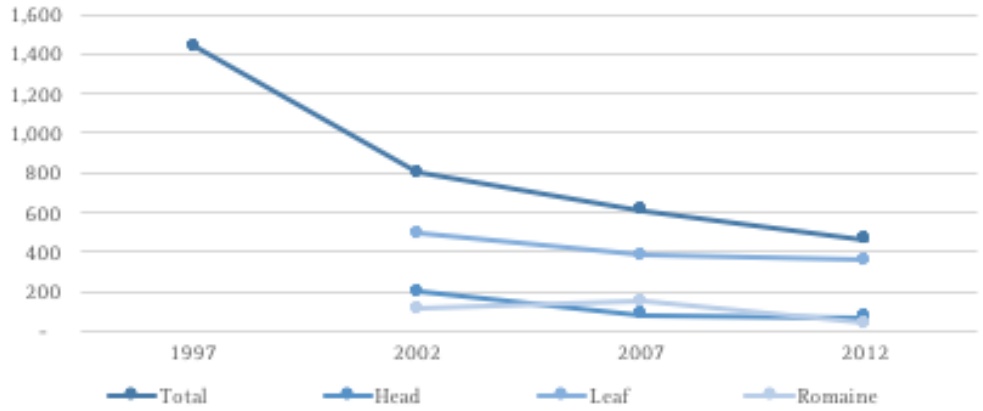

Figure 2. Lettuce: Total Acres Harvested, OR and WA, 1997-2012

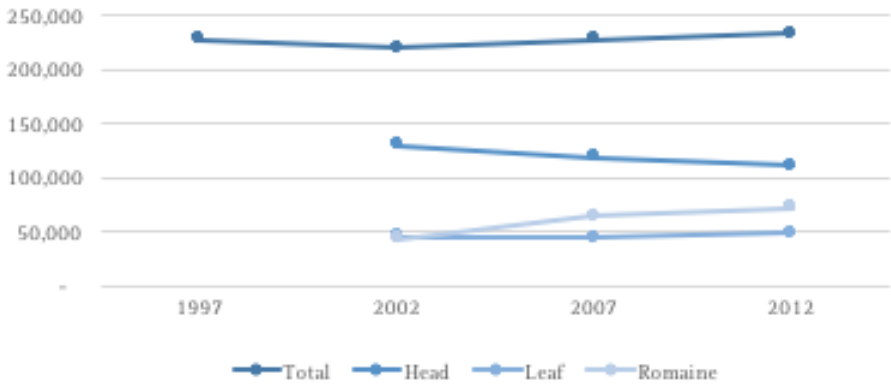

Figure 3. Lettuce: Total Acres Harvested, CA, 1997-2012

Turning to organic certified lettuce plantings, the picture looks very similar to the figures for lettuce as a whole: the Pacific Northwest region is dwarfed by California in acreage. Table 1 below provides data from the USDA Organic Survey on acreage, number of operations, production, and sales of organic certified lettuce (of all varieties) in the Pacific Northwest (Oregon and Washington), over the period 2008-2014. The data indicate that while acreage harvested and number of operations appears to have declined, production and sales have increased. Our contacts in the organics sector have expressed the informed opinion that changes in the reporting of organic lettuce data may account for these cross-cutting trends (Murray 2016). For example, organic growers may be reporting 2014 higher-value varieties of lettuce (such as mesclun) that were not reported in 2008.

	2008	2014
Acres Harvested	237	214
Number of Operations with Area Harvested	168	101
Production (cwt)	23,052	31,672
Total Sales ($)	$2,253,422	$2,621,842

Table 1. Organic Lettuce in the U.S. Pacific Northwest: Acreage, Production, and Sales (OR and WA), 2008-2014

Figure 4 and Figure 5 below display the total acres of organic certified lettuce (of all varieties) harvested for Oregon and Washington together, and California, over the period 2001-2011 (Economic Research Service 2013). The data from all three states cannot be displayed on the same graph, because the California figures are two orders of magnitude larger than those for Oregon and Washington. In 2014, Oregon and Washington cultivated 175 acres and 39 acres of organic lettuce, respectively. In that year, California cultivated 27,993 acres of organic lettuce: an area approximately 160 times larger than that of Oregon's organic lettuce crop, and 720 times larger than that of Washington. The Pacific Northwest simply does not compete with California on either organic or conventional lettuce. One of our farmer contacts expressed the inherent difficulty in marketing organic lettuce through even a regional distributor based in the Northwest, given that their 2-3 acres of lettuce are competing with farms in California that cultivate 1,000 acres of lettuce or more (Finkelstein 2016). The economies of scale in processing and purchasing are just too great for our region to compete with the giant to the south.

Figure 4 and Figure 5 display available data and linear trend lines (dotted lines) for organic lettuce acreage for the three states over the period 2000-2011 and 2014 (Economic Research Service 2013, NASS 2015).[6] Clearly, organic lettuce production in the Pacific Northwest grew over the period 2000-2010; however, between 2011 and 2014, acreage devoted to organic lettuce declined in both Northwest states. In California, by contrast, organic lettuce acreage continued to increase, albeit slowly. As of the most recent Census of Agriculture (2012), the Pacific Northwest is not gaining at California's expense.

It would take significant shifts in production for the Pacific Northwest region to become a significant producer of lettuce in comparison to its neighbor to the south. With the current drought and ongoing climate change affecting California, it is possible that the Pacific Northwest may eventually be able to gain share of the market for organic lettuce (and other leafy greens) at California's expense. However, as Section C, paragraph 5 below notes, the lower labor and overall production costs that prevail in Mexico makes that county a better candidate for production shifts than the Pacific Northwest, in which labor costs are comparable to those prevailing in California. Significant gains in this market for Pacific Northwest producers are unlikely in the short to medium run.

6 This chart combines two data sources: organic acreage data from state-level certifiers (2000-2011); and the most recent data from the USDA Organic Survey (2014).

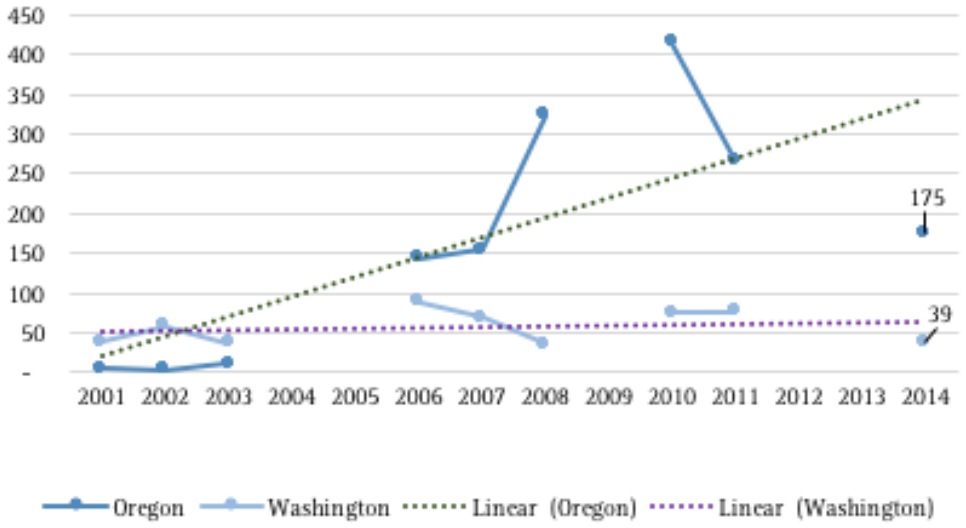

Figure 4. Organic Certified Lettuce: Total Acres Harvested, OR and WA, 2001–2011, 2014

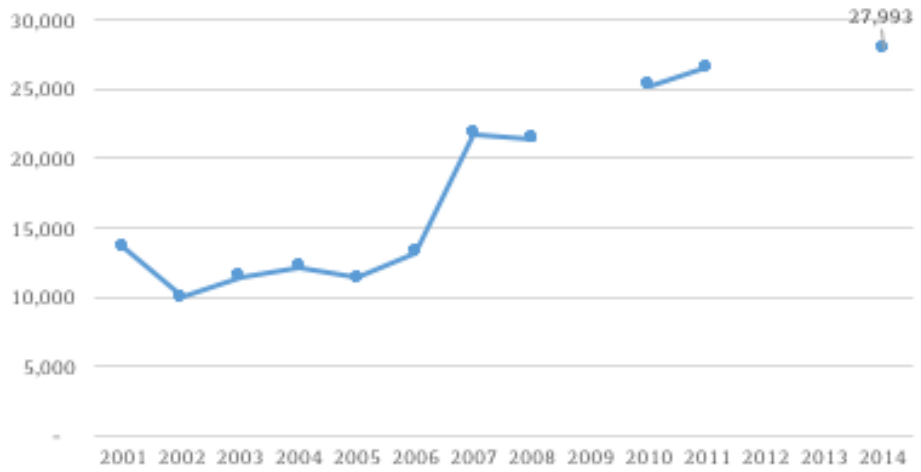

Figure 5. Organic Certified Lettuce: Total Acres Harvested, California, 2002–2011

Recent data on organic production from Washington State indicates that lettuce may not be the best vegetable crop in which to invest for the purposes of expanding organic production in general in the Pacific Northwest: other crops are simply more important. These data indicate that while lettuce is a significant organic crop compared to other leafy green vegetables, it is very insignificant in comparison to non-leafy vegetables.

Figure 6 below indicates the top five leafy green vegetables by certified organic acreage harvested in Washington State alone, between 2006 and 2014, using data sourced from the Washington State Department of Agriculture (WSDA) (Kirby and Granatstein 2015). The first thing to notice is that these figures contradict the USDA data displayed above: in 2010, for instance, while the USDA data indicates that Washington State grew 75 acres, the state-level data below indicate only 35 acres. This discrepancy is due to the different sources of the data: whereas the WSDA data was sourced from the organic certifiers, the USDA data was

sourced from growers. Washington State University professor David Granatstein notes that since the USDA data was unaudited, it is less reliable than the certifier data (Granatstein 2016) .

According to the state-level data below (Kirby and Granatstein 2015), as of 2013 lettuce was virtually tied with spinach as the leafy green vegetable crop with the largest area of organic certified acreage harvested (54 and 55 acres, respectively). But leafy greens themselves are not a significant organic crop category in the state. By way of a comparison, Figure 7 below provides acreage data on the top five organic certified vegetable crops of any type harvested in Washington between 2006-2014 (Kirby and Granatstein 2015). The top crops, sweet corn and peas, are each cultivated over areas two orders of magnitude larger than those of the top leafy green crops (7,330 acres and 4,776 acres respectively).

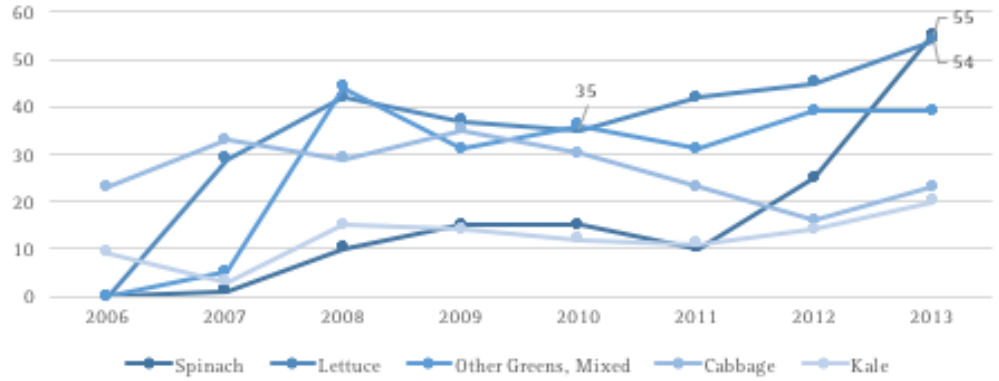

Figure 6. Top 5 Leafy Green Vegetables by Organic Acreage Harvested, WA, 2006-2014

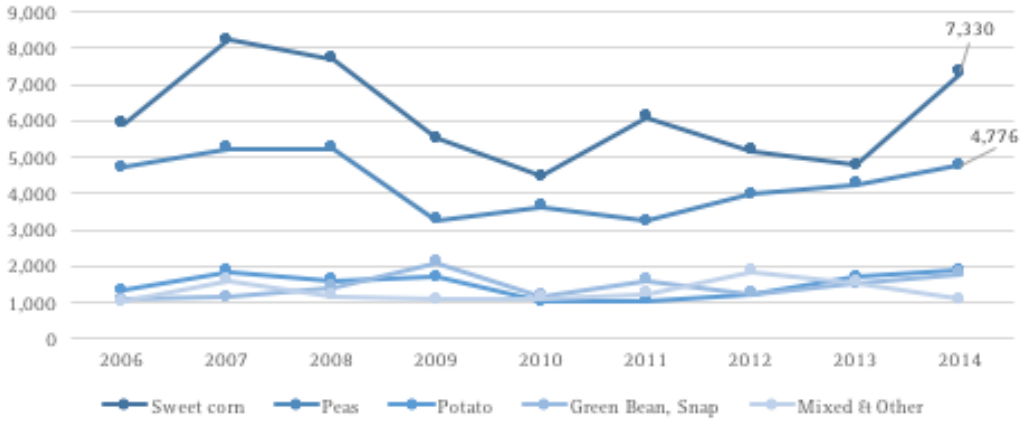

Figure 7. Top 5 Vegetable Crops by Organic Certified Acreage, WA, 2006-2014

To sum up, the data give us little reason to believe that leafy greens will play a significant role in the expansion of the organic vegetable sector in the Pacific Northwest.

