The Contribution of Arizona's Vegetable and Melon Industry Cluster to the State Economy

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Executive Summary

What Is the Issue?

- Vegetables and melons are an important part of the Arizona agricultural economy. While a common way of assessing the size of an industry is the value of its cash receipts, receipts do not fully capture the economic contributions of vegetables and melons to the state economy. There is a cluster of other industries that perform post-harvest activities, ensuring high-quality produce reaches consumers. The perishable nature of these products requires coordination between industries and logistical efficiency. **Estimating vegetable and melon's contribution to the Arizona economy warrants an examination of the whole value chain—the vegetable and melon industry cluster.** This cluster includes farming, packing, cooling, storing, processing, trucking, and wholesaling operations.
- In addition to the industry cluster's *direct effects* on the Arizona economy, a "ripple" of economic activity is stimulated in other Arizona industries to meet the demand for inputs by producers and the demand for consumer goods and services by households. Economists call these the *indirect* and *induced multiplier effects.*
  - *Indirect effects* measure the economic activity generated by the vegetable and melon industry cluster's demand for inputs. These effects occur in industries such as the agricultural support, fertilizer, electricity, banking, and farm machinery industries.
  - *Induced effects* measure the economic activity generated by households employed by the vegetable and melon industry cluster spending their earnings at Arizona businesses. These effects occur in industries that provide goods and services to households, such as the real estate, healthcare, retail, and restaurant industries.
- This study conducts an economic contribution analysis for the 2014 production year that estimates the direct, indirect, and induced effects of this larger vegetable and melon industry cluster on the Arizona economy.
- The study also estimates the cluster's labor requirements. Labor costs and availability are of great concern to vegetable and melon producers. Labor costs as a share of total production expenses are nearly double those in the rest of Arizona agriculture. Operators must recruit a labor force that is largely immigrant, mobile, and seasonal, with sharp peaks in labor demand. The number of workers employed on vegetable and melon operations is of interest because of fears that farm labor shortages could reduce the state's production of these high-value crops.
- Several challenges arise in attempting to measure the Arizona vegetable and melon work force.
  - There is no one single source of data on U.S. hired farm labor and there are no sources that report comprehensive data on labor employed in vegetable and melon production.
  - While agencies report the number of farm jobs, they do not report the number of individual workers filling those jobs. This presents a problem of defining what constitutes "a job." For example, if one person works at three jobs lasting three months each and is unemployed for three months, is this three jobs or ¾ of a job? Some previous labor studies have estimated the number of full-time equivalent jobs (FTEs) based on hours worked.
  - This FTE approach has its own problems, though. Studies from California have found that there were an average of two unique workers

employed for every full-time equivalent job. Measuring labor in FTEs also obscures sharp monthly fluctuations in labor demands. To better account for these fluctuations, this study estimated the number of hours of work employed on-farm per month in Arizona vegetable and melon production.

What Did the Study Find?

Economic Contribution

- **In 2014**, the vegetable and melon industry cluster contributed to **nearly $1.9 billion in sales to the Arizona economy**. This is considerably larger than the $727 million in direct revenues from on-farm production activities. The industry cluster's **total contribution to Arizona's gross state product (GSP) was $946 million**. This included approximately $745 million in wages, salaries, and proprietor income. The **total state/local tax contribution** attributable to the vegetable and melon industry cluster (including multiplier effects) was **$59.2 million** in 2014.
- **In 2015**, the vegetable and melon industry cluster contributed to **more than $2.5 billion in sales to the Arizona economy** and **contributed $1.4 billion to state GSP**. This included nearly $1.2 billion in wages, salaries, and proprietor income.

Employment

- In 2014, Arizona vegetable and melon production required more than **26.7 million hours of hired on-farm labor**. This included directly hired, contract, and other agricultural support service workers employed on-farm. Monthly labor demand fluctuated from lows of less than 1.5 million hours in slack months to highs above 3.5 million hours per month in peak winter months.
- **There were more than 17,700 full- and part-time jobs directly and indirectly supported by the vegetable and melon industry cluster in Arizona on an annualized basis**. Nearly 70% of these jobs were direct, on-farm jobs, which included farm proprietor jobs, directly hired farm labor, and agricultural support service workers (usually hired through farm labor contractors). Other jobs supported were in post-harvest industries, in industries that provide inputs to the cluster, and in industries that provide consumer goods and services to workers and proprietors in the cluster.
- The number of unique farm workers employed in vegetable and melon production is far greater than the number of full-time equivalent jobs. There are more than 2,900 unpaid (family) workers on vegetable and melon farms. Recent research from California found an average of two unique farm workers reported for each year-round equivalent farm job. Assuming this relationship holds for Arizona—with similar production systems—and including unpaid family workers, this suggests there are **more than 31,400 individuals working in jobs directly or indirectly supported by the Arizona vegetable and melon industry cluster**.

Industry Structure

- The vegetable and melon industry cluster is a highly integrated system comprised of industries working in tandem to get fresh and processed products to consumers—vegetable and melon farming, refrigerated warehousing, processing, wholesaling, and trucking. Businesses involved in this process can operate independently, conducting only one activity

in the value chain, or they can be vertically integrated, serving many roles along the value chain.

- Vegetables and melons consistently rank in the top three agricultural commodities produced in the state. **Arizona ranked second in the nation among states in vegetable and melon production by weight, third by value of production, and third by area harvested in 2014**. Arizona ranked second in the nation for production of broccoli, cantaloupe, honeydew, spinach, and head, leaf, and Romaine lettuce in 2014.
- Arizona vegetable and melon production has a dual structure, with many small-scale and hobby producers and a small number of large producers. **In Arizona, 96% of vegetable and melon sales come from 4% of farms**.
- A majority of the state's production of vegetables and melons occurs in Yuma and Maricopa Counties, accounting for 76% and 13% of state vegetable and melon sales, respectively. While most production occurs in western and central Arizona, most of Arizona's farms with sales of vegetables and melons are located in northeast Arizona. These are primarily small-scale producers.
- Also, according to the Census, **Yuma County was in the top 0.1%** of vegetable and melon sales among all counties growing these crops, while **Maricopa County was in the top 1%**.
- **The dominant forms of organization of Arizona vegetable and melon farms are family-based operations and partnerships**. Family/individual operations and partnerships accounted for 55% of sales, while family held corporations accounted for another 34% of sales. Non-family held corporations accounted for just 10% of Arizona vegetable and melons sales.

How Was the Study Conducted?

- The economic contribution analysis was conducted using input-output modeling and the premiere software for this types of analysis, IMPLAN Version 3.1. IMPLAN is a modeling system of a regional economy that is based on national averages of production conditions. This model is a snapshot of economic activity in 2014. It was refined based on best available, recent data to more accurately reflect economic conditions and agricultural practices in Arizona.
- Additional model customizations were conducted to parse out the estimated economic activity in cluster industries that is attributable to Arizona-produced vegetables and melons.
- The contributions of the vegetable and melon industry cluster to the Arizona economy in 2014 were modeled in IMPLAN and measured through the following metrics: sales, value added (also known as gross state product—GSP), labor income, and state and local taxes. Finally, the study also presents improved estimates of the industry's demand for labor and its overall contribution to state employment.
- Estimates of directly hired farm labor employed in vegetable and melon production were obtained from the U.S. Labor Department's *Quarterly Census of Employment and Wages* (*QCEW*). Most on-farm labor employed on Arizona vegetable and melon operations, however, are hired through farm labor contractors. Estimates of contract (and other agricultural support service) jobs do not provide separate estimates for jobs in vegetable and melon production. Research findings on per acre labor requirements and data on acreage by crop were used to estimate the percentage of total agricultural service jobs in vegetable and melon

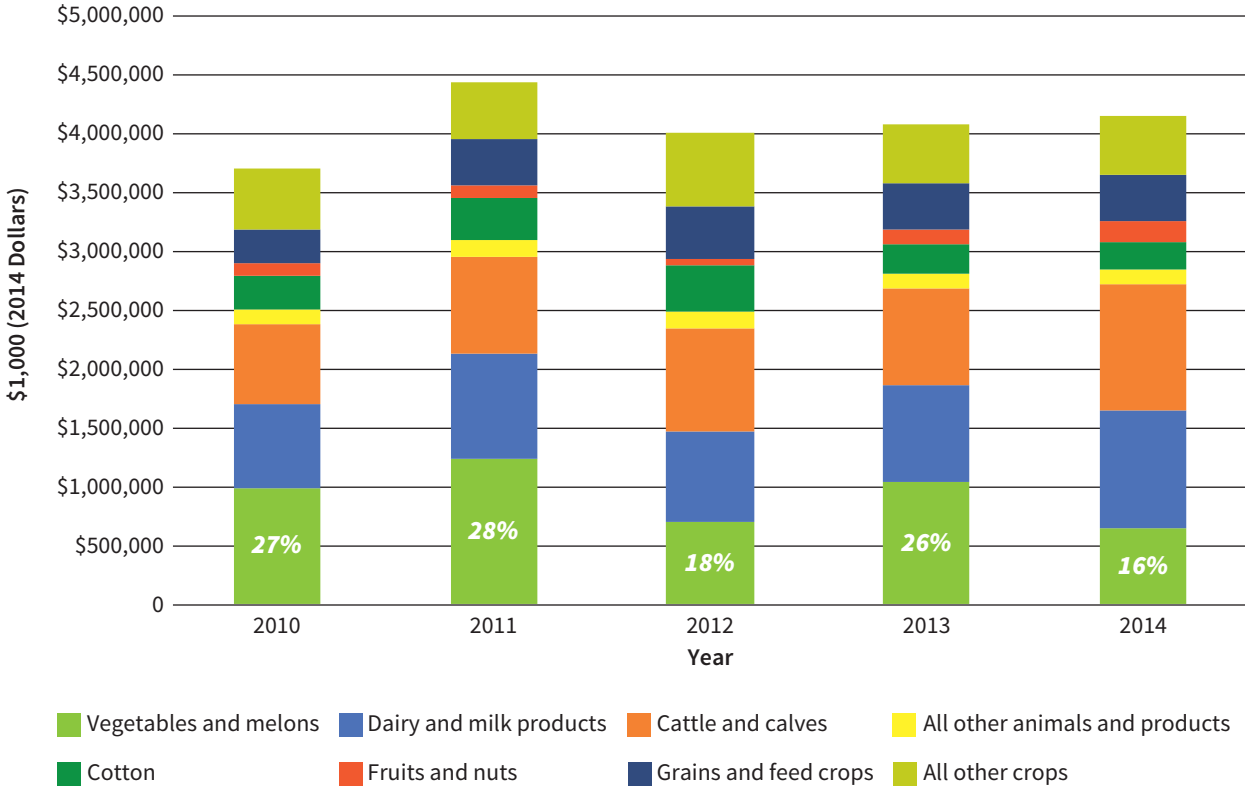
production. Data on wages paid to agricultural workers from the QCEW and average wage rates paid from the Department of Agriculture were combined to develop estimates of hours of work in vegetable production by month.

- Year-to-year changes in vegetable and melon prices and production can be quite large. This can lead to estimates of economic contributions that vary significantly from one year to the next. When this project was initiated, 2014 was the most recent year of data available for Arizona economy-wide modeling. Vegetable and melon revenues in 2014, however, were at their lowest level in 20 years in 2014. Vegetable and melon sales in 2015 more closely matched the long-term trend line for sales. Price increases between the two years was by far the biggest contributor to the increase in sales revenue. Applying newly available 2015 vegetable and melon sales data to the 2014 IMPLAN model, simulations were conducted to measure the direct, indirect, and induced effect contributions of these higher prices (see Addendum).