Defining Lettuce of the Middle: Acreage in Production

This section provides a ballpark estimate of the acreage needed to reach Agriculture of the Middle for organic leaf and romaine lettuce in the Pacific Northwest. We use the rule of thumb of $250,000-$500,000 in gross sales to define Agriculture of the Middle in this context (McAdams 2015). We use a 2007 enterprise budget from Oregon State University for leaf lettuce (Seavert, et al. 2007) to estimate gross sales over plausible ranges of acreage and yields, assuming a price point of $25/carton, which is a conservative mid-range estimate for organic lettuce prices as of 2013, the latest year for which data is publicly available.[7] Table 2 below presents these data. The range of acreage associated with Agriculture of the Middle at each yield level is highlighted in gold. At a yield level of 650, for example, acreage of 20-30 acres planted in lettuce will be considered Agriculture of the Middle. At a higher yield of 950 cartons/acre, however, 15-20 acres will suffice. For conventional agriculture, assuming conservatively a price point of $15/carton and a yield of 950 cartons/acre, an Agriculture of the Middle farm would require a harvested area of 17-35 acres.

ACRES	YIELD (Cartons/Acre)						
	350	450	550	650	750	850	950
5	$43,750	$56,250	$68,750	$81,250	$93,750	$106,250	$118,750
10	$87,500	$112,500	$137,500	$162,500	$187,500	$212,500	$237,500
15	$131,250	$168,750	$206,250	$243,750	$281,250	$318,750	$356,250
20	$175,000	$225,000	$275,000	$325,000	$375,000	$425,000	$475,000
25	$218,750	$281,250	$343,750	$406,250	$468,750	$531,250	$593,750
30	$262,500	$337,500	$412,500	$487,500	$562,500	$637,500	$712,500
40	$350,000	$450,000	$550,000	$650,000	$750,000	$850,000	$950,000
50	$437,500	$562,500	$687,500	$812,500	$937,500	$1,062,500	$1,187,500

Table 2. Estimated Gross Sales at Varying Acreages and Yields, Organic Certified Leaf Lettuce, Assuming $25/Carton, Oregon (2007)

How prevalent are lettuce farms of Agriculture of the Middle size in the Pacific Northwest? Given the insignificance of the crop for this region, there do not exist public data by farm size class for the Pacific Northwest from the Census of Agriculture; hence, we do not know. However, there do exist public farm size data from California, which is the largest producer of lettuce that consumed in the Pacific Northwest. These data cover lettuce producers as a whole, and are not divided by variety (e.g. leaf, romaine) or production system (e.g. organic).

Data on lettuce farm size classes in California over the period 1997-2012 is presented below in Table 3 (NASS 2015). The most noticeable features of these data are the rise in the number of "micro" scale farms (0.1 – 0.9) acres, and the relative decline of the farms that fall into the size class category of Agriculture of the Middle for either organic or conventional. Farms under one acre increased from 32.1% to 60.9% of all farms (from 323 to 1,392 total farms).

7 Organic wholesale lettuce prices are measured by the carton (24 heads). These prices are highly volatile. The latest publicly available data on organic wholesale lettuce prices (2013) cite price points ranging from a low of $18.90 in April 2013 to a high of $43.00 in October 2013 (Economic Research Service 2014).

Farms between 15 and 50 acres declined from 8.3% of all lettuce farms in 1997 to 3.1% of all lettuce farms in 2012 (from 83 to 71 total farms). Meanwhile, the number (though not the percentage) of farms in the largest two categories, 750-999 acres and over 1000 acres, increased significantly between 1997 and 2012 (from 74 to 137 total farms).

Size class (ac)	1997	2002	2007	2012	% Operations (1997)	% Operations (2012)
0.1 - 0.9	323	254	428	1392	32.1%	60.9%
1.0 - 4.9	170	106	139	343	16.9%	15.0%
5.0 - 14.9	88	59	59	68	8.7%	3.0%
15.0 - 24.9	31	41	22	37	3.1%	1.6%
25.0 - 49.9	52	38	53	34	5.2%	1.5%
50.0 - 99.9	58	82	65	54	5.8%	2.4%
100 - 249	81	127	108	90	8.0%	3.9%
250-499	69	88	85	73	6.9%	3.2%
500-749	51	48	69	57	5.1%	2.5%
750-999	19	28	33	32	1.9%	1.4%
>1000	65	98	106	104	6.5%	4.6%

Table 3.
Number of Farms by Size Class, Lettuce, California, 1997-2012

Drivers of Supply

This section presents the major drivers of the supply of organic leafy green vegetables, with a product focus on lettuce as indicated above. These drivers are as follows: production costs, for which we will focus on leaf lettuce; crop diversity, for which we will examine the related category of mixed vegetable farming; emerging production systems, for which we will focus on possible opportunities in urban vertical and hydroponic farming; and alternative distribution systems, for which we will touch on (briefly) community supported agriculture (CSAs), home delivery services, and organic-focused distributors. We conclude by talking about the projected impacts of environmental changes on organic leafy green vegetable cropping systems in the Pacific Northwest, with reference to California.

Production Costs

Table 4 and Table 5 below present sample costs of production per carton and acre for conventional and organic leaf lettuce in the Willamette Valley (Oregon), based on a recent (2007) enterprise budget from Oregon State University (Seavert, et al. 2007).[8] The table below provides a simplified presentation of the OSU enterprise budget by grouping like inputs into categories. For example, all fertilizer, herbicide, and soil amendment line items are grouped under the category "Fertilizers and Inputs." Fixed costs, which include items such as land rent and equipment depreciation, are aggregated and presented as a single line item. Units of product are measured in cartons; each carton contains 24 heads of lettuce. Yield is assumed to be 900 cartons/acre for conventional production, and 650 cartons/acre for organic production.

8 Detailed budgets are presented in the Appendix, Table 10 and Table 11.

In the original budget, each cost item is divided into three components: labor, materials, and machinery/equipment. The model assumes that general labor is paid $10/hr, and tractor drivers are paid $12/hr. Labor is the largest input into the harvesting cost category, and a significant input into transplanting. Tables 4 and 5 below break out the labor component of each cost item from the total, and report costs per acre and per carton for each. For example, in Table 4 labor costs per acre are $1,616; labor costs per carton are $1.80. Fixed costs, such as depreciation of machinery, do not include labor as an input.

From Tables 4 and 5 below we see that packing and materials, harvesting, and transplanting are the three most important cost categories in both the conventional and the organic lettuce grower's budget. These cost categories are highlighted in gold.

Table 4. Cost Breakdown by Top Level Category, Conventional Leaf Lettuce, Oregon (2007)

Cost Category	Total Cost/ Acre	Labor Cost/ Acre	Total Cost/ Carton	Labor Cost/ Carton	% Total Cost	% Labor Cost
Field Preparation	$128.57	$43.65	$0.14	$0.05	2.5%	2.7%
Fertilizers and Inputs	$394.72	$24.67	$0.44	$0.03	7.6%	1.5%
Transplanting	$1,108.65	$205.38	$1.23	$0.23	21.4%	12.7%
Irrigation	$107.50	$22.50	$0.12	$0.03	2.1%	1.4%
Harvesting	$1,373.74	$1,248.00	$1.53	$1.39	26.5%	77.2%
Packing & Materials	$1,422.00	$72.00	$1.58	$0.08	27.4%	4.5%
Other Costs	$238.48	$-	$0.27	$-	4.6%	0.0%
Total variable costs	$4,773.66	$1,616.20	$5.30	$1.80	92.1%	100.0%
Total fixed costs	$409.59	$-	$0.46	$-	7.9%	0.0%
Total Costs	$5,183.25	$1,616.20	$5.76	$1.80	100.0%	100.0%

Table 5. Cost Breakdown by Top Level Category, Organic Leaf Lettuce, Oregon (2007)

Cost Category	Total Cost/Acre	Labor Cost/ Acre	Total Cost/ Carton	Labor Cost/ Carton	% Total Cost	% Labor Cost
Field Preparations	$503.36	$363.90	$0.77	$0.56	9.5%	17.9%
Fertilizer and Inputs	$593.35	$10.91	$0.91	$0.02	11.2%	0.5%
Transplanting	$844.42	$205.38	$1.30	$0.32	16.0%	10.1%
Irrigation	$107.50	$22.50	$0.17	$0.03	2.0%	1.1%
Organic Certification	$45.50	$-	$0.07	$-	0.9%	0.0%
Harvesting	$1,503.74	$1,378.00	$2.31	$2.12	28.4%	67.8%
Packing and Materials	$1,027.00	$52.00	$1.58	$0.08	19.4%	2.6%
Other Costs	$240.28	$-	$0.37	$-	4.5%	0.0%
Total variable costs	$4,865.15	$2,032.68	$7.49	$3.13	92.0%	100.0%
Total fixed costs	$423.83	$-	$0.65	$-	8.0%	0.0%
Total costs	$5,288.98	$2,032.68	$8.14	$3.13	100.0%	100.0%

Comparing the results of Tables 4 and 5, the similarities and the differences between the production costs of the two systems come into focus. First, we notice that the total costs per acre for the two budgets are quite similar: $5,183 for conventional, vs. $5,288 for organic: per-acre costs for organic production are only 2% higher than per-acre conventional costs. Second, labor costs per acre are significantly higher for organic than for conventional ($2,032 vs. $1,616). Since per-acre costs are similar between the two budgets, the higher unit cost of organic production is due primarily to the lower yields. Whereas the conventional budget assumes a yield of 900 cartons/acre, the organic budget assumes a lower yield of 650 cartons/acre. That crucial difference translates into a significant difference in per-carton production costs: organic production costs per carton are 41% higher than conventional ($8.14 vs. $5.76), and organic labor costs per carton are 74% higher than conventional ($3.13 vs. $1.80).

The percentage breakdown of costs across the two budgets also differs. Field preparation, fertilizers and inputs are more significant cost items for organic production than for conventional. For example, while field preparations for conventional production are $0.14/carton, for organic they are $0.77/carton. Labor costs comprise the majority of the difference in field preparation costs: they are $0.56 / carton for organic field preparation, compared to only $0.04 / carton for conventional field preparation. The task of weed control by hand, which is present as a line item in the organic but not conventional production budgets, is the primary reason for this difference. As one of our expert interviewees puts it, in organic agriculture the farmer is frequently "replacing chemicals with people" (Murray 2016).

For the category of fertilizers and inputs, likewise organic applications tend to be more expensive than their conventional counterparts. For instance, organic insecticide application costs $315/acre, as compared to $108/acre for conventional insecticide. The harvesting process is also somewhat more labor-intensive per acre, and much more labor-intensive per carton, for organic than conventional production. Harvest labor for organic production costs 10% more per acre than conventional ($1,378 vs. $1,248), and 53% more per carton than conventional ($2.12 vs. 1.38).

Despite the lower yields, organic agriculture often earns a higher profit per acre due to price premiums. This result has been shown to be true on average across the globe (Crowder and Reganold 2015, Philpott 2015), and can be shown to be true over plausible yields and price points for leaf lettuce in the Pacific Northwest. The budgets prepared by the OSU researchers (Seavert, et al. 2007) provide projections of estimated returns per acre based on varying combinations of per-acre yield and output price per carton. In general, with the exception of very low yields, organic returns tend to be somewhat higher than conventional, due to the higher price per carton that organic certified lettuce can obtain on the market.