Introduction

Vegetables and melons are an important part of Arizona's agricultural economy. In terms of cash receipts, vegetables and melons have ranked within the top three agricultural commodities produced in Arizona since 2010. Vegetables and melons, on average, account for approximately 23% of annual agricultural sales in Arizona, though market fluctuations affect the share of total agricultural cash receipts from year to year (Figure 1). In 2014, the year for this economic contribution analysis, vegetables and melons accounted for 16% of Arizona's total agricultural cash receipts.

Figure 1. Arizona Cash Receipts by Agricultural Commodity, 2010–2014

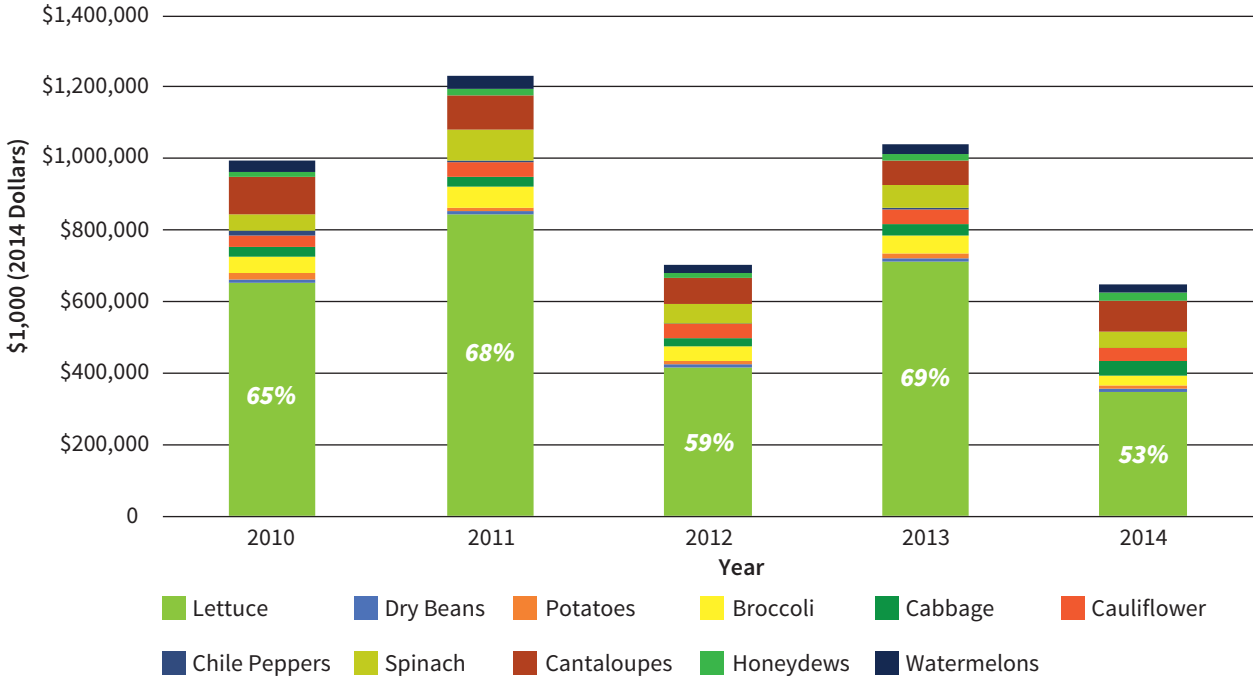


Source: USDA, ERS Farm Income and Wealth Statistics, 2014.

Vegetable and melon commodities produced in Arizona include lettuce, spinach, broccoli, cantaloupes, and honeydew, among others. The production of leafy greens—in particular head, leaf, and Romaine lettuce—is very important to state vegetable and melon production. On average, lettuce accounts for more than 60% of vegetable and melon cash receipts (Figure 2). Figure 2 suggests that when cash receipts for lettuce are high, vegetable and melon sales as a whole are typically higher for the state.

Arizona vegetables and melons are not only an important part of the state's agricultural economy; they are also important in terms of national production. Arizona plays a leading role in the production of fresh market vegetables and melons for the United States. In 2014, Arizona ranked second in the nation for vegetable and melon production by hundredweight (cwt), third in the nation for the value of production, and third in the nation for area harvested (USDA Vegetables 2014 Annual Summary, 2015).

Figure 2. Arizona Cash Receipts for Vegetable and Melons by Commodity, 2010–2014



Source: USDA, ERS, Farm Income and Wealth Statistics, 2014.

At the county level, two of Arizona's 15 counties were ranked in the top 30 U.S. counties for the value of vegetable and melon sales. In 2012, Yuma County ranked 4th nationally in terms of the value of production of vegetable and melons (Table 1). The only counties with higher values of production were Monterey, Fresno, and Imperial Counties in California. Arizona's Maricopa County also ranked in the top 30 vegetable and melon producing counties. With sales of approximately $100 million in 2012, Maricopa County ranked 27th nationally. According to these statistics, Yuma County was in the top 0.1% of all counties growing vegetables and melons and Maricopa County was in the top 1.0% of all counties growing vegetables and melons.

When analyzing production by commodity, in 2014 Arizona ranked second (only to California) in the production of broccoli, cantaloupe, cauliflower, honeydew, spinach, and lettuce (head, leaf, and Romaine). As demonstrated in Table 2, Arizona also ranked in the top 10 for states producing cabbage and chili peppers (fourth) and watermelon (seventh). In fact, the only vegetable and melon commodity produced in Arizona that was not ranked in the top ten was potatoes.

Table 1. Arizona's Rankings in the Top 30 Vegetable and Melon Producing Counties, 2012

National Rank	County	State	Value of Sales
1	Monterey	California	$1,677,054,000
2	Fresno	California	$726,887,000
3	Imperial	California	$702,358,000
4	**Yuma**	**Arizona**	**$579,124,000**
	...		
25	Power	Idaho	$107,579,000
26	Collier	Florida	$104,500,000
27	**Maricopa**	**Arizona**	**$101,259,000**
28	Adams	Washington	$101,230,000
29	Santa Clara	California	$98,004,000
30	Morrow	Oregon	$96,295,000

Source: USDA, 2012 Census of Agriculture.

Table 2. Arizona's National Rank in Vegetable and Melon Production by Commodity, 2014

Commodity	Arizona		Leading State		National
	Rank	*Production (1,000 cwt)*	*State*	*Production (1,000 cwt)*	*Production (1,000 cwt)*
Broccoli	2	800	California	19,110	19,910
Cabbage (fresh market)	4	1,906	California	5,670	21,141
Cantaloupe (fresh market)	2	3,840	California	8,060	13,612
Cauliflower (fresh market)	2	720	California	5,505	6,286
Honeydew	2	805	California	2,835	3,739
Lettuce, head	2	12,248	California	33,670	45,918
Lettuce, leaf	2	1,944	California	11,040	12,984
Lettuce, Romaine	2	6,899	California	17,780	24,679
Peppers, chili	4	80	California	3,186	4,625
Potatoes	23	1,085	Idaho	132,880	442,170
Spinach	2	1,240	California	4,160	5,919
Watermelon	7	1,334	California	6,384	33,263

Source: USDA, NASS Quick Stats Annual Survey, 2014.

Playing such a central role in Arizona agriculture and a leading role in national production, vegetables and melons provide important contributions to the state economy. These contributions, however, are not limited to the production of vegetables and melons on Arizona farms. There is a cluster of industries that performs the necessary post-harvest activities that enable and ensure that high-quality vegetable and melon produce reach consumers. Because collaboration amongst these industries is essential in delivering vegetable and melon produce to consumers, we examine the vegetable and melon value chain and estimate the contribution of the **vegetable and melon industry cluster** to the Arizona economy. The vegetable and melon industry cluster includes on-farm production of vegetables and melons, as well as other Arizona industries that provide essential post-harvest activities such as packing, cooling, storing, processing, trucking, and wholesaling.

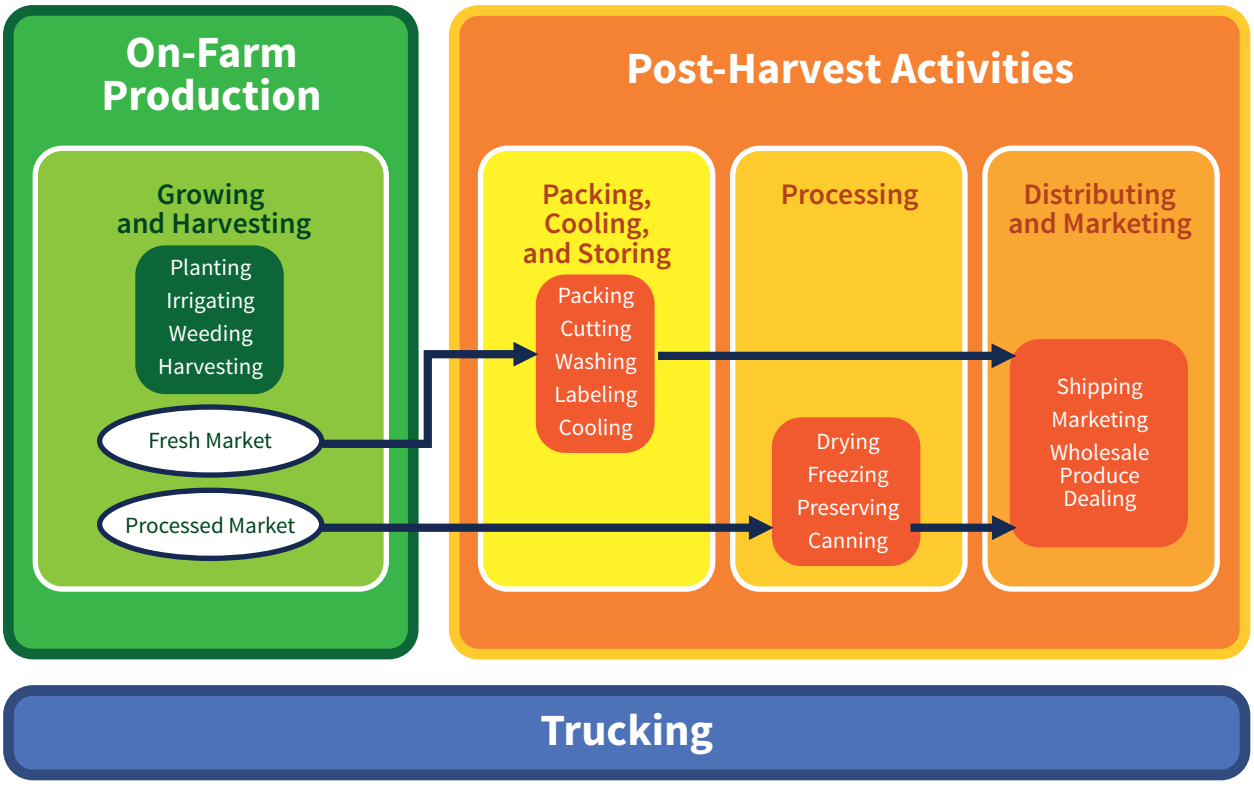
Furthermore, in addition to estimating the *direct effects* of the vegetable and melon industry cluster on the Arizona economy, we also estimate the "ripple" of economic activity that is generated when businesses within the cluster and households employed by the industry cluster purchase goods and services from other Arizona businesses. Economists call these the *indirect* and *induced multiplier effects*. Together, the *direct*, *indirect,* and *induced effects* measure the total contributions of the vegetable and melon industry cluster to the Arizona economy.