Tables 6 and 7 below demonstrate this finding. The recent Oregon Food Infrastructure Gap Analysis analyzed national data on annual average conventional and organic prices from 2013, and found organic premiums that range between 55% and 105% (Ecotrust 2015). For example, suppose conventional leaf lettuce prices are $8.00/carton; organic prices will be between $12.00 and $16.00/carton. This range of premiums gives rise to higher returns to organic production over plausible yield ranges. At the lower premium price point of $12/carton, an organic yield of 550 cartons/acre or more will achieve competitive returns with a conventional yield of 800 cartons/acre. At the higher premium price point of $16/carton, an organic yield of 350 cartons/acre will achieve competitive returns with a conventional yield of 750 cartons/acre at the $8.00/carton price point.

Table 6. Estimated Returns per Acre over Total Costs by Yield and Price per Carton, Conventional Lettuce, Oregon (2007)

PRICE	YIELD						
	700	750	800	850	900	950	1000
$6.00	$(407)	$(251)	$(95)	$61	$217	$373	$529
$6.50	$(57)	$124	$305	$486	$667	$848	$1,029
$7.00	$293	$499	$705	$911	$1,117	$1,323	$1,529
$7.50	$643	$874	$1,105	$1,336	$1,567	$1,798	$2,029
$8.00	$993	$1,249	$1,505	$1,761	$2,017	$2,273	$2,529
$8.50	$1,343	$1,624	$1,905	$2,186	$2,467	$2,748	$3,029
$9.00	$1,693	$1,999	$2,305	$2,611	$2,917	$3,223	$3,529

Table 7. Estimated Returns per Acre over Total Costs by Yield and Price per Carton, Organic Lettuce, Oregon (2007)

PRICE	YIELD					
	350	450	550	650	750	850
$7.00	$(1,765)	$(1,423)	$(1,081)	$(739)	$(397)	$(55)
$8.00	$(1,415)	$(973)	$(531)	$(89)	$353	$795
$9.00	$(1,065)	$(523)	$19	$561	$1,103	$1,645
$10.00	$(715)	$(73)	$569	$1,211	$1,853	$2,495
$11.00	$(365)	$377	$1,119	$1,861	$2,603	$3,345
$12.00	$(15)	$827	$1,669	$2,511	$3,353	$4,195
$13.00	$335	$1,277	$2,219	$3,161	$4,103	$5,045
$14.00	$685	$1,727	$2,769	$3,811	$4,853	$5,895
$15.00	$1,035	$2,177	$3,319	$4,461	$5,603	$6,745
$16.00	$1,385	$2,627	$3,869	$5,111	$6,353	$7,595

How accurate or up-to-date are the yield assumptions presented in the budget above? USDA data indicates that average conventional yields in California in 2014 were 240 hundredweight/acre (cwt/ac) (NASS 2015).[9] Assuming each head of lettuce weighs about 1.04 lbs. (Meister 2004), average yields were 960 cartons/acre.[10]

9 Lettuce is not a significant enough crop in Oregon and Washington for yield data to be collected.

10 Since California's lettuce yields are exceptionally high, it is likely that conventional lettuce yields in Oregon and Washington are somewhat lower on average than this figure. An empirical study of lettuce yields in Washington State estimated that yields were 200 cwt/ac, or about 800 cartons/acre (IPM Center 2000).

We do not have directly publicly available data on organic lettuce yields in Oregon and Washington, but we can approximate yield data by dividing production by acreage, as given in Table 1 above. Based on these figures and using the above assumptions about the average weight of a head of lettuce, average yields were 592 cartons/acre in 2014. By these figures, if conventional lettuce sells at $8.00/carton, organic leaf lettuce would be competitive with conventional at $16.00/carton, but not $12.00/carton. Our contact at Helsing Junction Farm, a diversified vegetable farm that distributes its produce through community-supported agriculture (CSA), indicated that Helsing Junction's lettuce yields were 17,000 heads/acre (708 cartons/acre) on average (Finkelstein 2016). At that yield, Helsing Junction's lettuces would bring competitive returns with conventional lettuces at either $12.00/carton or $16.00/carton.

How consistent are organic price premiums over time? Wholesale price data from San Francisco over the period 2012-2013 reveal that on a monthly basis, premiums for organic lettuce in the San Francisco market tended to fluctuate over a considerably wider range than the 55% - 105% annual averages given in 2014 for the Infrastructure Report (Ecotrust 2015). For instance, the lowest organic premiums during this period, paid in February 2013, were $1.25/carton or 6%. The highest premiums, paid in November 2013, were $25.75/carton or 169% (Economic Research Service 2014).

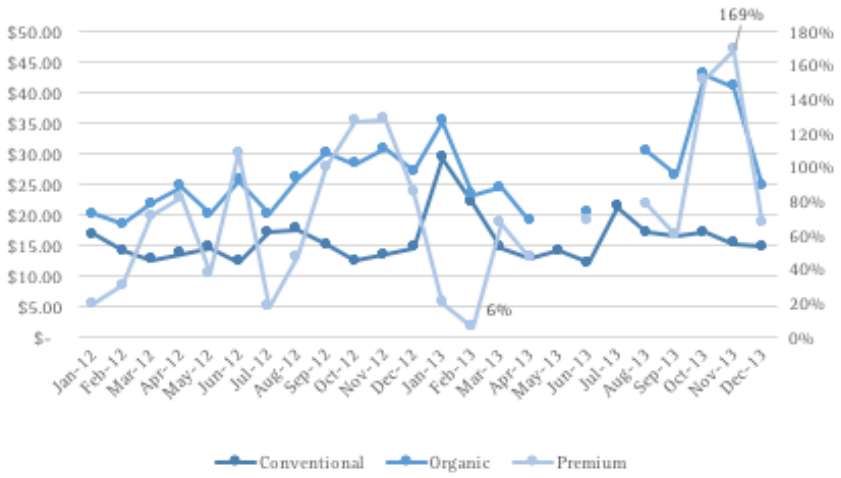

Figure 8. Wholesale Prices and Premiums in $/carton, Green leaf lettuce, Organic and Conventional, 24 units, San Francisco (2012-2013)

To sum up, we have good reason to believe that overall, returns to organic agriculture will be competitive, if not exceed, returns to conventional agriculture for leaf lettuce. However, volatile prices for both organic and conventional crops entail that this may not always be the case.

Crop Diversity: Organic Mixed Vegetable Farming in the Pacific Northwest

1. Mixed Vegetables: A Significant Sector

Mixed vegetable farming is more important, quantitatively, to organic agriculture in the Pacific Northwest, than single-crop farming for lettuce or other greens.[11] In the Pacific Northwest, mixed vegetable farming is the production system for leafy greens that is best suited to both alternative techniques of production, including cover cropping, crop rotation, and compost-based fertilizers, and alternative methods of distribution, such as CSAs, farmers' markets, farm-to-table restaurants, and related forms of locally and regionally oriented sourcing. Mixed vegetable farming includes not only leafy greens, but also root crops (e.g. beets, squash), brassicas (e.g. broccoli, cauliflower), tomatoes, beans, peas, and many other crop types. Mixed vegetables can be grown for fresh market or processing. Jason Bradford, managing director of farmland investment company Farmland LP, cites organic vegetables grown for processing, such as winter squash and green beans, as some of the most profitable organic crops grown under Farmland LP's model (Bradford 2016).

Organic mixed vegetable farming is more prevalent than single-crop lettuce in the Pacific Northwest. In 2011, a total of 4,111 acres of mixed vegetables were grown across Oregon and Washington (2,840 and 1,271 respectively), while a total of 19,077 were grown across California (Economic Research Service 2013). Data from USDA Economic Research Service (ERS) are presented below in Figure 9 and Figure 10. Data from 2009 for all states, as well as Washington State data from 2007, are missing from the data.

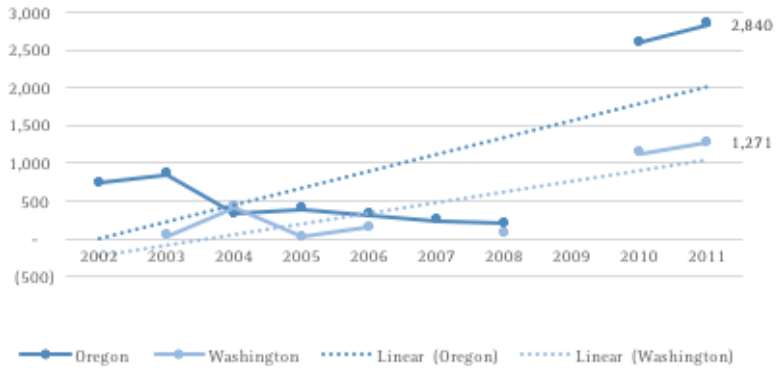

Figure 9. Organic Certified Mixed Vegetables: Total Acreage Harvested, Oregon and Washington, 2002-2011

11 Production systems for mixed vegetable farming are too diverse for an enterprise budget to provide an adequate guide.

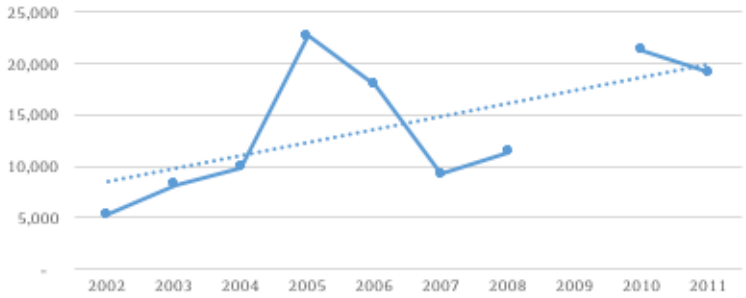

Figure 10. Organic Certified Mixed Vegetables: Total Acreage Harvested, California 2002–2011

2. Beyond Mixed Vegetables: Pasture and Rotations

Emerging organic agriculture systems go beyond mixed vegetables to include pasture/forage for livestock and grain crops in rotation. For example, Farmland LP, a farmland investment management company, focuses on a crop rotation that includes grains, livestock, and mixed vegetables. The company purchases conventional cropland, supervises its transition to organic certified land, and leases to organic livestock and crop farmers in succession. During the period of transition from conventional to organic, the company plants a pasture or forage crop, such as clover, and leases the land to livestock producers including sheep, pastured poultry, and grass-fed cattle. The presence of livestock in a rotational pattern on the soil restores its fertility through manure deposits while generating income for the farmer and the landowner. One difficulty Farmland LP has faced is finding markets for organic certified forage and pasture seed crops. According to the national organic standards, if organic forage or pasture is not available, than producers of organic meats and dairy are not required to source it; the certification standards do not spur demand in this case (Bradford 2016).

Farmland LP's financial and management model rests of the profitability of rotating livestock with vegetables and grains. Once the purchased farmland has been certified organic and fertility restored, Farmland LP leases plots to mixed vegetable and/or grain growers (Wichner 2012). When vegetable plots begin to lose soil fertility, the company rotates back to either a grain crop, or a cover crop plus livestock, as vegetable growers are transitioned to new, higher-fertility plots. The Farmland LP model rests on diversity of crops and livestock over time. Individual farmers, who lease land from the company, tend to specialize in either mixed vegetables and/or grains, or livestock, but not both (Bradford 2016). The model generates financial returns through two sources, lease income and asset appreciation; it is based on long-term land ownership (at least 30 years), and a vision of agriculture that seeks to increase crop diversity while minimizing external inputs (Wichner 2012).

Alternative Production Systems: Urban and Vertical Farming

In recent years, substantial press attention has been given to emerging alternative production systems for intensive, indoor farming that promise to produce high yields of a variety of leafy green crops to urban consumers, grown within cities. These systems have attracted attention from scientists, entrepreneurs, and investors as a potential future wave of urban agriculture. In this section, we introduce three of these production systems – hydroponic, aeroponic, and aquaponics. We discuss the most popular of these systems to date, hydroponics, in greater depth, and call attention to emerging aquaponics systems as well.

Hydroponic farming is an important alternative production system for leafy greens that can be installed indoors at a scale as small as 400 square feet, or the size of a garage. A hydroponic farm requires a growing medium, a fertilizer, and a lighting system — most commonly in the form of LED lights. Plants are then grown in shallow troughs of water with minerals added (H 2014) Similar to hydroponics, aeroponic vertical farming involves suspending plants in the air and then applying a nutrient-rich mist to the roots (H 2014). While it requires "sophisticated pumps and control systems," aeroponic farms can be more desirable than hydroponic production because they "waste very little water, are less susceptible to diseases, and [are] easier to automate" (H 2014).

In addition to these two methods, aquaponics is another option for urban farmers. Aquaponics combines aquaculture and hydroponics to produce crops (Perkins 2013). The basic process involves adding nitrogen-fixing bacteria to basins containing water and fish, which converts the ammonia in piscine waste to nitrates (Perkins 2013). Similar to hydroponics, plant roots soak up and use this nutritious solution to grow. While there are more moving parts than hydroponic growing, the advantage of aquaponics is that it requires less cleaning between harvests, since added bacteria often out-compete harmful germs (H 2014). In addition to healthy produce, an aquaponics system will raise sustainably-farmed fish that can be sold through local supply chains. The biggest challenge for commercial aquaponics companies is filtration: if waste collects, fish will die and the water's chemical balance will no longer be able to support plant growth (McCollow 2014). Some practitioners of hydroponics have expressed pessimism about aquaponics: one of our interviewees noted that balancing the nutrient needs of two separate systems, the fish and the greens, can be quite difficult and require intensive monitoring, without which there is a risk of compromising the nutritional integrity of both crops (Knaus 2016).

Mobius Microgreens, a Portland-based aquaponics start-up founded in 2013, has found a unique niche in the urban farming movement. Principal grower and founder Anne Phillip offers a commercial CSA, as well as modular systems that can be leased (or purchased) by consumers and then installed in restaurants, homes, or offices. For Anne, this model offers something new: by providing a "ready to go"

modular system "where you [can] grow a substantial amount of food in your house" (Phillip 2016) or business, Anne hopes to meet growing urban demand for nutrient-rich greens. Mobius is gaining notoriety in Portland; the company recently installed an aquaponics system at Airbnb's Portland headquarters, and recently began selling at New Seasons Market. Both Mobius and New Seasons Market plan to gauge consumer demand for aquaponically-grown produce, with the potential for a longer-term partnership. Anne believes customers will respond positively, particularly because aquaponics is "an incredibly safe, clean way to grow greens" (Phillip 2016). If so, supplying to New Seasons Markets (now with stores in Oregon, Washington and California) could present a valuable opportunity for Mobius to scale up commercial microgreens production. Möbius will also be participating in the Cascadia CleanTech Accelerator this summer, sponsored by Oregon BEST and the CleanTech Alliance in Washington.

In the short term, Anne aims to increase microgreens production to keep up with growing demand. Expanding her production to include mainstream crops like spinach or kale will depend on her revenue-stream and available capital, since those crops require more space, and therefore higher rent. For now, sticking with "proving the microgreens concept" (Phillip 2016) makes the most sense, as products sell at higher-value, are nutrient-dense for the consumer, and require little space to grow. At the same time, Anne sees her model as one that could, and should, be replicated: "The reason why I got involved in [aquaponics] was the idea of growing food in cities" (Phillip 2016). In the long-term, she envisions larger-scale installations and even "regional nodes" of urban aquaponics systems that could respond to local demand, stretching throughout Portland, Gresham, and even up to Seattle (Phillip 2016).

Startup costs for a small-scale commercial hydroponic operation can be in the ballpark of $80,000 - $100,000 (Knaus 2016). The process is labor-intensive; affording enough workers to harvest produce, especially leafy greens with a short shelf-life, can be a significant financial obstacle for large-scale vertical farmers (Rose 2015). Yields can be very high, though the estimated range of yields we discovered was wide. One of our sources cited a range of yields between 2-4 million pounds per year on a footprint as small as 30,000 square feet: 66 – 132 lbs/sf (Bhanoo 2014). Another source estimated that for a small commercial operation (2,000-3,000 sf) growing baby salad mix, yields of 20-30 lbs/sf could be expected (Knaus 2016).

As lighting technology continues to advance, hydroponic systems have become more sophisticated, promising higher yields. Multinational companies like Philips are actively developing LED lights that are "suitable and cost effective for vertical urban farming" (Bhanoo 2014) and this sector is continuing to grow. For example, the use of "pinkhouses" — lighting systems that emit only blue and red light — optimize growth by meeting the photosynthetic needs of plants while using less energy than regular LEDs. In some cases, vertical farmers noticed a 20% increase in plant growth as a result of using specialized lights (Doucleff 2013). The growth of the marijuana market for both

recreational and medical uses promises to expand the market for hydroponic lighting systems, holding the potential to spur ongoing technological innovation and dissemination.

In hydroponic farming, the crop choice often depends on the scale of production. Small-scale hydroponic farms tend to be most successful when growing high-priced crops such as microgreens. The basic microgreens mix consists of brassicas such as kale and broccoli, along with mustard greens, arugula, pea shoots, and sunflower shoots. Difficult-to-grow herbs, such as different varieties of basil, can also be grown profitably, due to their appeal to restaurants. Lower-priced crops, such as lettuce and herbs, tend to require larger indoor spaces. In major cities, large-scale urban indoor farms can be as large as 90,000 square feet. At this larger scale, while rental costs can become a major issue, one aquaponics company found that their vegetables grew "so fast that production [offset] the energy costs of the building, which was already only 40% of the energy used in the same square footage of Class A, high-rent office space" (McCollow 2014). Major crops in large-scale hydroponic farming include leafy greens, such as spinach, kale, swiss chard, and baby lettuce varieties, as well as herbs like parsley, basil, and cilantro (McCollow 2014). Due to their short growing cycle, leafy greens and herbs are perfectly suited to a vertical farming system (H 2014) with a turnaround as short as 35 days from seed to harvest (McCollow 2014). Since greens tend to wilt and lose nutritional value shortly after harvest, some commercial operations plan to create value-added products, like baby food or salad dressing, as a way to extend produce shelf life (Peters 2015).

Vertical hydroponic farming has three major environmental advantages over conventional agriculture. First, it is generally pesticide-free. Second, food safety issues are simplified due to the controlled and clean indoor environment. Environmental parameters (temperature, humidity, etc.) can be adjusted to levels that will reduce the risk of bacteria and disease, and make pests easier to manage. Third, hydroponic farming is extremely water efficient. New Jersey-based Aerofarms claims to use 95% less water than required to grow the same amount of leafy greens in a field (Peters 2015). Similarly, aquaponics systems use only 2% of the water required in traditional agriculture, as well as being a closed-loop, waste-free system with no unusable byproducts (McCollow 2014).

Since it is inherently pesticide-free, hydroponic crops can be grown in compliance with organic certification, but the process adds a layer of complexity: the use of organic certified fertilizers and growing mediums can lead to issues with growth of undesired biomass and can create a waste management problem. One grower we spoke with observed that the organic approach did not tend to resonate with practitioners of indoor, vertical hydroponic farming, given that such growing systems by their nature do not use pesticides or herbicides (Christensen 2016). Another grower contact expressed the opinion that organic and hydroponic systems were compatible; however, "it requires flexibility on both sides" (Knaus 2016). A working group at the National Organic Program has been formed to review restrictions around organic certification of hydroponic operations. If these restrictions are

relaxed, it will become easier for a hydroponic farm to attain organic certification, potentially expanding the market for hydroponic crops. The decision is set to be made in December 2016.

Commercial microgreens from Möbius Microfarms in Portland, OR

Microgreens and other hydroponic crops are not (yet) a mass market phenomenon. However, as more urban and vertical farms are able to produce high yields of leafy greens and reduce transportation distances, large retailers like Whole Foods are becoming a more common link in the supply chain (Bhanoo 2014). “The market is wide open right now,” says local hydroponic farming specialist David Knaus (Knaus 2016). One model, used by Pennsylvania-based hydroponic grower BrightFarms, involves building greenhouses near local retailers, who then sign long-term purchase agreements to buy vegetables grown by BrightFarms (Shemkus 2015). For a consumer, one of the biggest perks of vertical farming is its reliability (Bhanoo 2014). Protected from pests, weather, and drought in a highly-controlled environment, hydroponically-grown produce not only looks “pristine,” but is also guaranteed year-round (Bhanoo 2014).

Hydroponic production systems for specialty crops, such as microgreens, have been in use at commercial scale since the early 2000s. According to our grower contact, in Portland (Oregon) demand for specialty crops like microgreens is stable, but not increasing at an unusual rate (Christensen 2016). In addition, our contact observed that the market has become somewhat saturated with growers, while customer base has remained the same size. Consumers tend to perceive these crops as having a high price point, which can deter purchasing despite the high nutritional content of the crops (Christensen 2016).

Historically, microgreens and other hydroponic crops tend to sell through a few key market channels: restaurants, farmers’ markets, and specialty retail shops including food co-ops. Large-scale retailers tend not to stock microgreens; they are often associated with sprouts, which have faced food safety issues recently. Because sprouts are grown in a warm, humid environment, they often become a breeding ground for harmful bacteria. In recent years, both raw and lightly-cooked sprouts

have been associated with outbreaks of foodborne illnesses, mainly by E. coli and Salmonella (Newgent 2015). To minimize risk, consumers are encouraged to avoid raw sprouts when dining out, or to cook them fully at home. According to the Academy of Nutrition and Dietetics, "while there are approved plant treatments to reduce contamination, there is no way to guarantee all harmful bacteria are destroyed in raw sprouts" (Newgent 2015).

One social benefit of hydroponics and other methods of urban farming are their potential to boost urban renewal. Fred Haberman, founder of Urban Organics in St. Paul, Minnesota, saw the growth of his aquaponics company revitalize the neighborhood. According to Haberman,"Food deserts are business deserts; they're job deserts. What we're trying to do here is prove the economic viability of aquaponics in an area that needs urban renewal" (McCollow 2014). In Haberman's words, "when that happens, jobs are created directly and indirectly, and the culture of food in a particular community begins to change for the better" (McCollow 2014). In St. Paul, this vision is coming true: not long after Urban Organics took over an old brewery building, three restaurants opened nearby (McCollow 2014).

Indoor vertical farming operation being developed by Green Spirit Farms in Michigan

Critics oppose the tendency of large-scale hydroponic operations to promote their crops as "local" produce while they operate indoors, removed from the community. According to program director for Sustainable Agriculture Education, Poppy Davis, the problem is that if "[small] farmers are seen in their communities, selling into their communities, they're also going to be motivated to be accountable to their communities" (Shemkus 2015). Critics also question the relative nutrition of produce grown without soil or sunlight. While hydroponic crops may look flawless to a consumer, some believe "they can't possibly have the vitamins and minerals that lettuce grown in soil would have" (Whoriskey 2015).

With 70% of the population projected to live in cities by 2050, the need for large quantities of fresh produce in urban areas will only continue to grow. Hydroponic, vertical farming methods have been shown to

produce high yields of leafy greens, and successfully distribute them through local and mass market channels. Compared to traditional farms, which use as much as four times more energy processing, packaging, and transporting produce than growing them (H 2014), urban farmers can help increase efficiency within our food system. At the same time, an in-depth cost analysis is necessary (Bhanoo 2014). Urban farmers note that "it isn't clear yet how the carbon footprint [of hydroponic farming] compares to traditional farming of leafy greens" (Peters 2015). Hydroponics can also form part of a farming system that also includes open field-based agriculture, extending the growing season and providing the grower with supplemental income (Knaus 2016).

Alternative Distribution Systems: Organic Distributors, CSAs, and Home Delivery

Investors seeking to pay attention to the trajectory of organic vegetable markets should also pay attention to alternative distribution systems. Three of these systems are worth mentioning. The first system is closest to the conventional model of a distributor, but one that targets organic produce specifically. The second is the CSA model: the most community focused, it also tends to operate at the smallest scale with the greatest crop diversity at the individual farm level. The third model is the home delivery service, of which Washington-based Full Circle is the best existing example.

In general, organics experts seeking to expand market channels for producers in the Pacific Northwest have pointed to the importance of supply chain coordination in the market in general (Murray 2016). Oregon Tilth's 2014 analysis of the organic market in Oregon concluded that "collaborative relationships between growers and buyers (are) an effective way to coordinate supply and demand" (Murray and Chambers 2015). From the grower's perspective, it is desirable to establish supply chain relationships in advance of the growing season, before making cropping choices. Establishing relationships with buyers, particularly large ones (e.g. Safeway, Fred Meyer) can help growers make decisions not only about which crops it is profitable to grow, but at which scale (Murray 2016). These relationships are important, since fresh-market vegetable supply chains tend to operate by handshake agreement, in contrast to processed vegetables, in which fixed contracting is more common (Murray 2016).