The first section of this report provides a basic description of the vegetable and melon industry cluster and value chain. Next, the results of the economic contribution analysis are presented. The contributions of the vegetable and melon industry cluster are discussed in terms of total sales, value added (also known as Gross State Product–GSP), labor income (employee compensation and proprietor income), and state and local taxes. Finally, the study also presents improved estimates of the industry cluster's demand for labor and its overall contribution to state employment.

Arizona's Vegetable and Melon Industry Cluster

The vegetable and melon industry cluster is a highly integrated system that is comprised of a variety of industries that work in tandem with one another to get fresh, as well as processed, vegetable and melon produce and products to consumers (Kaufmann et al., 2000). A cluster is a group of interconnected firms, suppliers, and related industries that mutually support each other to gain competitive advantage (Porter, 1990).

Figure 3. Vegetable and Melon Value Chain



Source: Authors' interpretation adapted from Fernandez-Stark et al., 2011.

Figure 3 presents a simplified illustration of the vegetable and melon value chain. The value chain is comprised of two primary components: on-farm production and post-harvest activities. On-farm production involves growing vegetables and melons on Arizona farms and harvesting the crops either for the fresh market or for the processed market. The second component, post-harvest activities, includes: (1) transforming the raw product into a saleable product by cutting, washing, packing, and labeling the product, (2) ensuring the quality and shelf-life of fresh produce by maintaining climate-controlled environments, (3) processing the product if it is not going to the fresh market, and (4) distributing and marketing the product for final consumption. Transportation, particularly trucking, is critical throughout the entire production process.

The perishable nature of vegetables and melons requires that the industries have an incredible amount of coordination and logistical efficiency. Businesses involved in this process can operate independently, conducting only one activity in the value chain, or they can be vertically integrated, serving many roles along the value chain.

On-Farm Production

Growing

Using data from the 2012 Census of Agriculture, the most recent and comprehensive data on agriculture available, we provide a profile of Arizona vegetable and melon farming, taking into consideration the geographic distribution across the state. The following section includes the number of vegetable and melon farming operations, the size of those operations (in terms of both sales and acreage), and the total value of production (if disclosed[1]) for each county. To illustrate these points geographically, we have developed a map as shown in Figure 4. The map is color coded by the county's rank in the state's sale of vegetables and melons. Counties with darker colors indicate a higher ranking.

Number of Farms

According to the 2012 Census of Agriculture, there were a total of 1,750 farms in Arizona that had sales of vegetables and melons. Approximately 93% of these farms (1,625) would be considered specialized[2] in vegetable and melon production, meaning that the farm received greater than 50% of their total agricultural sales from vegetables and melons.

Most vegetable and melon operations in 2012 were located in northeast Arizona in Navajo and Apache counties (Figure 4). These two counties accounted for nearly 70% of all vegetable and melon farms in the state, with 628 farms in Navajo County and 550 farms in Apache County. This is likely due to a large number of small farms located on tribal lands. Although available data are not disaggregated in a way to determine the number of vegetable and melon farms on tribal lands, there is some data to suggest this phenomenon. In 2012, the Navajo Nation, spanning the Four Corners area with a large swath of land in Navajo and Apache counties, had 1,905 farms with land in vegetable production. While some of these operations could be located in other parts of the Navajo Nation (in southern Utah or western New Mexico), based on the fact that a large amount of the Navajo Nation is located in northeastern Arizona, it is safe to assume that a large majority of vegetable and melon farms in this region are located on tribal lands. Furthermore, approximately 95% and 90% of all farms in Apache and Navajo counties, respectively, have an American Indian or Alaska Native principal operator.

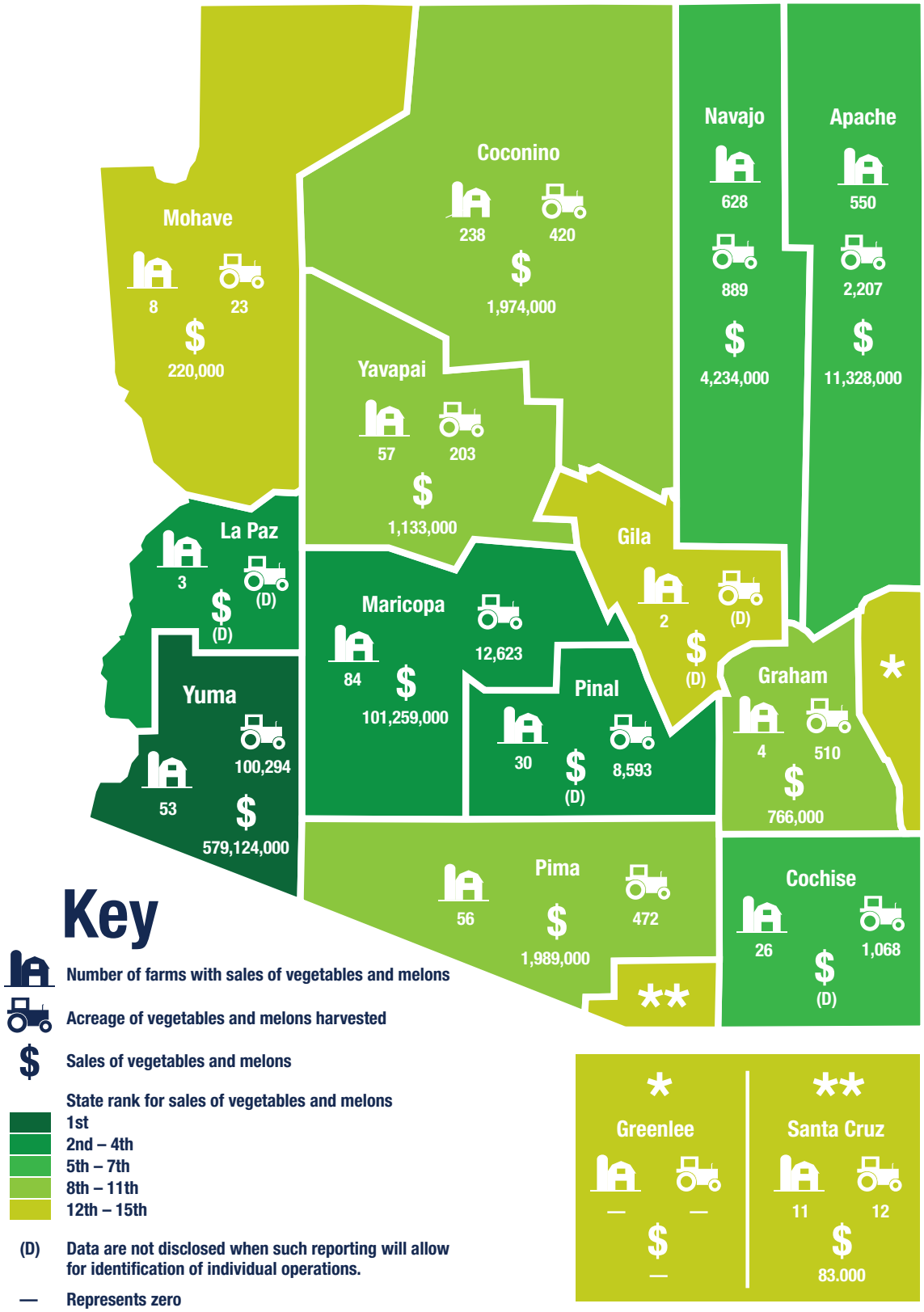
It may be surprising to note that Yuma and Maricopa counties, known for their high value of production of vegetable and melons, have only 53 and 84 farms with sales of vegetables and melons, respectively. Counties with the fewest number of vegetable and melon farms include Greenlee County with no farms, Gila County with 2 farms, La Paz County with 3 farms, and Graham County with only 4 farms.

Acreage

In 2012, more than 130,000 acres of vegetable and melons crops were harvested in Arizona. Most farms have very small acreage—in fact, of the 1,750 farms with vegetable and melon sales, approximately 60% have acreage of less than 10 acres. Figure 5 demonstrates the distribution of Arizona vegetable and melon farms by farm size in terms of acreage. The second most common size (in terms of acreage) is farms with acreage of 10 to 49 acres. Approximately one-fourth of Arizona farms fall into this category. On the far side of the spectrum, only about 2% of Arizona farms have acreage of 2,000 acres or more.

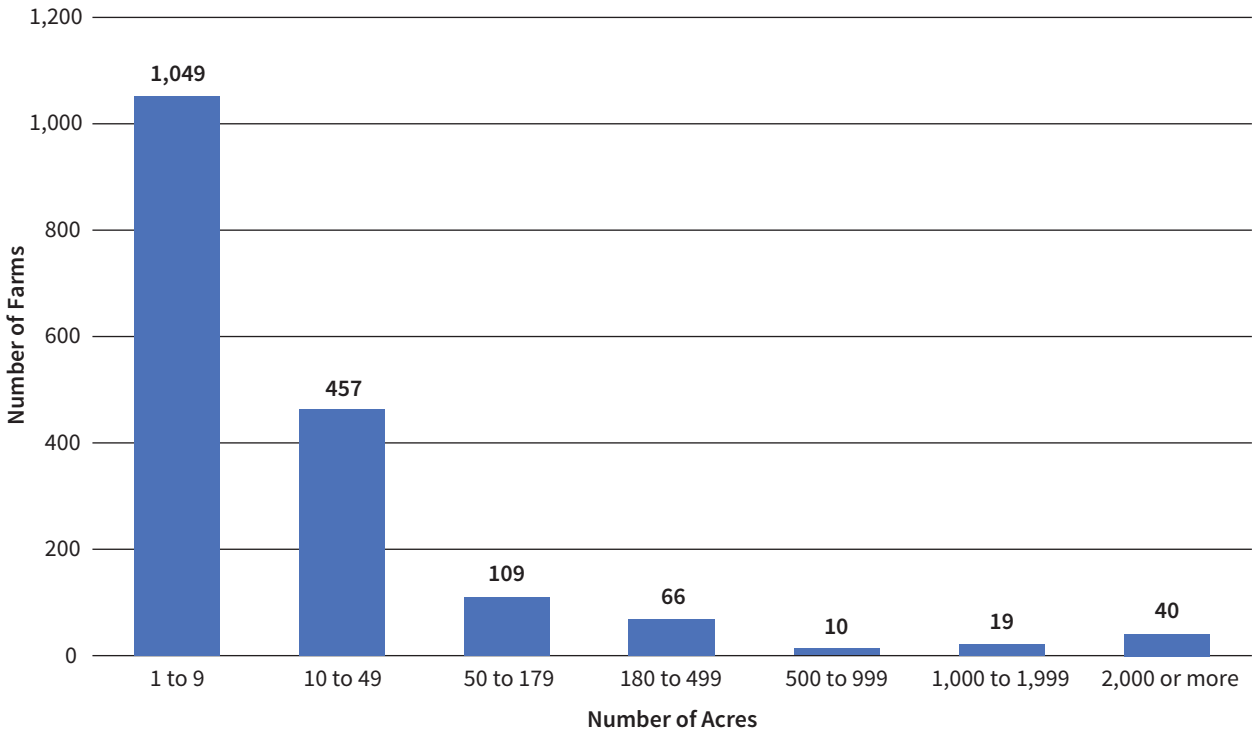
1 Government statistics are not reported when such reporting will identify individual operations.
2 Specialization is defined by the North American Industry Classification Systems (NAICS), where a farm is categorized as specialized in a particular commodity when that commodity constitutes the majority (greater than 50%) of the total sales of the operation.

Figure 4. Map of Arizona Vegetable and Melon Farms, Acreage, and Sales, 2012



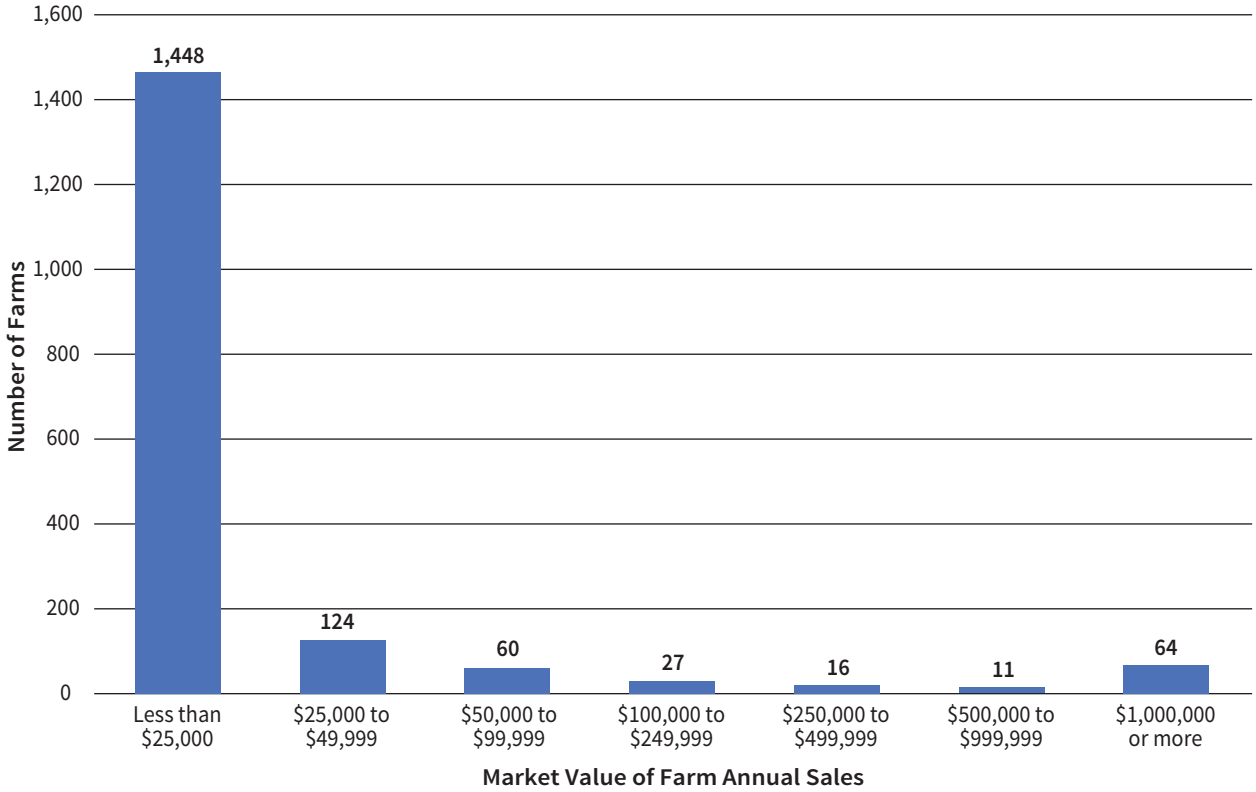
Source: Source: USDA, 2012 Census of Agriculture: Arizona State and County Data: Table 2.

Figure 5. Arizona Vegetable and Melon Farms by Farm Size (Acreage), 2012



Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 64.

Figure 6. Arizona Vegetable and Melon Farms by Farm Size (Annual Sales), 2012



Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 65.

Again referring to Figure 4, when considering where most vegetables and melons are harvested, Yuma County dominates, representing 78% of all vegetable and melon acreage harvested in the state. Of the state's 130,000 acres harvested, Yuma County accounts for slightly more than 100,000 acres. The counties with the second and third highest number of harvested acres were Maricopa County with just over 12,600 acres and Pinal County with nearly 8,600 acres.

Sales

Not only are most Arizona vegetable and melon farms small-scale based on their acreage, more than 80% of vegetable and melon farms have sales of less than $25,000. In fact, approximately 37% of Arizona farms with vegetable and melon sales have annual sales of less than $5,000. On the other end of the spectrum, approximately 4% of farms have annual sales of $1 million or more. Figure 6 demonstrates the distribution of Arizona vegetable and melon farms by farm size in terms of sales.

While a majority of vegetable and melon farms are considered small-scale, there are a few farms in Arizona that are very large and account for the bulk of vegetable and melon sales. The distribution of total Arizona vegetable and melon sales by annual farm sales is presented in Table 3. The same 4% of operations that have sales of $1 million or more, account for 96% of the state's vegetable and melon sales. Even more astounding, fewer than 100 farms account for 98% of Arizona sales of vegetables and melons. The remaining 1,659 farms account for only 2% of Arizona vegetable and melon sales.

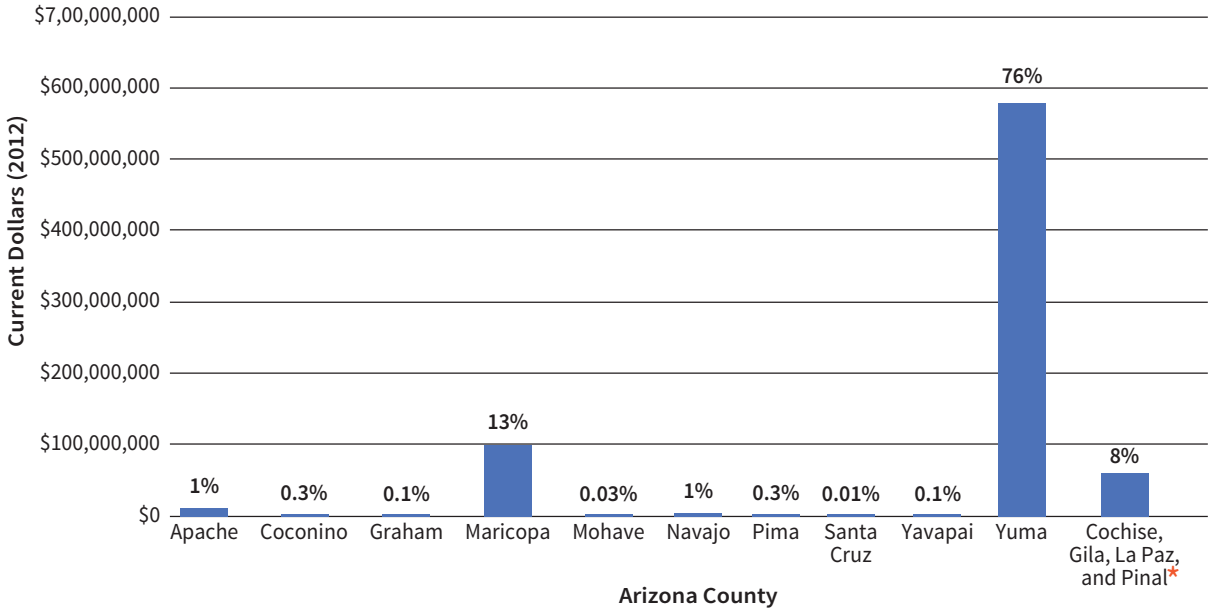
A majority of vegetable and melon sales occurred in Yuma County (Figure 7). In 2012, Yuma County accounted for more than three-fourths of all vege-

Table 3. Total Vegetable and Melon Sales by Farm Size (Annual Sales), 2012

Sales Category	Number of Farms	Market Value of Sales	Percentage of Total Sales
Less than $25,000	1,448	$9,128,000	1.2%
$25,000 to $49,999	124	$3,646,000	0.5%
$50,000 to $99,999	60	$3,204,000	0.4%
$100,000 to $249,999	27	$2,698,000	0.4%
$250,000 to $499,999	16	$4,250,000	0.6%
$500,000 to $999,999	11	$5,189,000	0.7%
$1,000,000 or more	64	$735,946,000	96%
Total	**1,750**	**$764,062,000**	**100%**

Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 65.

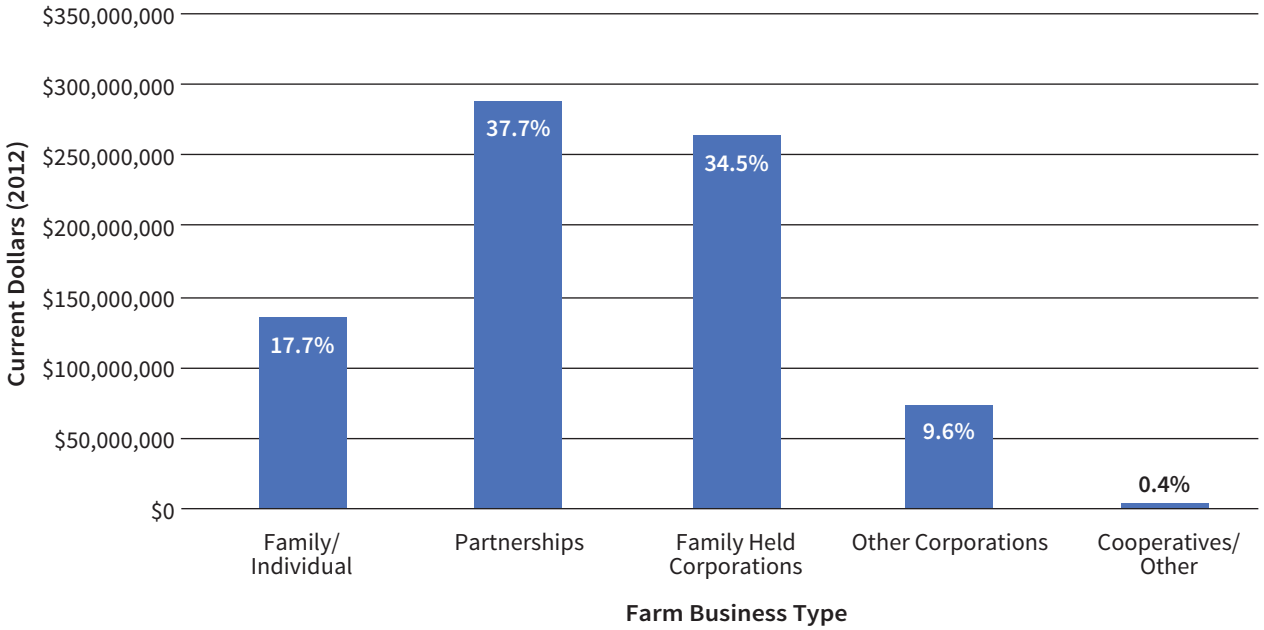
Figure 7. Arizona Vegetable and Melon Sales by County, 2012



*Data for these counties are not disclosed. Data are not disclosed when the reporting will allow for identification of individual operations. In 2012, Greenlee County did not report sales.

Source: USDA, 2012 Census of Agriculture: Arizona State and County Data: Table 2.

Figure 8. Arizona Vegetable and Melon Sales by Farm Business Type, 2012



Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 67.

table and melon sales in the state. Maricopa County accounted for 13% of the state's sales of vegetables and melons, Apache County accounted for 1%, and the remaining 12 counties accounted for a total of 10% of sales.