The need for supply chain coordination extends beyond organic-focused market channels, and into the large-scale, mass retail market, which has consistently increased its sourcing of organic certified produce as demand for organics has grown (Dimitri and Greene 2002). Currently, there is no consistent forum, conference, or clearinghouse for producers of organic crops to network and establish relationships with large-scale, conventional buyers and retailers of fresh produce. These relationships are often formed at trade conferences such as the Pacific Northwest Vegetable Association; however, the coordination needs of producers are much greater than what an individual industry event or industry-wide association can provide, given the dominance of conventional and large-scale agriculture in the industry as a whole.

1. Organic Distributors: Organically Grown Company

There are a small number of organic-focused produce distributors in the Pacific Northwest that work primarily with organic producers of vegetables, fruits, tree nuts, and other related crops. Organically Grown Company (OGC), a farmer-owned business in operation consistently since 1978, is perhaps the foremost distributor in this category. While some broadline distributors may in fact be moving a larger volume of organic product than OGC, the latter company stands out for its commitment to organic agriculture and relationship-based approach. OGC sources from approximately 340 suppliers in the Pacific Northwest and California, ranging from 3 acres to 25,000 acres. OGC's customers are primarily retailers, well-positioned to capture the organic price-premium (unlike institutional foodservice or restaurant). The company's most important crops by value are avocados, berries, broccoli, bananas, potatoes, onions, and citrus; of these, citrus, avocados, and berries are growing the fastest. OGC's revenue has grown over the last three years, but its supplier list is stable; it is not constrained by available financing (Organically Grown Company 2016).

OGC's company practices exemplify the kind of supply chain coordination cited by organic education specialist Tanya Murray. The company provides a suite of services to their suppliers that include production planning, logistics, food safety, consulting on product quality and packaging, seed development, advocacy, flexible and customized purchasing programs that reflect the grower's needs, and many more (Murray and Chambers 2015). Prices are often negotiated with supplier farms; in some cases, OGC simply accepts the price that the supplier offers. OGC Sustainability Manager Kimberlee Chambers notes, "(Organic produce) is a relationship-based industry. Once we have a relationship with you, we are going to do everything we can to maintain and enhance that relationship... these types of relationships can take years to cultivate" (Murray and Chambers 2015).
The major sources of information about OGC are its weekly Market Reports (Organically Grown Company 2016) and annual Sustainability Report (Organically Grown Company 2015).

2. Community Supported Agriculture (CSA)

Community-supported agriculture (CSA) is a membership-based model for food distribution, in which members purchase shares of the produce of a farm in advance of the harvest. By purchasing shares in advance, members share in the risks of the agriculture enterprise. CSAs have become an increasingly important model both regionally and nationally: from the founding of the model in 1986, there were 6,200 documented CSA farms by 2014 (Paul 2015). The majority of this growth has taken place since 2009. While CSAs still represent less than 1% of U.S. farms, their profile and popularity have become more significant than their relatively small number and size would suggest. The USDA directory of CSAs lists 26 such farms in Oregon, and 23 in Washington (Agricultural Marketing Service 2016). The true number is probably higher due to incomplete reporting; the Portland Area CSA Coalition website lists 44 separate CSAs delivering to the Portland

metro area alone (Portland Area CSA Coalition 2016). CSA farms tend to grow mixed vegetables, offering consumers a diverse basket of produce. They may also raise livestock and offer dairy, meat, and eggs as part of the offering; for example, Willamette Valley-based Winter Green Farm offers grass-fed beef in addition to mixed vegetables, fruits, and herbs (Portland Area CSA Coalition 2016).

Though CSAs on average return higher net income than non-CSA farms of comparable size (Paul 2015), returns to these farms are still very low: a recent study conducted in western Massachusetts found that most of the CSA farms examined paid below commonly accepted living wages (Paul 2015). A comparable study for Pacific Northwest CSAs does not exist. The Massachusetts study found that CSAs improve young and beginning farmers' access to land and working capital; CSA farming was also shown to lead to increased environmental benefits such as soil and water quality (Paul 2015).

We spoke with two separate CSA farmers in the course of conducting this research; the next two paragraphs summarize our findings from these interviews. The main conclusions we can tentatively draw from these interviews are as follows. First, diversity is very important to the CSA business model. Second, for these farms, the CSA itself is the dominant market channel. Third, neither of these farms is growing consistently or rapidly, though both have been in existence for over a decade and appear to be stable.

Helsing Junction Farm is a 45-acre CSA with 1,000 members based in Rochester, WA (near Olympia), in operation since 1992; the farm offers delivery to Seattle, Portland, Olympia, and several other cities and towns in the Pacific Northwest. The farm employs about 5 year-round workers, and hires 15-20 seasonal workers during the summer months. An estimated 80% of the farm's sales come from the CSA, and the rest from sales to wholesalers and distributors (Finkelstein 2016). Helsing is a classic mixed vegetable CSA farm that grows "every vegetable," in the estimation of the farm manager (Finkelstein 2016). They grow several leafy green crops, including lettuce, arugula, spinach, and tatsoi. They tend to cultivate about 2-3 acres in lettuce, at an estimated average yield of 17,000 heads/acre (708 cartons/acre). Lettuce varieties include green and red butter, green and red leaf, iceberg, and romaine (Finkelstein 2016). Helsing struggles with the high markups and exclusive nature of most distribution contracts; the exclusive contracts often prohibit Helsing from selling directly to the same stores that source from the distributor (Finkelstein 2016). Helsing has grown by about 5-8 acres over the last three years, but plans not to grow anymore, as they have run out of available farmland.

Boistfort Valley Farm is another mixed vegetable CSA of approximately 50 acres, located in Curtis, WA, in operation for about 15 years and certified organic for 13 years (Heidi 2016). The farm employs 3 year-round staff; during the long summer season (late June through November) they employ about 20 staff. The farm grows mixed vegetables in a 5-year rotation, including multiple leafy green crops. Leafy greens include lettuce, arugula, mizuna, bok choi, four varieties

of kale, and red and gold Swiss chard. They grow multiple varieties of lettuce over ½ acre, including Romaine/Bibb cross, green and red leaf, green and red butter, romaine, red oak, and occasionally a specialty lettuce (e.g. French Crisp, Lollo Rossa). Their non-leafy vegetable offerings include carrots, beets, squash, beans, and corn. The majority of the farm's sales come from the CSA and farmers' markets; they have on occasion sold to restaurants. They have not grown in acreage over the last 3 years.

CSA production at Boistfort Valley Farm

3. Home Delivery: Full Circle

Over the past decade, home delivery services have become an important distribution channel for organic produce. Examples include Portland's Organics to You, northern California's Farm Fresh to You, and Seattle's Full Circle. Full Circle is probably the largest of the home delivery services targeting the Northwest, with approximately 8,000 households served spanning five states – Washington, Oregon, Alaska, Idaho, and California. The company's stated mission is "to change the food system.... Organic and sustainable farming, transparency, and access to healthy food for everyone" (Ostrom and Stevenson 2013). Full Circle's distribution channels have included farmers' markets, CSA boxes, restaurants, wholesalers, and (some) institutions such as hospitals: it now focuses primarily on home delivery.

From its beginnings as a five-acre organic farm in 1996, Full Circle has split into two separate companies, a 130-acre farm focusing on producing organic vegetables, and a distribution service focusing on home delivery of organics from a broad and deep network of partner firms spanning five states. The distribution company offers a weekly box of assorted produce at a range of sizes, complemented by offerings of milk, cheese, eggs, bread, and a variety of meat products. As of

2012, the company had attained revenues of over $20 million and employed 150 people (Ostrom and Stevenson 2013). All of the products Full Circle sources are certified organic.

The story of Full Circle is worth exploring in some detail, since it sheds light on the dynamics of the organic produce market in the Pacific Northwest. Until 2014, Full Circle had been growing at a breakneck pace – average annual growth of 20%-40% since the recession. In 2014, the company conducted a capital raising effort with a private equity firm, which fell through at the eleventh hour; 2015 has seen a course correction involving a small contraction of the firm (~6%), a few layoffs, and a strong push for reduction in overhead, general and administrative (G&A), and variable operating costs. The farm's current size (130 acres) is down from a peak of over 400 acres (Ostrom and Stevenson 2013). Andrew Stout, CEO of Full Circle, described the current phase of the company as "Right sizing; we are profitable, stable and strong, doing what we do on a solid base...we've been around 20 years, and we plan to be around for a while" (Stout 2016). The firm has been through one Series A round (venture capital) funding; aside from that round, it has been self-financed. In general, the company prefers not to be dependent on outside capital.

Increasing competition in regional food markets was probably the major factor behind Full Circle's course correction. The rise of prepared, ready to eat meals, food carts, and the expansion of Amazon into food sales and delivery have all affected Full Circle's revenue and bottom line (Stout 2016). The general outlook for food investment, Stout told me, is somewhat bearish: "There's been an amazing amount of investment in the food space over the last couple years, and we see that shrinking now" (Stout 2016).

Full Circle's crop offerings tend to mirror the market for fresh vegetables as a whole: there is no single dominant crop. Broccoli, carrots, cucumbers, celery, beans, onions, and potatoes are the top vegetable crops; demand for leafy greens is growing. The company's approach, Stout says, is "to create a rounded offering with some seasonal vegetables, fruits, greens, and allium... filling your basket for recipes" (Stout 2016).

To source this level of diversity year-round, Full Circle works with a large network of individual producers and distributors. As of 2012, the company had about 30 "key partner" farms and relationships with 50 – 75 other farms (Ostrom and Stevenson 2013). Individual farms are profiled on the company's website. Most of the partner farms grow more than one crop, but the farms tend to be larger, and not as diverse, as the typical diversified CSA, direct-marketing farm; such farms tend to sell product at price points that the Full Circle model cannot support (Stout 2016). CEO Stout: "We look for quality first, at a large enough volume that we can make it work; if there's a supplier that has multiple (crops) – great! Generally they do... have a number of items." (Stout 2016) The company coordinates cropping plans with some, but not most, of its growers, preferring to remain flexible based on what the grower offers. That flexibility supports the financial stability of

the suppliers; for example, Full Circle will accept produce that does not meet mainstream retailers' standards of appearance and size (Stout 2016). In the Northwest, Full Circle also works with distributors Organically Grown Company (see above) and Charlie's Produce. Finally, the company has built a network of relationships with small-scale producers of dairy, eggs, baked goods, meat, seafood, and tofu.

Full Circle offers pricing based on a cost-plus model, with quality taken into account. The purchase price tends to reflect what the grower is offering; the range of prices offered tends to be set by the largest purchasers. Says CEO Stout: "The (price) is somewhat already selected by the marketplace, dominated by the wholesale distribution market – which is dominated by California. Nobody is working too far outside the boundaries: Safeway sets the tone. We're not dominant on price" (Stout 2016). The retail price of the core product, the weekly produce box, reflects the company's offering of a premium, organic certified product: Stout acknowledges, "our product is not necessarily ready for the masses: high-end organic artisanal, bought online" (Stout 2016). At the same time, produce at an unusually high price point cannot be supported by the customer base. "If someone wants to sell something at twice the (usual) price, you can buy a little, but not a lot. We make sure we have a healthy margin ... so we aren't forced to buy the cheapest. We add value to the product to make that margin" (Stout 2016).

The next step for Full Circle, according to CEO Stout, is to innovate in the product line. "We're primarily a curated grocer; now we want to expand more into prepared foods. There's a lot of opportunity there: we're investing in commercial kitchen space and partnerships to realize those product lines, develop and broaden our producer reach" (Stout 2016). By remaining, as Stout puts it, "nimble in the marketplace," Full Circle promises to remain a significant company in the organic food space; home delivery of organic food, whether ingredients or prepared, promises to remain an important market niche.

Environmental Change: A Market Opportunity?

The current drought in California, combined with ongoing climate change leading to an increase in average temperatures throughout North America, have led observers of agriculture to wonder whether the Pacific Northwest will become a prime destination for farmers and agribusiness investors fleeing California's parched and overheated landscape. This section examines the current decline in California's vegetable production and explores the possibility of the Pacific Northwest becoming the "next California."