Not surprisingly, Yuma County ranked first in the state for vegetable and melon sales. The map in Figure 4 ranks Arizona counties by the county's total value of production (sales) of vegetables and melons, with darker colors indicating a higher rank. Similar to harvested acreage, Yuma County is followed by Maricopa, Pinal, and La Paz counties in terms of sales. Interestingly, even though La Paz County has very few vegetable and melon farms, it ranked third in the state for the value of production of vegetables and melons. The exact level of sales, however, is not disclosed to prevent the identification of individual operations.

Farm Business Type

The most dominant forms of organization of Arizona vegetable and melon farms are partnerships and family-based operations (Figure 8). In 2012, partnerships and family/individual operations accounted for more than 55% of vegetable and melon sales. Partnership forms led the way with 38% of sales and family/individual operations accounted for 18% of sales. Family held corporations also contributed significantly, accounting for more than 34% of total vegetable and melon sales. Of all family held corporations nearly one-hundred percent have 10 stockholders or fewer. Non-family held corporations accounted for just 10% of Arizona vegetable and melon sales.

Economic Specialization

Arizona has economic specialization in vegetable and melon production. One of the most common methods to determine economic specialization is to conduct an economic base analysis. An economic base analysis determines the relative importance of an industry to the local economy by analyzing the industry's share of local employment or earnings relative to the national average (Siegel, et al., 1995). This analysis uses an analytical tool known as

Location Quotients (LQs). When an industry has an LQ >1.00, it means that the region employs more people (or produces more output) than is needed to meet the demands of their local residents. These industries are referred to as basic industries and demonstrate that the region is more specialized in production than the same industry at the national level. An LQ >1.25 indicates that the industry is part of the economic base—exporting goods and services outside the region and bringing money into the region from outside. Industries with LQs ≤ 1.00 indicate that the industry is equally specialized or less specialized than the nation. Using employment data from the Bureau of Labor Statistics, we estimated the location quotients for the vegetable and melon farming industry in Arizona.

At the state level in 2014, vegetable and melon farming had a LQ of 1.85 (Table 4), suggesting that Arizona is more specialized than the nation in vegetable and melon production. According to this calculation, the vegetable and melon industry in Arizona employed nearly twice as many people as the nation. This demonstrates the importance of this agricultural industry as part of Arizona's economic base.

When examining LQs at a smaller geographic scale, there were two counties in Arizona that exhibit specialization in vegetable and melon farming. These two counties were Yuma County and Pinal County. In 2014, Yuma County had a remarkable LQ of 51.47. This means that the vegetable and melon industry in Yuma County employs nearly 52 times the national average share of employment. As to be expected, the vegetable and melon farming industry is certainly a part of Yuma County's economic base. Pinal County was also specialized in vegetable and melon farming, with a LQ of 2.33. Maricopa County fell just short of breaking the 1.00 threshold, with a LQ of 0.81. However, this isn't to say that vegetable and melon farming is not important in Maricopa County. Recall that Maricopa County accounts for the second highest value of sales of vegetables and melons in the state. One reason that Maricopa County doesn't have a high LQ for vegetable and melon farming is that the Phoenix metropolitan area has high levels of employment in other non-agricultural industries.

Table 4. Arizona Vegetable and Melon Farming Jobs-based Location Quotients, 2014

Geography	Location Quotient
Arizona	1.85
Yuma County	51.47
Pinal County	2.33
Maricopa County	0.81

Source: Department of Labor, Bureau of Labor Statistics: QCEW Data, 2014.

Harvesting

Harvesting is the second component of on-farm production and is considered an input for vegetable and melon farming. Lettuce, Arizona's leading vegetable and melon commodity, is primarily harvested during the winter months from November or December through March or April (Kerns et al., 1999, personal communication with YFVA members). Lettuce is typically "harvested, packaged in the field, and shipped to market with no further processing" (Kerns et al., 1999). This is called field packing. A typical setup for harvesting lettuce includes a field packing harvest aid and a crew of eight groups of three individuals—two people to cut and trim the outer lettuce leaves and one packer to bag the lettuce or wrap it with cellophane. Lettuce can also be bulk harvested meaning that it is simply placed it in a cardboard carton. Lettuce that is packed this way is typically sent to be fresh-cut or fresh-processed to create prepackaged or ready-made salads.

Melons are primarily harvested in the summer and fall, providing an extended harvest period for the industry. In Yuma, melons can be harvested in mid-May all the way through November (Riggs, 2010). The typical harvest crew for melons ranges "from nine to 12 people, including two to three cutters, four to six loaders, two stackers, and one truck driver" (University of Georgia Cooperative Extension Service, 2000).

Harvesting vegetables and melons can be carried out by the growers themselves, farm labor contracting services, or by shippers that have already purchased the fresh vegetables (Kaufman et al., 2000; Fernandez-Stark et al., 2011). As harvesting vegetables is labor-intensive and there is very high demand for labor during the harvest season, many farms use farm labor contracting services.

Once vegetables and melons have been harvested, they can follow one of two production tracks: the fresh market or the processed market. The following sections describes the activities that take place in each production track.

Fresh Market Post-Harvest Activities

Packing, Cooling, and Storing

Post-harvest activities for vegetables and melons entering the fresh market include packing, cooling, storing, distributing, and marketing. Packers "transform the loose product into a saleable product by packing it into cartons, boxes or bags as appropriate" (Gunderson, et al., 2009). Packers also may wash, cut, and label the produce. As mentioned previously, packing can take place in the field with farm labor contractors (such as the case with leafy greens) or it can take place in a packing warehouse with the packing done by packers and shippers. According to the Arizona Department of Agriculture's *Citrus, Fruit and Vegetable Standardization Annual Report*, there were 48 Arizona packers licensed in FY2015.[3]

An unbroken cold chain is essential to maintaining the quality and shelf life of vegetable and melon produce. This includes harvesting while it is cool in the field, keeping the produce in a cold environment during storing and packing, and transporting the produce in refrigerated vehicles (Ezeike and Hung, 2009). All of this must be done very quickly. In fact, Ezeike and Hung suggest that the general rule of thumb is that "a one-hour delay in cooling reduces a product's shelf life by one day" (p. 526). Depending on the type of produce, there are different cooling requirements. For crops with very high respiration rates, like broccoli, leaf lettuce, and spinach, cooling should occur within 90 minutes of harvest. Other vegetables, like cauliflower, snap beans, and head lettuce, should be cooled within three hours of harvest. Finally, vegetables and melons such as cabbage, cantaloupe, peppers, and squash can be cooled up to 4–5 hours after harvest (Ezeike and Hung, 2009).

Cooling and storage takes place in refrigerated warehouses that can be owned by a grower and/or shipper or an independent business. In Yuma, coolers are concentrated in one area of town known as Cooler Row.

Distributing and Marketing

The final stage of production for fresh vegetables and melons is distributing and marketing the produce. Shippers connect the buyers (wholesalers, grocery store retail chains, and food service distributors) to the sellers (growers). Shippers can serve a variety of roles and "can be very large, vertically-integrated growers, a cooperative of growers, or an independent business" (Gunderson, et al., 2009). As one industry expert so aptly described them, shippers are the "name on the box." They are responsible for consolidating produce and marketing it in quantities large enough for distribution to large wholesale, retail, and food service companies. A shipper may have their own farming operation (a grower-shipper) or they may source from multiple, independent

3 A packer is considered an Arizona packer when it reports a mailing address within the state of Arizona.

growers. Shippers may also have their own refrigerated trucks to transport produce or they may contract with other specialized refrigerated trucking companies. According to the Arizona Department of Agriculture's *Citrus, Fruit and Vegetable Standardization Annual Report*, there were 81 Arizona shippers licensed in FY2015.[4]

Wholesale produce dealing is the second component of distributing and marketing the produce. Produce wholesalers buy vegetables and melons directly from the grower or through a grower-shipper. Most wholesalers are "merchant wholesalers who take title to the product, which they handle" (Kaufman et al., 2000). According to the Arizona Department of Agriculture's *Citrus, Fruit & Vegetable Standardization Annual Report*, there were 190 Arizona produce dealers licensed in FY2015.[5]

Processed Market Post-Harvest Activities

Processing

Vegetables and melons that are harvested for processing typically go straight from the farm to the processing establishment. According to the 2012 Census of Agriculture, only 7% of Arizona vegetable and melon acreage was harvested for processing. In 2012, 43 farms harvested 8,886 acres of vegetables and melons for processing. A majority of the acreage in Arizona that was harvested for processing (55%) occurs in Yuma County. Vegetables produced in Yuma County for processing include broccoli, Chinese cabbage, head cabbage, cauliflower, mustard greens, green onions, parsley, radishes, spinach, and turnip greens. Only three other counties have information disclosed[6] on acreage harvested for processing. These counties are Pinal, Apache, and Navajo. Pinal County accounted for 27% of the vegetable and melon acreage harvested for processing. Vegetables produced in Pinal County for processing include chili peppers, potatoes, and other vegetables. Together, Apache and Navajo counties accounted for slightly less than 2% of vegetables harvested for processing. Vegetables and melons produced in Apache County for processing include snap peas (both bush and pole), cantaloupes, muskmelons, and summer squash. The only vegetable produced in Navajo County for processing is summer squash. Together, these four counties accounted for approximately 84% of all vegetable acreage that is harvested in Arizona for processing.

Processing establishments, while once located near the farm, have moved away from on-farm production areas and are now located closer to metropolitan areas (Gunderson, et al., 2009). The reason for this is primarily due to the cost of shipping the produce. It is typically less expensive to ship the raw product than the processed product. This can also be true for value added activities in the fresh market for vegetables and melons. One example of this is the movement of large fresh-cut lettuce processors out of Yuma County. Large companies that once had salad processing plants and machinery in Yuma shifted their management so that processing establishments are located in a single, concentrated area. This is due to the fact that these processors were only in business in Yuma a fraction of the year and, ultimately, it was cheaper to transport bulk lettuce than it was to ship bags of chopped salad (personal communication with YFVA members and Kurt Nolte). Processed

4 A shipper is considered an Arizona shipper when it reports a mailing address within the state of Arizona.
5 A produce dealer is considered an Arizona produce dealer when it reports a mailing address within the state of Arizona.
6 Government statistics are not reported when such reporting will identify individual operations.

goods are then distributed and marketed to wholesalers or sent directly to grocery store retail chains and food service distributors.

Trucking

Transportation, in particular trucking, is critical throughout the entire production process. During harvest there can be a shortage of trucks because there is such high demand for transportation services to haul machinery used to harvest the vegetables and melons as well as transport the produce to consumer markets. Specialized trucks transport vegetables and melons from the field to the cooler and from the cooler to the end user. Due to the perishable nature of vegetables and melons, swift action and climate-controlled environments are required (Gunderson, et al., 2009). Furthermore, because "consumers now demand access to their favorite fruits and vegetables year-round," efficient transportation has become even more important (AREC, 2007). In winter months, vegetables are shipped from the Southwest to all over the nation.

Economic Contributions of the Vegetable and Melon Industry Cluster

This study presents the results of an economic contribution analysis of the vegetable and melon industry cluster to the Arizona economy in 2014. As described previously, these contributions were not limited to the production of vegetables and melons in Arizona farms, but also include economic activity in industries that perform essential vegetable and melon post-harvest activities. These post-harvest activities include packing, cooling, storing, processing, distributing and marketing Arizona produced vegetables and melons.[7] Because collaboration amongst these industries is essential in delivering vegetable and melon produce to consumers, we estimate the contribution of the **vegetable and melon industry cluster** to the Arizona economy. These are called the *direct effects*.

In addition to estimating the *direct effects* of the vegetable and melon industry cluster on the Arizona economy, we also estimate the "ripple" of economic activity that is generated when businesses within the vegetable and melon supply chain and households employed by the vegetable and melon industry cluster purchase inputs and consumer goods and services from other Arizona businesses. Economists call these the *indirect* and *induced multiplier effects*.

Indirect effects measure the economic activity resulting from business-to-business transactions, or when businesses are purchasing inputs to production. For example, vegetable and melon farms, the primary industry in the industry cluster, require inputs (water, irrigation supplies, fertilizer, tractors, contract labor, etc.) to grow and harvest vegetables and melons. When farms purchase these inputs from other Arizona businesses, economic activity is generated in industries that produce those inputs (water distributors, irrigation suppliers, and fertilizer and farm machinery manufacturers, and farm labor contractors). Similarly, industries involved in vegetable and melon post-harvest activities, such as refrigerated warehousing, also require inputs (land, electricity, industrial machinery, etc.) and these demands generate economic activity in industries selling those goods and services.

Induced effects are generated when employees in the vegetable and melon industry cluster spend their earnings (profits and wages) on consumer goods and services within the state. Households employed by the vegetable and melon industry cluster take the paychecks they earn and spend them at the grocery store, optometrist, car dealership, or the movie theater, generating economic activity in industries completely unrelated to agriculture.

Combined, the *direct*, *indirect*, and *induced effects* measure the total contributions of the vegetable and melon industry cluster to the Arizona economy. The total contributions in 2014 [8] were estimated using the input-output modeling software IMPLAN Version 3.1.[9] The economic contribution is estimated by "removing" the vegetable and melon industry cluster from the Arizona economy and assessing how the removal affects economic activity in other Arizona industries.[10]

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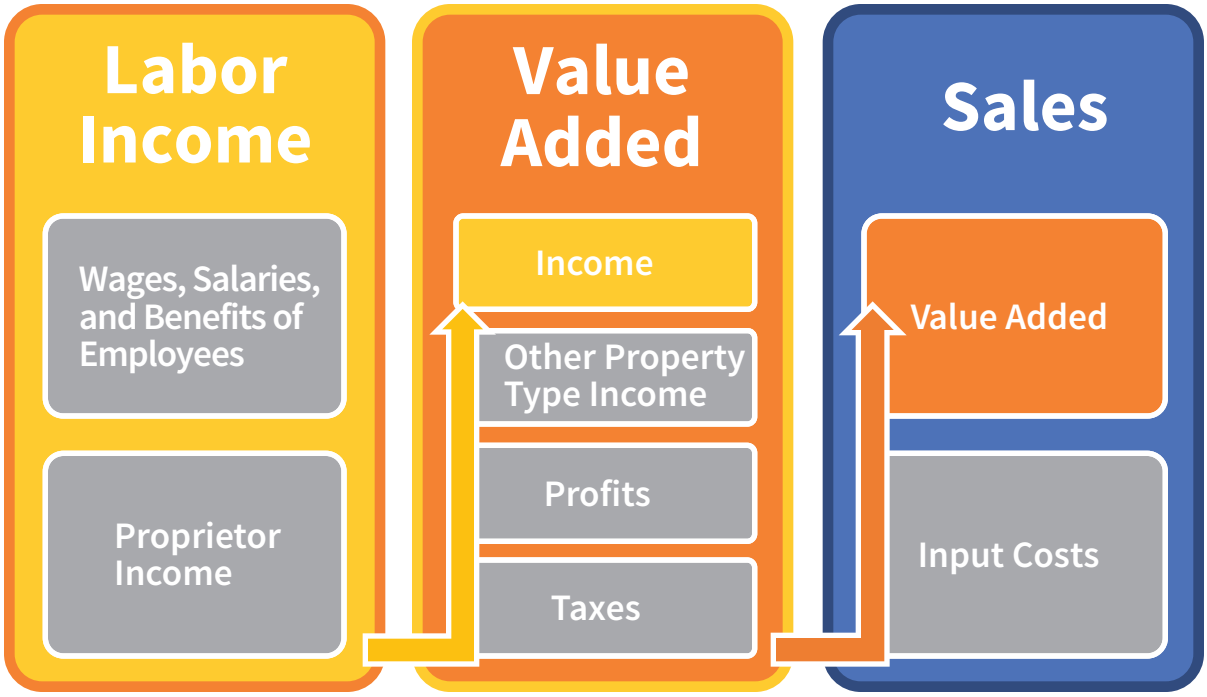
7 Retailing is not included in this analysis because economic activity in this industry cannot be easily attributed solely to vegetables and melons produced in Arizona.
8 This analysis is a snapshot in time. We select 2014 as the year for analysis because it accords with the base year of the most recent IMPLAN model. Estimating the contribution for a different year may provide significantly different results (as shown in the Addendum).
9 IMPLAN is a widely used input-output data and modelling system that provides and detailed account of the Arizona economy and is used to demonstrate how each industry in the economy is linked to one another and estimate how changes in one industry can affect other industries through backward linkages with suppliers of inputs to production.
10 A more detailed description of the research methods is presented in the Appendix.

Figure 9. Illustration of Relationship between Economic Metrics



The economic metrics used to describe the industry cluster's contribution to the Arizona economy include sales, value added (GSP or Gross State Product), labor income (employee compensation and proprietor income), state and local taxes, and overall employment. It's important to note that many of these economic metrics are interconnected and, therefore, cannot be added together. Figure 9 demonstrates the relationship between sales, value added, and labor income.

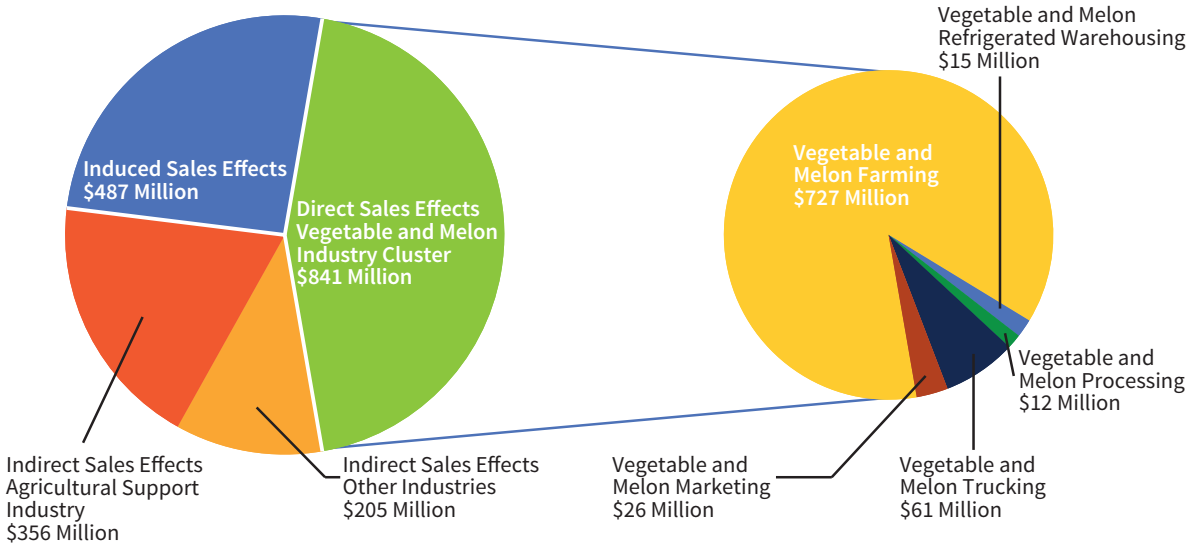
Sales, also known as output, measures the total final value of goods and services produced by an industry. Sales is a gross measure of economic activity as it includes the value of economic activity generated in the industry (value added) as well as the costs of inputs. While sales is the easiest metric to understand, the most precise metric to measure an industry's contribution to the Arizona economy is value added. Value added is the net incremental change in value from the last stage of production. It measures the *additional* gain in economic activity that can be attributed a particular industry. This metric is synonymous to the official measure of gross state product (GSP), the measure that is most often used to measure the size of a state economy. Value added is comprised of the incomes paid to workers, the profits of the industry, and the taxes paid to the government (IMPLAN Group, LLC). Finally, labor income measures the total personal income generated by the industry. It includes the wages, salaries, and benefits of employees as well as the income of proprietors.

The following section of the report summarizes the results of the economic contribution analysis. Estimates of the *direct*, *indirect*, and *induced* contributions of the vegetable and melon industry cluster in 2014 are reported in terms of sales, value added (GSP), labor income, state and local taxes, and employment.

Sales Contributions

In 2014, the vegetable and melon industry cluster directly and indirectly contributed approximately $1.9 billion in sales to the Arizona economy. This sales contribution included $841 million in direct sales from the vegetable and melon

Figure 10. Total Sales Contribution of the Vegetable and Melon Industry Cluster to the Arizona Economy, 2014



Source: Authors' estimates using IMPLAN, 2014.

industry cluster and more than $1.0 billion in sales generated through indirect and induced multiplier effects. Figure 10 demonstrates the sales values attributable to the various vegetable and melon cluster industries and economic effects.

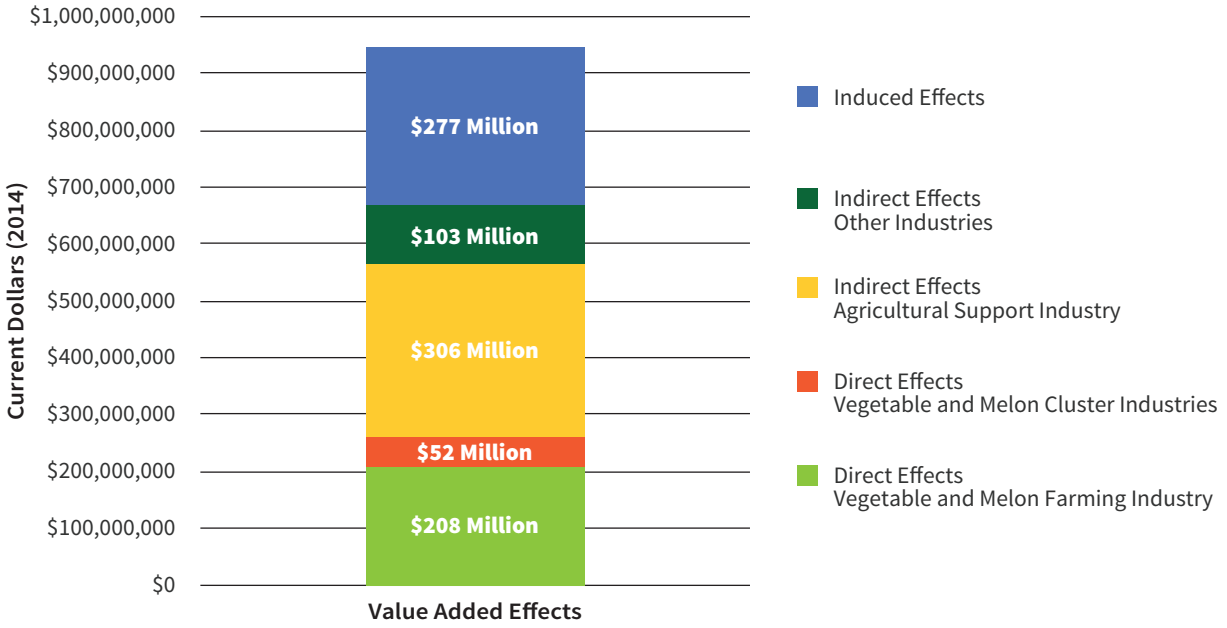
The vegetable and melon industry cluster's direct contribution to Arizona sales in 2014 was approximately $841 million. Of this, vegetable and melon production in Arizona farms accounted for the majority of sales. In 2014, Arizona farms produced an estimated $727 million in sales of vegetables and melons.[11] Arizona-produced vegetables and melons supported an estimated $15 million in sales for the refrigerated warehousing industry (packing, cooling, and storing activities), $12 million in sales for the vegetable and melon processing industry (processing activities), $61 million in sales for the trucking industry, and $26 million in sales for the vegetable and melon wholesaling industry (distributing and marketing activities) in Arizona.[12] Therefore, the estimated total *direct* sales contribution of the vegetable and melon industry cluster was approximately $841 million.