1. The Decline of California Vegetable Production

Over the last four years, drought has led to a consistent decline in the state of California's vegetable production. Widespread dependence on California's produce supply has made this crisis particularly alarming, revealing weaknesses in our food system on a national scale. As a result of multi-year drought, a range of consequences have been put in motion: from obvious water shortages, to an estimated 27 California-

based agriculture companies, employing more than 23,500 workers, moving crop production outside the U.S. (Wheat 2015). Overall, the challenges facing California point to the need for large-scale investment in diversified vegetable production, both locally and regionally, to relieve pressure on an unsustainable system. The Pacific Northwest may be able to capitalize on the decline of California vegetable agriculture, but it remains too early to tell whether the environmental and market changes that have led to this decline present a significant opportunity for the region.

According to a 2015 study by the Pacific Institute, vegetable production in California has been declining since 2000 (Cooley et. al. 2015). This change reflects a long-term trend toward higher value fruit and nut crops, but has been accelerating throughout the recent drought as farmers have been forced to fallow acreage or adjust planting plans based on scarce water resources and warming temperatures. Additionally, citing labor and regulatory issues along with the drought and demand for year-round production, some western U.S. growers have already ventured south to Mexico and beyond (Wheat 2015). A survey by Western Growers estimates that crops grown outside of the U.S. "represent a potential loss of nearly $1 billion annually in direct economic activity for California" (Wheat 2015). While the drought appears to have had little effect on California's agricultural revenue – "2013 and 2014 [were] the highest and second highest, respectively, in California history" (Cooley et. al. 2015) – these numbers are misleading. Pacific Institute's 2015 study explains that California's "high crop revenue can largely be attributed to the expansion of fruit and nut crop acreage and strong market prices" (Cooley et. al. 2015), not robust production of vegetables or leafy greens.

Currently, California is first in U.S. production of romaine lettuce (76%), leaf lettuce (86%), head lettuce (75%), and spinach (63%), but according to the USDA's Economic Research Service, "reports out of California indicate fewer plantings for short-season crops such as lettuce, particularly in the San Joaquin Valley where groundwater is less available and water allocations have been curtailed" (Perez et. al. 2015). Two thirds of California's lettuce is grown in the central coast region which, despite illusions that crops are continuing to thrive during drought, is actually dependent on aquifers that are in a major state of overdraft, with nitrate contamination concerns looming. The situation was illustrated on the front page of the regional agricultural newspaper, the Capital Press, on February 26, 2016:

While uncertainty still exists about the long-term impacts of California's drought and climate change, it is clear that agricultural systems need to focus on resiliency (Knox and Scheuring 1991), for which organic farming methods are better suited than conventional methods (see section B above for more details).

2. The Need for Infrastructure

To take advantage of the opportunity presented by California's decline, building agricultural infrastructure in the Pacific Northwest would be necessary. Existing data demonstrates a general decline in the availability of post-harvest processing infrastructure in the Pacific Northwest. Table 8 and Table 9 below present data from the U.S. Census Bureau's County Business Patterns dataset for Postharvest Crop Activities excluding cotton-ginning (NAICS category 115114) in two locations: the U.S. Pacific Northwest (Oregon and Washington) and California (U.S. Census Bureau 2015). From 2000-2013, the number of postharvest crop facilities declined by 8% overall in the Pacific Northwest, and only 3% in California. Notably, the number of large facilities (50 or more employees) in California increased by 4%, and the number of small facilities (1-4 employees) increased by 6%. By comparison, mid-size facilities (10-19 employees) increased by 23% in the Pacific Northwest, while large facilities decreased by 8%.

Table 8.
Number of Postharvest Crop Facilities (except cotton-ginning), U.S. Pacific Northwest (Oregon and Washington), 2000-2013

Number of Employees	2000	2013	Difference
1-4	39	36	-8%
5-9	13	12	-8%
10-19	10	13	23%
20-49	14	9	-56%
50 or more	27	25	-8%
Total	103	95	-8%

Source: (U.S. Census Bureau 2015)

Table 9.
Number of Postharvest Crop Facilities (except cotton-ginning), California, 2000-2013

Number of Employees	2000	2013	Difference
1-4	68	72	6%
5-9	43	35	-23%
10-19	44	43	-2%
20-49	48	44	-9%
50 or more	50	52	4%
Total	253	246	-3%

Source: (U.S. Census Bureau 2015)

3. Regionalizing the Food System

The California drought has illuminated the long-term dangers of relying on one region as the primary source for produce. Looking at water use alone, California's agricultural economy has reached a tipping point with regard to sustainability: "Continued groundwater overdraft, while reducing the economic impacts of the drought for the agricultural sector now, has shifted the burden to others... future generations will pay more to access groundwater from greater depths and have less water available to meet their needs" (Cooley et. al. 2015). With this issue in mind, some argue that "it's time to 'de-Californify' the nation's supply of fruits and [vegetables], to make it more diversified, resilient, and ready for a changing climate" (Philpott 2015).

Various regions of the United States have been proposed as candidates for a revival of diversified vegetable production. Food and Agriculture reporter Tom Philpott has suggested "the Corn Belt states of the Midwest as a prime candidate for a veggie revival" (Philpott 2015). Referencing a 2010 Iowa State University study, Philpott notes that transferring "about a quarter million acres from corn and soy to veggies could have a huge impact on regional supply" (Philpott 2015). In addition to the Midwest, southern "Cotton Belt" states could also boost domestic vegetable supply, especially as the cotton industry suffers from a combination of low global trading prices, water shortages, and plagues of herbicide-tolerant weeds (Philpott 2015). Overall, investing in regional diversified vegetable production could not only limit widespread dependency on an unsustainable California market, but also encourage a necessary shift: from thinking of California produce as the only option, to supporting both new and local supply chains.

Prospects for the Pacific Northwest's ability to capture market share from California remain uncertain. If the food system undergoes

regionalization, as authors such as Philpott advocate, then some production is likely to shift northward as the region supplies a greater share of its own demand for produce. However, these northward shifts are likely to benefit primarily the larger players in the marketplace. Andrew Stout, CEO of Full Circle: "I see bigger agribusiness plays in the Willamette and Columbia Valleys; more established and larger West Coast farms are expanding acreage. It's smart to play different regions: moving up here is another hedge against seasonality. When you're at (large) scale, you can have a chance to (capitalize on) variances in climate." (Stout 2016). At the same time, climate change is likely to affect the Pacific Northwest significantly as well, and not necessarily in positive ways. Our contact at Organically Grown Company cited climate change, and the resulting unpredictable weather, as a major challenge facing organic fruit and vegetable producers and markets in the Pacific Northwest (Organically Grown Company 2016).

Existing changes in regional demand for farmland are related to multiple factors, of which climate change and drought are just two of many; shifting demand for food products is another. Jason Bradford of Farmland LP, which invests in farmland in the Willamette Valley as well as California, notes a trend towards increasing demand for irrigated cropland in the Willamette Valley. "This could be due to the drought in California and the need for more secure water rights," he suggests (Bradford 2016). This demand for farmland could also be driven by increased demand for blueberries and hazelnuts, both of which require irrigation water (especially blueberries). The two factors might be interrelated: drought in California may be influencing growers to switch crops and regions, from California-based almonds to Oregon-based hazelnuts.

Investment management company Equilibrium Capital, which invests in real assets with an environmental focus, has identified permanent crops - which include blueberries and hazelnuts – as a profitable investment opportunity (Equilibrium Capital 2013). Equilibrium Capital finds that the average rate of return for permanent crops exceeds that of row crops (such as corn, wheat, and soy) over the last 20 years. The authors argue, "Fragmented and capital constrained, the permanent crop industry is poised for institutional investment by transitioning to professional management and scaling operations" (Equilibrium Capital 2013). The Pacific Northwest's array of permanent crops, which include apples, pears, grapes, and a variety of berries and tree nuts, may be well positioned to attract such investment.

Moving forward, there is a large data gap with regard to California's agricultural future. While much speculation exists, data that projects long-term economic impacts and usable climate models are lacking. For example, the Pacific Institute study notes that "economic costs... are not included in this analysis, and no good estimate is available" (Cooley et. al.), referring to the indirect impacts of groundwater overdraft. Overall, more research and cost analyses are needed to find long-term solutions for California's agricultural economy, and to address the growing demand for vegetables and leafy greens across the U.S., including the Pacific Northwest.

Drivers of Demand

Consumer Trends: Searching For the "Next Big Thing"

Consumer trends play an important role in determining demand for organic greens. Among greens crops, none have garnered more media attention in recent years than kale. It has adorned T-shirts, been featured on the menus of hip restaurants in urban centers, and spawned a new and popular processed food product, kale chips. The kale boom has given rise to the search for the "next big thing" in the greens industry. For example, in October 2015, a poll appeared on the website of popular physician and television personality Dr. Mehmet Oz entitled "What's the Next Kale?" (Dr. Oz 2015) It had only three options: broccoli leaf (which won), kohlrabi (the second place), and dulse (see below). While the results of the poll may not have been terribly informative, the existence of the poll did point to a key dimension of the market for leafy greens, which also reflects to a great degree the U.S. food market as a whole: it is driven by trends (Irwin 2014).

Dulse, a lettuce-like sea vegetable red in color, has recently emerged as another contender for the Pacific Northwest's next trendy vegetable (Herring 2015). Considered by some observers to be a "superfood," dulse is rich in numerous nutrients including minerals, vitamins, antioxidants, and proteins. It's also a versatile vegetable that can be used in salads, stir frys, snack foods, and veggie burgers, among other categories; it's said to taste somewhat like bacon when fried. Though it grows wild as a seaweed in the north Pacific, it can also be farmed indoors, in saltwater tanks. Dulse has attracted attention at Oregon State University's Food Innovation Center, Marine Science Center, and College of Business; it's been supported by the Oregon Department of Agriculture, and was recently featured at the Fancy Food Show in San Francisco. In 2015, dulse was listed as a specialty crop by the USDA.

Environmental and Social Values

In general, consumers have revealed willingness to pay (WTP) price premiums for organic food, both in the marketplace and in experimental economic studies (Strzok and Huffman 2012). Consumers' stated reasons for higher WTP include concern for the natural environment, food safety, nutrition / health, freshness, and taste (Adams and Salois 2010). Since the national organic certification standards were adopted by the U.S. Department of Agriculture in 2002, many consumers that value environmental protection and social equity have changed their allegiances from organic certified to local food. Beginning in the late 1990s, studies on consumer WTP began to find an increasing preference of consumers for local over organic food; for instance, a 2000 study in Colorado found that the average WTP premium for organic foods was 6.64%, while for local it was 9.37% (Adams and Salois 2010). Existing research indicates that this shift has occurred due to perceptions that the national (USDA) organic certification ignores fundamental values of social equity, community, biodiversity, and broader environmental concerns beyond the minimal exclusion of chemical inputs.

The Rise of Mass Market Organic

The increased availability of organic products through mass-market channels is another factor driving increases in consumer demand. Mass retailers such as Wal-Mart, Krogers, and Costco now increasingly source organic products. Jason Bradford of Farmland LP notes, "There's a schism in the organic market; it's bifurcating. The (mass retailers) are some of the largest sellers of organics now, but they don't care what their source is; so organic imports are increasing, out of season from the other hemisphere." (Bradford 2016)

In general, the value of organic certified imports exceeds that of organic exports: $1.38 billion vs. $537 million in 2013 (Economic Research Service 2014). Many organic imports (such as bananas and coffee) are not produced in significant quantities within the United States. Both organic imports and exports are increasing over time. Figure 11 displays the trajectory of the organic certified imports and exports for which public data is collected, over the time period for which such data is available (2011-2013).[12] The most significant five imported organic products are bananas, coffee, red and white wine, and soybeans. Organic bananas are the top imported crop, with $259 million in imports in 2013. The top imported organic vegetable crop in 2013 was avocado, with $19 million in imports (Economic Research Service 2014).

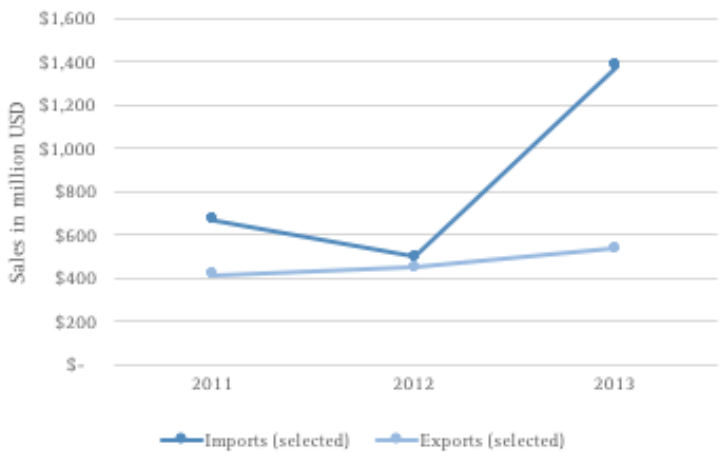

Figure 11. Value of Organic Certified Imports and Exports, National (U.S.), 2011-2013

12 The USDA National Organic Program began collecting data on organic exports and imports in 2011, and do not display publicly data from 2014 or after (Economic Research Service 2014).

Figure 12 presents data on the top five U.S. organic certified export crops by value: they are apples, lettuce, grapes, spinach, and strawberries. [13] The lettuce series includes leaf and romaine only, not head lettuce. The lettuce and spinach counted series are exported in both fresh and chilled form; apples, grapes, and strawberries counted are exported fresh only (Economic Research Service 2014).

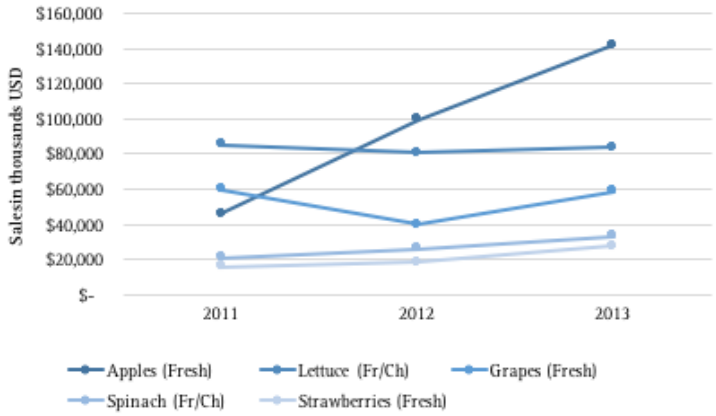

Figure 12.
Top Five Organic Certified Exports by Value, National (U.S.), 2011-2013

Conclusion and Recommendations

The organic vegetable market is defined by steady growth in production and market share, regionally as well as nationally (Stout 2016). This growth is spread across a wide variety of crops, production systems, and distribution channels, as well as imports from other countries. As the organic market grows, it appears to be diversifying and deepening. Jason Bradford of Farmland LP observes: "I don't see the organic market slowing down; it may be getting more sophisticated" (Bradford 2016). Some of this diversity can be traced to the expansion of mass market channels; but growth in diverse, locally and regionally oriented production and distribution is taking place as well.

Organic vegetables form a diverse market, with a wide range of production and distribution systems. Leafy greens are not the major crop category within the organic vegetable market; greens, however, do play an important role in diversified, mixed vegetable cropping systems, as well as alternative distribution systems that include community-supported agriculture (CSA).

Quantitatively, the consumer market for organic vegetables in the Pacific Northwest is currently dominated by large-scale commercial organic production from California, sold through mainstream market channels. While California's dominance may be waning under pressures of drought and climate change, the Pacific Northwest will face stiff competition from Mexico in capturing market share in organic vegetables. On the producer side, organic vegetables in the Pacific Northwest tend not to be leafy greens; data from Washington State certifiers indicate that sweet corn, peas, and green beans are all more important in terms of acreage.

13 Data on organic imports are not of sufficient quality to display on a time series graph such as the one I display for exports above.

Organic leaf lettuce, our product focus, commands price premiums over conventionally grown leaf lettuce that tend to range widely: monthly data from San Francisco markets showed a range of premiums from 6% - 169%. On average, yields of organic leaf lettuce are lower than for conventional lettuce; however, organic yields vary widely as well dependent on soil and climate conditions.

Alternative production systems are a small but growing segment of the leafy greens market. Hydroponics, in particular, is emerging as an option for urban farmers seeking high-yield production techniques with a small land footprint. Aquaponics are also emerging as an area of potential growth and innovation.

Distribution systems for organic products are diverse, ranging from mainstream distribution channels to community-supported agriculture and home delivery. Participants in the organic market cite supply chain coordination as a necessary ingredient in successful distribution of organic produce (Murray 2016) . Organic distributors such as Organically Grown Company have played an important role in advocacy for food system reform; home delivery distribution services such as Full Circle have expanded the market for a wide range of farms, which include those in California as well as the Pacific Northwest. Investment in organic distribution appears to be slowing in the short run (Stout 2016), but may resume as the market continues to grow.

The organic vegetable sector intersects with the developing food culture in the Pacific Northwest that values local varieties, high quality, environmental stewardship, and crop diversity. Says Andrew Stout of Full Circle: “We’re emerging as an interesting food culture, and that is going to help. It comes down to a consumer base desiring a supportive economy. There’s a sense of locale (in the Pacific Northwest) that runs deep.” (Stout 2016)

The most important recommendation we can offer prospective impact investors is: sustained attention to this complex and internally diverse market is the best way to stay on top of emerging trends and identify profitable and catalytic investment opportunities. High-yield alternative production systems, such as hydroponics, offer one area of potentially impactful market growth. Scalable distribution systems, such as home delivery, offer another. Production of organic crops for processing, to be used in mass marketed frozen vegetables, are a third emerging area that may benefit from investment.

Bibliography

Adams, D.C., and M.J. Salois. "Local versus organic: a turn in consumer preferences and willingness-to-pay." Renewable Agriculture and Food Systems 25, no. 4 (2010): 331-341.

Agricultural Marketing Service . Fruit and Vegetable Market News User Guide. Fruit and Vegetable Programs, Washington, D.C.: United States Department of Agriculture, 2012.

Agricultural Marketing Service. "Local Food Directories: Community Supported Agriculture (CSA) Directory." United States Department of Agriculture. February 10, 2016. https://www.ams.usda.gov/local-food-directories/csas (accessed February 16, 2016).

Ahearn, Ashley. "Organic Farming Better Suited to Climate Change, Study Finds." KUOW.org. February 3, 2016. (accessed February 10, 2016).

Barber, Dan. "What Farm-to-Table Got Wrong." New York Times, May 17, 2014.

Barrett, Megan. "Interviewed by Clean Currents." Farmland LP. November 20, 2012. http://www.farmlandlp.com/2012/11/interviewed-by-clean-currents/ (accessed February 17, 2016).

Bhanoo, Sindya N. "Vertical Farms Will Be Big, But For Whom?" Fast Company. December 3, 2014. http://www.fastcompany.com/3039087/elasticity/vertical-farms-will-be-big-but-for-who (accessed February 4, 2016).

Bradford, Jason, interview by Noah Enelow. Organic Agriculture in the Pacific Northwest: Market Trends and Investment Prospects (February 16, 2016).

Christensen, Dan, interview by Noah Enelow. Hydroponic Farming: Production and Market Trends (February 3, 2016).

Cooley, Heather, Kristina Donnelly, Rapichan Phurisamban, and Madhyama Subramanian. Impacts of California's Ongoing Drought: Agriculture. Print, Oakland, CA: Pacific Institute, 2015.
Crowder, David W., and John P. Reganold. "Financial competitiveness of organic agriculture on a global scale." Proceedings of the National Academy of Sciences of the United States of America, June 16, 2015: 7611-7616.

Dimitri, Carolyn, and Catherine Greene. Recent Growth Patterns in the U.S. Organic Foods Market. Agriculture Information Bulletin Number 777, Washington, DC: USDA, Economic Research Service: Market and Trade Economics Division and Resource Economics Division, 2002.

Doucleff, Michelle. "Vertical 'Pinkhouses:' The Future of Urban Farming?" NPR: The Salt. May 21, 2013. http://www.npr.org/sections/thesalt/2013/05/21/185758529/vertical-pinkhouses-the-future-of-urban-farming (accessed February 10, 2016).

Dr. Oz. "Poll: What's the Next Kale." The Dr. Oz Show. October 15, 2015. http://www.doctoroz.com/article/poll-whats-next-kale (accessed January 19, 2016).

Economic Research Service. "Food Availability (Per Capita) Data System." United States Department of Agriculture. November 12, 2015. http://www.ers.usda.gov/data-products/

food-availability-(per-capita)-data-system.aspx (accessed February 9, 2016).

—. "Organic Market Overview." United States Department of Agriculture. April 7, 2014. http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-market-overview.aspx (accessed February 9, 2016).

—. "Organic Prices." United States Department of Agriculture. August 28, 2014. http://www.ers.usda.gov/data-products/organic-prices.aspx (accessed January 4, 2016).

—. "Organic Production." United States Department of Agriculture, Economic Research Service. October 24, 2013. http://www.ers.usda.gov/data-products/organic-production.aspx (accessed February 1, 2016).

—. "Organic Trade." United States Department of Agriculture. April 7, 2014. http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-trade.aspx (accessed February 16, 2016).

Ecotrust. Oregon Food Infrastructure Gap Analysis. Portland, OR: Ecotrust, 2015.

Equilibrium Capital. The Opportunity in Permanent Crops. San Francisco, CA; Portland, OR: Equilibrium Capital, 2013.

FAO. "What is Organic Agriculture?" Food and Agriculture Organization of the United Nations. 2016. http://www.fao.org/organicag/oa-faq/oa-faq1/en/ (accessed January 12, 2016).

Finkelstein, Dan, interview by Stacey Sobell. Helsing Junction Farm (January 12, 2016).

Granatstein, David, interview by Noah Enelow. Washington State Organic Crops: Data Issues (February 17, 2016).

Greene, Catherine. "Organic Provisions in the 2014 Farm Act." United States Department of Agriculture. June 2, 2015. http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-provisions-in-the-2014-farm-act.aspx (accessed February 5, 2016).

Guthman, Julie. Agrarian Dreams: The Paradox of Organic Farming in California. Oakland: University of California Press, 2014.

H, M. "Indoor Farms: Making Light Work of City Dining." The Economist. April 29, 2014. http://www.economist.com/blogs/babbage/2014/04/indoor-farms (accessed 4 2016, February).

Heidi, interview by Stacey Sobell. Boistfort Valley Farm: Organic Vegetable Farming for CSA (January 12, 2016).

Herring, Peg. "Expect to see seaweed on the menu." Oregon State Unviersity: Oregon's Agricultural Progress. Summer 2015. http://oregonprogress.oregonstate.edu/summer-2015/next-big-thing-sea-vegetables (accessed February 2, 2016).

IPM Center. "Crop Profile for Lettuce in Washington." IPM Center. 2000. http://www.ipmcenters.org/cropprofiles/docs/Walettuce.pdf (accessed February 15, 2016).

Irwin, Neil. “Special Sauce for Measuring Food Trends: The Fried Calamari Index.” New York Times. August 12, 2014. http://www.nytimes.com/2014/08/12/upshot/special-sauce-for-measuring-food-trends-the-fried-calamari-index.html?_r=0 (accessed January 19, 2016).

Kirby, Elizabeth, and David Granatstein. Certified Organic Acreage and Sales in Washington State: 2006-2014. Organic Trends series, Wenatchee, WA: Washington State University, Center for Sustaining Agriculture and Natural Resources, 2015.

Knaus, David, interview by Noah Enelow. Hydroponic and Organic Farming for Local Markets: Market Trends and Opportunities (February 11, 2016).

Knox, Joseph, and Ann Foley Scheuring. Global Climate Change and California: Potential Impacts and Responses. Berkeley: University of California Press, 1991.

McCollow, Katie. “Aquaponics Revives An Ancient Farming Technique To Feed The World.” Newsweek. May 15, 2014. http://www.newsweek.com/2014/05/23/aquaponics-revives-ancient-farming-technique-feed-world-251020.html (accessed February 8, 2016).

Meister, Herman S. Sample Cost to Establish and Produce Leaf Lettuce. Enterprise Budget, Imperial County: U.C. Cooperative Extension, 2004.

Murray, Tanya, interview by Noah Enelow. Organic Production in the Pacific Northwest: Data and Supply Chain Issues (February 2, 2016).