By purchasing inputs to production, another $561 million of sales is generated through indirect effects. Of the $561 million in sales contributed through indirect effects, more than $350 million or 60% of the sales were generated in the agricultural support industry. The agricultural support industry is the industry that provides farm labor contracting services (labor for harvest). Because this is by far the highest input cost for vegetable and melon producers, the agricultural support industry generates a significant amount of the indirect sales effects.

An additional $487 million in sales is supported through induced effects, or when employees take their earnings and spend them at other Arizona businesses. The industries most affected by induced effects tend to be industries that provide essential goods and services to meet basic needs. For example, model results suggest that industries supported by the vegetable and melon industry cluster through induced effects include the real estate, healthcare, wholesale, insurance, and restaurant industries, among others.

11 This value includes both commodity cash receipts in 2014 as well as an estimate of additional farm income earned.
12 Sales for each of the vegetable and melon post-harvest industries were estimated and parsed out from their larger industry aggregation. See Appendix for estimation methods.

Figure 11. Total Value Added Contribution of the Vegetable and Melon Industry Cluster to the Arizona Economy, 2014



Source: Authors' estimates using IMPLAN, 2014.

Value Added Contributions

The vegetable and melon industry cluster's total contribution to state value added or the gross state product (GSP) in 2014 was $946 million. This includes direct value added effects from the industry cluster of more than $260 million, indirect value added effects of $409 million, and induced value added effects of $277 million. Figure 11 demonstrates the breakdown of effects.

Of the $260 million in direct value added effects supported by the vegetable and melon industry cluster, most of the net gain in economic activity was attributable to the vegetable and melon farming industry. This industry contributed approximately $208 million to the Arizona GSP.

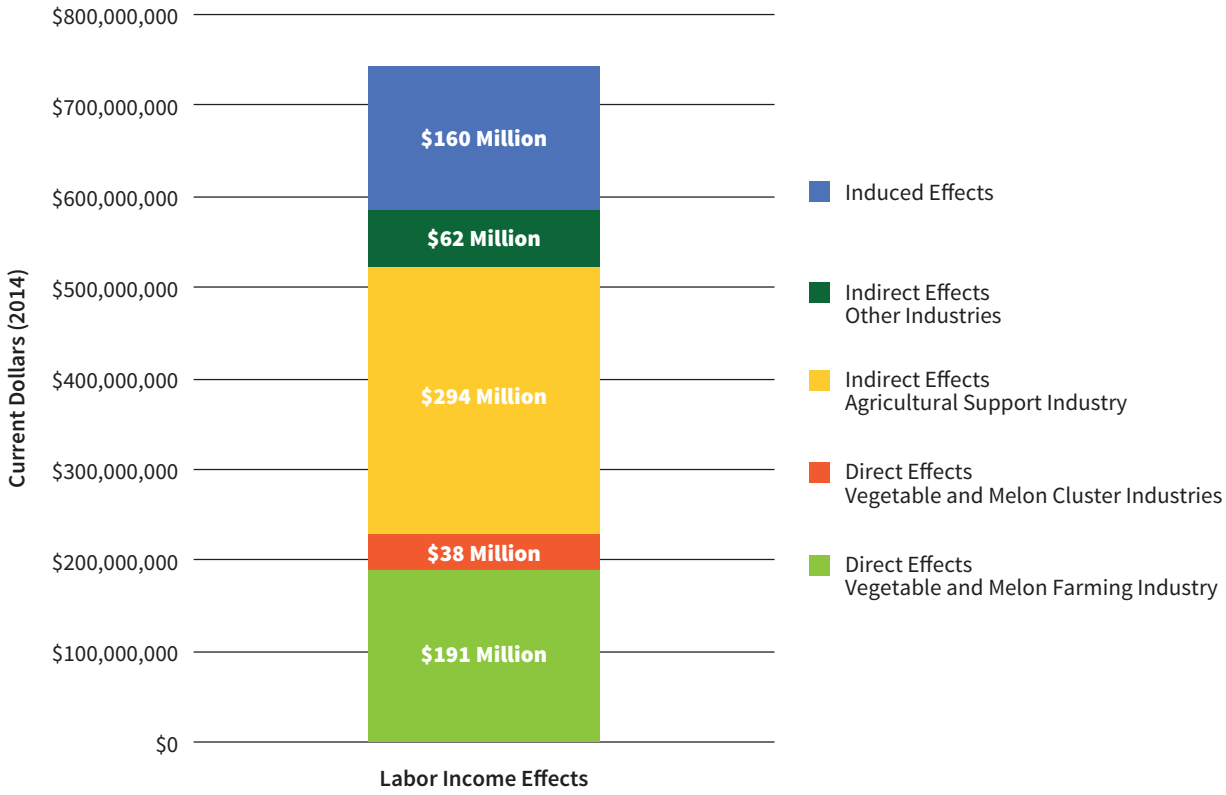
Through its demand for contract labor, the vegetable and melon industry cluster also helped to generate significant value added contributions to the Arizona economy through indirect effects. Of the $409 million in indirect effects supported by the vegetable and melon industry cluster, approximately 75% or $306 million occurred in the agricultural support industry.

Finally, an estimated $277 million in additional value added is supported through induced effects. As mentioned previously, the industries most affected by induced effects tend to be industries that provide essential goods and services to meet basic needs.

Labor Income Contributions

Including multiplier effects, the vegetable and melon industry cluster contributed an estimated $745 million in labor income (employee compensation and proprietor income) to Arizona's economy (Figure 12). Of this amount, 83% of the income supported by the industry cluster went to employee compensation with remaining 17% earned by proprietors. Of the total labor income, $191 million was supported by the vegetable and melon farming industry, $38 million was supported by post-harvest cluster industries, and $294 million was supported by the agricultural support services industry. Approximately $62 million was supported by input supply industries (indirect effects) and $160 million was supported by consumer goods and services industries (induced effects).

Figure 12. Total Labor Income Contribution of the Vegetable and Melon Industry Cluster to the Arizona Economy, 2014



Source: Authors' estimates using IMPLAN, 2014.

Tax Contributions

Including indirect and induced multiplier effects, the total estimated state and local tax contribution from the vegetable and melon industry cluster to the Arizona economy was approximately $59.2 million. This includes an estimated direct state and local tax contribution of $11.8 million. This direct contribution to state and local taxes includes approximately $7.0 million in taxes on production and imports, $4.0 million in personal taxes such as personal income and property taxes, and $0.8 million in corporate profit and social security taxes. Through indirect and induced effects, the vegetable and melon industry cluster also supported an additional $47.4 million in state and local taxes. These tax revenues are received through other industries in the Arizona economy, but are stimulated by demands from the vegetable and melon industry cluster.

Employment Contributions

Arizona's vegetable and melon cluster supports a host of different jobs in the state, directly and indirectly. On-farm employment accounts for the largest number of jobs and is also the area where the number of jobs is most difficult to measure. Hired on-farm labor includes workers directly hired by farm operations and agricultural support services. Support services include activities like soil preparation, cultivation, and harvesting. The bulk of these workers are hired through the services of farm labor contractors. In addition to hired workers, there are the self-employed farm operators themselves. There are also a substantial number of unpaid family workers that may not draw formal salaries but work on the farm nonetheless.

Next, beyond the farm gate, there are a number of jobs in post-harvest industries such as refrigerated warehousing, processing, trucking, and wholesaling. Furthermore, as demonstrated above, the vegetable and melon cluster also creates demand for jobs in industries supplying inputs such as fertilizers, agricultural chemicals, farm machinery, and fuels. Finally farm laborers and operators spend their paychecks and farm profits on housing and a variety of other consumer goods and services. This increased demand for consumer goods and services in turns supports jobs in those industries.

On-Farm Employment

There are several challenges to measuring on-farm employment in vegetable and melon production. One issue is lack of data and another is the discrepancies in sources of data that are available. The following sections outline the data and methodologies used to estimate on-farm employment in vegetable and melon production. On-farm employment includes farm proprietor jobs, directly hired farm labor, and agricultural support service workers (usually hired through farm labor contractors).

Proprietors

The USDA's Census of Agriculture surveys vegetable and melon growers (defined as operations where vegetable and melon sales account for the majority of their farm income) at the state level once every five years. The most recent Census was conducted in 2012. In that survey, vegetable and melon farmers were asked whether farming was the primary occupation of the principal operator. According to the 2012 Census of Agriculture, there were 1,413 farms with vegetable and melon sales where farming was the primary occupation of the principal operator. The Bureau of Economic Analysis (BEA) Regional Economic Accounts reports the total number of farm proprietor jobs in Arizona, but in this data source, farm proprietors are not identified by the crop that they produce. Therefore, estimates of the number of self-employed vegetable and melon farm proprietors were based on data from the 2012 Census of Agriculture. As vegetable and melon sales and acreage were comparable between the 2012 Census year and the 2014 data used for our contribution analysis, it was assumed that there were 1,413 vegetable and melon proprietors.

Hired Labor

One potential source of data on hired labor is from the Census of Agriculture. Arizona vegetable and melon growers, again defined by where vegetable and melon sales account for the majority of their farm income, produced other crops, but also accounted for 97% of all vegetable and melon sales in the state. The Census of Agriculture asks growers about the number of workers directly hired and whether they were hired for more or less than 150 days. Another source of data is the Quarterly Census of Employment and Wages (QCEW) conducted by the Department of Labor's Bureau of Labor Statistics. The QCEW reports data on monthly jobs and quarterly salaries paid out to workers on vegetable and melon farms. However, QCEW only includes data for operations large enough to pay into the unemployment insurance system. Finally, the BEA reports the number of farm jobs and the employment compensation paid to salaried workers in Arizona. However, similar to farm proprietors, it does not provide estimates by type of crop grown so one cannot directly estimate how many of these jobs are related to vegetable and melon production. To estimate the total number of hired labor workers in vegetable and melon production, we used annual average number of direct hire jobs from the 2014 QCEW survey for vegetable and melon operations. The annual

average was 3,435 but monthly averages ranged from a low of 1,814 in August to a high of 4,314 in January. A more in-depth discussion of the seasonality of on-farm employment is presented in later sections of this report.