Murray, Tanya, and Kimberlee Chambers. “Analysis of the Organic Market in Oregon.” Oregon Tilth. December 4, 2015. https://tilth.org/resources/analysis-of-the-organic-market-in-oregon/ (accessed January 27, 2016).

NASS. QuickStats. Washington, DC: National Agriculture Statistics Service, 2015.

Newgent, Jackie. “Are Sprouts Safe To Eat? .” Academy of Nutrition and Dietetics. June 23, 2015. http://www.eatright.org/resource/homefoodsafety/safety-tips/food/are-sprouts-safe-to-eat (accessed February 10, 2016).

Office of Financial Management. “April 1, 2015 Population of Cities, Towns and Counties.” State of Washington. April 1, 2015. http://www.ofm.wa.gov/pop/april1/ofm_april1_population_final.pdf (accessed February 9, 2016).

Organic Trade Association. “Organic Industry Survey.” Organic Trade Association. 2016. https://www.ota.com/what-ota-does/market-analysis/organic-industry-survey/organic-industry-survey?oprtid=012G0000001BAsuIAG&tcaid=701G0000000yqzN (accessed February 4, 2016).

Organically Grown Company. Survey: Organic Distribution and Marketing. Portland, OR, February 16, 2016.

—. “Sustainability: Our Efforts.” Organically Grown Company. 2015. http://www.organicgrown.com/sustainability/our-efforts/ (accessed February 12, 2016).

—. “Weekly Market Reports.” Organically Grown Company. February 12, 2016. http://www.organicgrown.com/news/weekly-market-reports/ (accessed February 12, 2016).

Ostrom, Marcia, and G.W. Stevenson. Values-based food supply chains: Full Circle. Case Study, Madison, WI: Agriculture of the Middle Initiative, 2013.

Paul, Mark. "Community Supported Agriculture: A Model for the Farmer and the Community?" The Future Economy Initiative. February 2nd, 2015. http://futureecon.com/wp-content/uploads/MP_Final_PDF.pdf (accessed February 16, 2016).

Perez, Agnes, Kristy Plattner, Hodan Farah Wells, Leslie Meyers, and Nathan Childs. "California Drought: Crop Sectors." USDA Economic Research Service. December 15, 2015. (accessed February 10, 2016).

Perkins, Cory. "A Koi-Fueled Nursery in New Orleans Yields Tasty Profits." Wired.com: Conde Nast Digital. December 14, 2013. http://www.wired.com/2013/12/veggi/ (accessed February 4, 2016).

Peters, Adele. "FarmedHere Wants To Bring A Vertical Farm To your City." FastCompany: Co.Exist. November 11, 2015. http://www.fastcoexist.com/3053217/farmedhere-wants-to-bring-a-vertical-farm-to-your-city (accessed February 4, 2016).

—. "Meet The Startup That Wants To Make Vertical Farming Mainstream." FastCompany: Co.exist. April 7, 2015. http://www.fastcoexist.com/3043850/meet-the-startup-that-wants-to-make-vertical-farming-mainstream (accessed February 4, 2016).

Phillip, Anne, interview by Bowman Leigh and Noah Enelow. Mobius Microgreens: Entrepreneurship, Market Challenges, and Expansion (February 17, 2016).

Philpott, Tom. "There's a Place That's Nearly Perfect for Growing Food. It's Not California." Mother Jones, April 20, 2015.

—. "Study: Organic Farming Is More Profitable Than Conventional." Mother Jones. June 4, 2015. http://www.motherjones.com/tom-philpott/2015/06/organic-farming-more-profitable-conventional (accessed January 27, 2016).

Portland Area CSA Coalition. "CSA List." Portland Area CSA Coalition. 2016. http://www.portlandcsa.org/c/csa-pick-up-locations-in/ (accessed February 16, 2016).

—. "Winter Green Farm." Portland Area CSA Coalition. 2016. http://www.portlandcsa.org/2014/04/winter-green-farm/ (accessed February 16, 2016).

Pullano, Gary. "More Growers Riding the Kale Production Bandwagon." Vegetable Growers News. June 18, 2015. http://vegetablegrowersnews.com/article/more-growers-riding-the-kale-production-bandwagon/ (accessed January 19, 2016).

Reganold, John P, and Jonathan M. Wachter. "Organic Agriculture in the Twenty-First Century." Nature Plants, 2016.

Rodale Institute. "About Us." Rodale Institute. 2016. http://rodaleinstitute.org/about-us/ (accessed February 12, 2016).

Rose, Joel. "Green Pie in the Sky? Vertical Farming is On the Rise in Newark." NPR: The Salt. August 5, 2015. http://www.npr.org/sections/thesalt/2015/08/05/429345848/green-pie-in-the-sky-vertical-farming-is-on-the-rise-in-newark (accessed February 10, 2016).

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. Enterprise Budget: Leaf Lettuce, Conventional, Fresh Market, Willamette Valley Region. Enterprise Budget, Corvallis, OR: Oregon State University, 2007.

Seufert, Verena, Navin Ramankutty, and Jonathan A. Foley. "Comparing the yields of organic and conventional agriculture." Nature, 2012: 229-232.

Shemkus, Sarah. "Can Large, Corporate Urban Farms Grow 'Local Food'? ." Civil Eats. December 14, 2015. http://civileats.com/2015/12/14/can-large-corporate-urban-farms-grow-local-food/ (accessed February 4, 2016).

Stout, Andrew, interview by Noah Enelow. Full Circle: Supply Chain and Market Dynamics (February 12, 2016).

Strzok, Jesse L., and Wallace E. Huffman. Willingness-to-Pay for Organic Food Products and Organic Purity: Experimental Evidence. Department of Economics Working Paper No. 12017, Ames, IA: Iowa State University , 2012.

Suo, Steve, and Portland State University Population Research Center. "Oregon Population, 2014-2015." OregonLive. November 16, 2015. http://projects.oregonlive.com/census/oregon-population-estimates/2015/cities (accessed February 9, 2016).

Swenson, Dave. Selected Measures of the Economic Value of Increased Fruit and Vegetable Production and Consumption in the Upper Midwest. Ames, IA: Department of Economics, Iowa State University, 2010.

U.S. Census Bureau. "County Business Patterns." U.S. Census Bureau. April 2015. http://www.census.gov/econ/cbp/ (accessed January 22, 2016).

von der Groeben, Norbert. "Little evidence of health benefits from organic foods, study finds." Stanford Medicine News Center. September 3, 2012. https://med.stanford.edu/news/all-news/2012/09/little-evidence-of-health-benefits-from-organic-foods-study-finds.html (accessed February 12, 2016).

Wheat, Dan. "Some Worry as More Production Moves Outside U.S. ." Capital Press, June 18, 2015.

Whoriskey, Peter. "Are These Beautiful Lettuce and Tomatoes Really Organic? The Debate over an Agricultural Innovation." Washington Post. April 24, 2015. https://www.washingtonpost.com/news/wonk/wp/2015/04/24/theres-a-raging-debate-over-whether-these-types-of-lettuce-and-tomato-are-really-organic/ (accessed February 8, 2016).

Wichner, Craig, interview by Chris Martenson. A New Model for Investing in Farmland (December 14, 2012).

Appendix: Detailed Production Cost Data, Organic and Conventional Leaf Lettuce (Seavert, et al. 2007)

Variable Costs	Total Cost/Acre	Labor Cost/Acre	Total Cost/Carton	Labor Cost/Carton
Field Preparation				
Deep chisel	$ 11.50	$ 3.64	$ 0.01	$ 0.00
Moldboard plow	$ 31.90	$ 9.70	$ 0.04	$ 0.01
Disk	$ 16.38	$ 5.15	$ 0.02	$ 0.01
Rotary till	$ 34.88	$ 9.70	$ 0.04	$ 0.01
Cultivating weeds	$ 33.91	$ 15.46	$ 0.04	$ 0.02
Transplanting	$ 1,108.65	$ 205.38	$ 1.23	$ 0.23
Irrigation	$ 107.50	$ 22.50	$ 0.12	$ 0.03
Fertilizers and Inputs				
Fertilizer Sidedresser	$ 29.11	$ 13.75	$ 0.03	$ 0.02
Spray herbicide	$ 20.01	$ 3.05	$ 0.02	$ 0.00
Lime application, custom	$ 75.00	$ -	$ 0.08	$ -
Spray insecticides	$ 108.01	$ 3.05	$ 0.12	$ 0.00
Fertilize	$ 94.58	$ 1.77	$ 0.11	$ 0.00
Spray herbicide	$ 68.01	$ 3.05	$ 0.08	$ 0.00
Harvesting				
Harvesting labor	$ 1,170.00	$ 1,170.00	$ 1.30	$ 1.30
Tractor & trailer	$ 203.74	$ 78.00	$ 0.23	$ 0.09
Packing & Materials				
Cartons	$ 1,170.00	$ -	$ 1.30	$ -
Hydro-cooling	$ 90.00	$ -	$ 0.10	$ -
Refrigeration	$ 90.00	$ -	$ 0.10	$ -
Delivery to market	$ 72.00	$ 72.00	$ 0.08	$ 0.08
Other Costs				
Pickups, truck & ATV	$ 103.38	$ -	$ 0.11	$ -
Shop & machine shed	$ 4.00	$ -	$ 0.00	$ -
Miscellaneous and overhead	$ 37.50	$ -	$ 0.04	$ -
Interest: operating capital	$ 93.60	$ -	$ 0.10	$ -
Total variable costs	$ 4,773.66	$ 1,616.18	$ 5.30	$ 1.80
Total fixed costs	$ 409.59		$ 0.46	$ -
Total Costs	$ 5,183.25		$ 5.76	$ 1.80

Table 10.
Costs of Production per Carton and Acre, Conventional Leaf Lettuce, Oregon (2007)

Variable Costs	Total Cost/Acre	Labor Cost/Acre	Total Cost/Carton	Labor Cost/Carton
Field Preparations				
Moldboard plow	$ 31.93	$ 9.70	$ 0.05	$ 0.01
Disk	$ 21.96	$ 6.87	$ 0.03	$ 0.01
Deep chisel	$ 11.51	$ 3.64	$ 0.02	$ 0.01
Disk	$ 21.96	$ 6.87	$ 0.03	$ 0.01
Disk before plowing	$ 21.96	$ 6.87	$ 0.03	$ 0.01
Cultivating weeds	$ 57.49	$ 24.74	$ 0.09	$ 0.04
Weed control Hand labor	$ 300.00	$ 300.00	$ 0.46	$ 0.46
Seed Cover Crop	$ 25.57	$ 1.77	$ 0.04	$ 0.00
Disk down cover crop	$ 10.98	$ 3.44	$ 0.02	$ 0.01
Fertilizer and Inputs				
Lime application, custom	$ 75.00	$ -	$ 0.12	$ -
Fertilize	$ 94.54	$ 1.77	$ 0.15	$ 0.00
Topdress fertilizer	$ 107.94	$ 3.05	$ 0.17	$ 0.00
Spray insecticides	$ 315.87	$ 6.09	$ 0.49	$ 0.01
Transplanting	$ 844.42	$ 205.38	$ 1.30	$ 0.32
Irrigation	$ 107.50	$ 22.50	$ 0.17	$ 0.03
Organic Certification	$ 45.50	$ -	$ 0.07	$ -
Harvesting				
Harvesting labor	$ 1,300.00	$ 1,300.00	$ 2.00	$ 2.00
Tractor & trailer	$ 203.74	$ 78.00	$ 0.31	$ 0.12
Packing and Materials				
Cartons	$ 845.00	$ -	$ 1.30	$ -
Hydro-cooling	$ 65.00	$ -	$ 0.10	$ -
Refrigeration	$ 65.00	$ -	$ 0.10	$ -
Delivery to market	$ 52.00	$ 52.00	$ 0.08	$ 0.08
Other Costs				
Pickups, truck & ATV	$ 103.38	$ -	$ 0.16	$ -
Shop & machine shed	$ 4.00	$ -	$ 0.01	$ -
Miscellaneous and overhead	$ 37.50	$ -	$ 0.06	$ -
Interest: operating capital	$ 95.40	$ -	$ 0.15	$ -
Total variable costs	$ 4,865.15	$ 2,032.68	$ 7.49	$ 3.13
Total fixed costs	$ 423.83	$ -	$ 0.65	$ -
Total costs	$ 5,288.98	$ 2,032.68	$ 8.14	$ 3.13

Table 11. Costs of Production per Carton and Acre, Organic Leaf Lettuce, Oregon (2007)