Agricultural Support Services Labor

Estimating the employment in the agricultural support service industry related to vegetable and melon production is even more complicated. While the Census of Agriculture asks about expenses paid for contract labor and labor hired for custom work, it does not provide data on the number of laborers hired under these arrangements. Additionally, the QCEW reports data on jobs in agricultural support services, but it does not indicate the type of farming operation that is using these services. So, again, one cannot directly infer how many of these workers are employed in vegetable and melon production. QCEW data from Yuma County suggest that agricultural support services is the main source of hired on-farm vegetable and melon employment. The bulk of these workers in Yuma are listed as working for farm labor contractors. Seasonal agricultural support services employment in Yuma ranges from equal to the number of directly hired vegetable and melon workers to triple (or more) of directly hired labor. In sum, the main labor category accounting for hired on-farm vegetable and melon production is agricultural support services, but data for this category are not broken out by type of crop where the work is done. The BEA also provides data on total number of jobs in agricultural support services, combining crop, livestock, and forestry support services. Again, these data alone are not disaggregated in a way to infer the number of agricultural support services jobs in vegetable and melon production. However, based on QCEW data, support services related to crop production make up the bulk of these jobs. Data on total agricultural support services from BEA and QCEW are largely in agreement.

To construct employment estimates of agricultural support services we proceeded as follows. First, we used annual average number of direct hire jobs from the 2014 QCEW survey for vegetable and melon operations. The annual average of direct hire jobs was 3,435. Second, to estimate the total number of agricultural support service jobs, data on labor requirements per acre of different crops grown in Yuma County were first obtained from Wishon et al. (2015). Next, these data were combined with detailed acreage data from the 2012 Census of Agriculture. Vegetable and melon crops required significantly more labor per acre than other crops and also accounted for more than half of all harvested cropland in the county. Combining acreage and labor requirement data, we estimate that vegetables and melons account for roughly 89% of agricultural hired labor requirements in Yuma County for crops grown in the open. Directly-hired jobs were deducted from labor requirements for each crop category. Then, agricultural support jobs were allocated to each crop category so that a crop's share of total agricultural jobs (direct-hire and agricultural support services) matched their total labor requirement share. Details of this procedure are provided in the Appendix. A similar procedure was then used to allocate agricultural support service jobs to vegetable and melon production in the rest of Arizona, outside Yuma County. Following this procedure there were an average annual number of 7,338 agricultural support service jobs on Arizona vegetable and melon farms.

Another challenge of measuring on-farm employment is defining what constitutes "a job." If one worker holds four two-month-long jobs and is unemployed for four months, does this count as four jobs or 8/12 (or 2/3) of a job? Data from the various government sources do not make clear distinctions between part-time and full-time jobs. For this study, we attempted to convert

reported jobs based on government statistics into year-round full-time job equivalents. The estimates of agricultural support service jobs were converted to year-round equivalent jobs as follows. First, it was assumed that total salary payments to agricultural support service workers in vegetable and melon production were proportional to their total share of such jobs in Arizona. Second, quarterly salary payments were calculated for agricultural support service workers in vegetable and melon production based on QCEW salary data. Third, quarterly salary payments were divided by quarterly reported hourly wage rates to obtain the total number of hours worked. Hired agricultural field worker wage rates were obtained from the USDA Farm Labor Survey. This survey combines data from Arizona and New Mexico, but Arizona accounts for the bulk of the labor. It was assumed that agricultural support service workers received comparable wages to hired agricultural labor. Fourth, total work hours were divided by 2,000 hours to estimate the number of year-round full-time equivalent jobs. The 2,000 hours assumes 50 weeks of work at 40 hours per week.

The number of full-time equivalent jobs in agricultural support services actually increases to 8,262 jobs following this procedure. Why does the number of full-time equivalent jobs increase? This occurs because although agricultural jobs are highly seasonal, when laborers are working, they usually work more than 40 hours per week. So, perhaps the best way to think of this estimate is as follows. Payments for agricultural support labor in Arizona vegetables and melons is sufficient to support the equivalent of 8,262 people working 40-hour weeks for 50 weeks out of the year, and being paid the average regional wage rate paid to hired agricultural field labor. This does not mean that this is the actual number of individuals employed in vegetable and melon agricultural support services. As discussed below, the number of unique workers can be considerably greater than this figure.

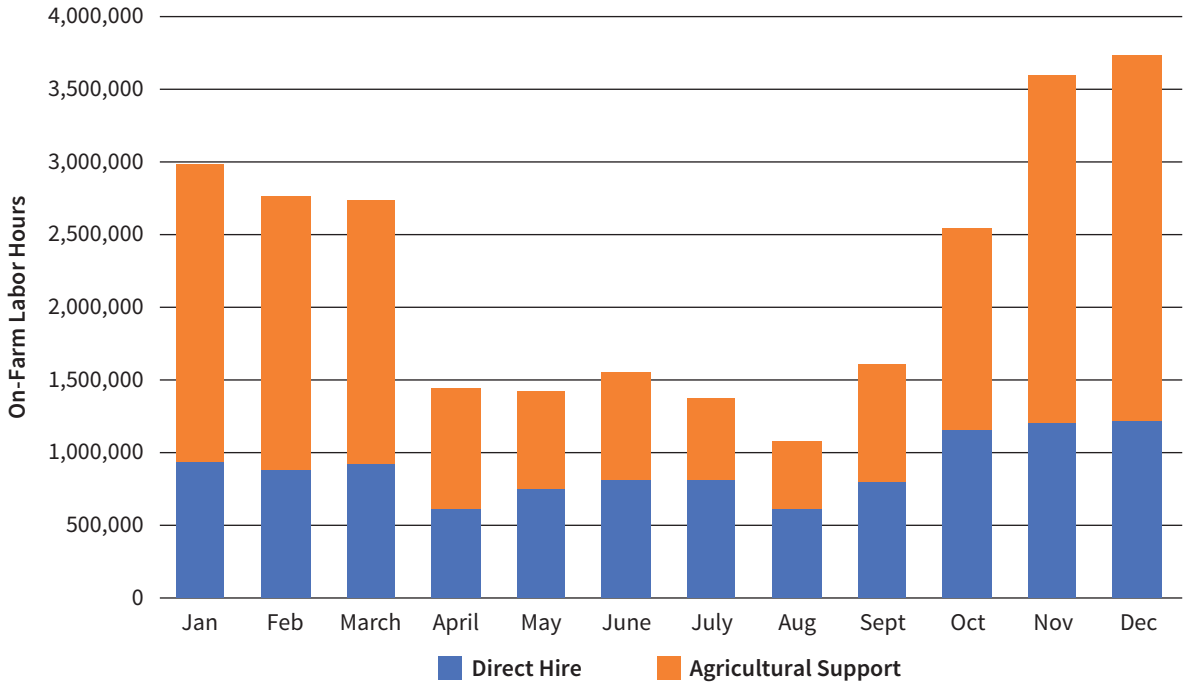
Seasonality of Labor Demand

Another challenge of employment estimation is the seasonal nature of agricultural employment. Annualized job estimates do not accurately capture peak labor demands for vegetable and melon production. Estimates of hours of labor employed on-farm for vegetable and melon production were developed as follows. Total quarterly salary payments to directly-hired workers on vegetable and melon farms from the QCEW were divided by the quarterly field worker wage rate for the Mountain III region from the USDA Farm Labor Survey. This yielded an estimate of quarterly hours worked. Quarterly hour estimates were allocated to each month based on that month's reported share of total direct-hire vegetable and melon jobs.

A similar procedure was followed for agricultural support service jobs. The share of support service salaries paid to workers in vegetable and melon production from the QCEW was scaled to match those workers' share of total agricultural support service jobs. Again, dollar payments were divided by average wage rates to obtain quarterly hour estimates. Quarterly hour estimates were allocated to months based on each month's share of quarterly jobs in agricultural support services on vegetable and melon farms.

Results of this exercise are shown in Figure 13. In total, in 2014, more than 26.7 million hours of on-farm labor were devoted to vegetable and melon production in Arizona. This represents an average of 2.2 million hours per month, but this average masks large seasonal fluctuations in labor demand. Between April and September, monthly labor demand ranged between 1.0 and 1.6 million hours. From October through March, however, labor demands ramp up considerably. In November through January, labor demands ranged from about 3.0 to 3.7 million hours per month. As Figure 13 shows,

Figure 13. On-farm Labor Hours Worked on Vegetable and Melon Farms by Month, 2014



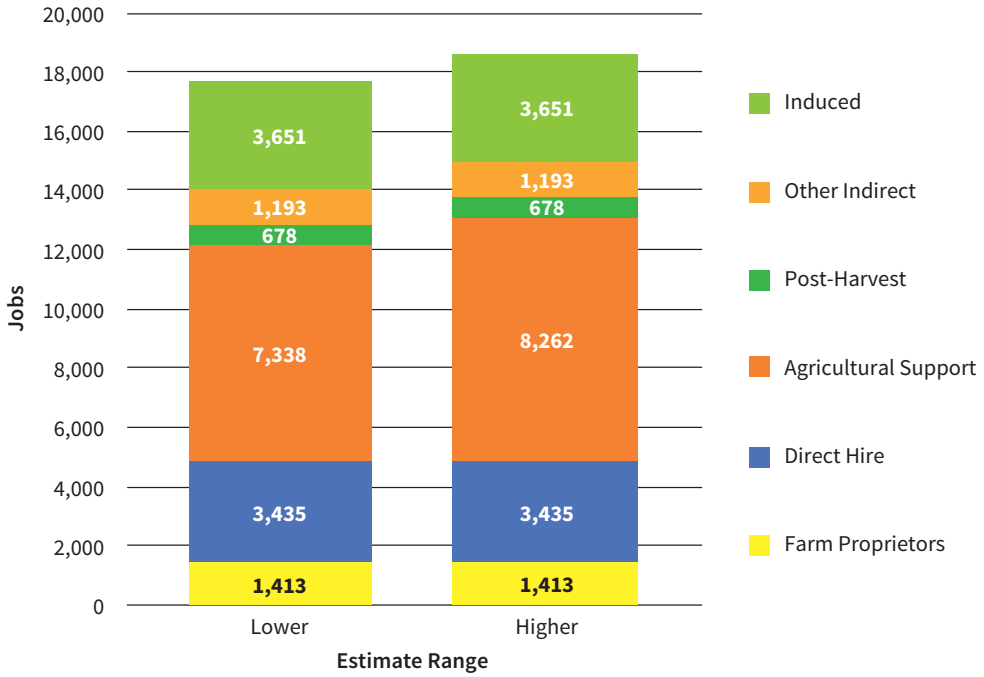
Source: Quarterly Census of Employment and Wages, USDA Farm Labor Survey, and authors' calculations.

the demand for agricultural support service labor fluctuates more dramatically than demand for directly hired labor. The figure also suggests the challenges for labor recruitment as peak season labor requirements can be more than double slack season demands

Post-Harvest and Other Employment

In addition to on-farm employment, there are a number of jobs supported in other industries in the vegetable and melon industry cluster. Jobs supported in post-harvest industries include an estimated 387 jobs in the transportation industry, 157 jobs in the refrigerated warehousing industry, 110 jobs in the vegetable and melon wholesaling industry, and 24 jobs in the vegetable and melon processing industry. The cluster also supported an additional 1,193 jobs in industries supplying inputs to the cluster (the indirect effects) and 3,651 jobs in other industries providing consumer goods and services paid for by wages and profits from people working within the cluster (the induced effects).

Figure 14. Jobs Supported by the Arizona Vegetable and Melon Industry Cluster by Job Type, Lower and Higher Range Estimates, 2014

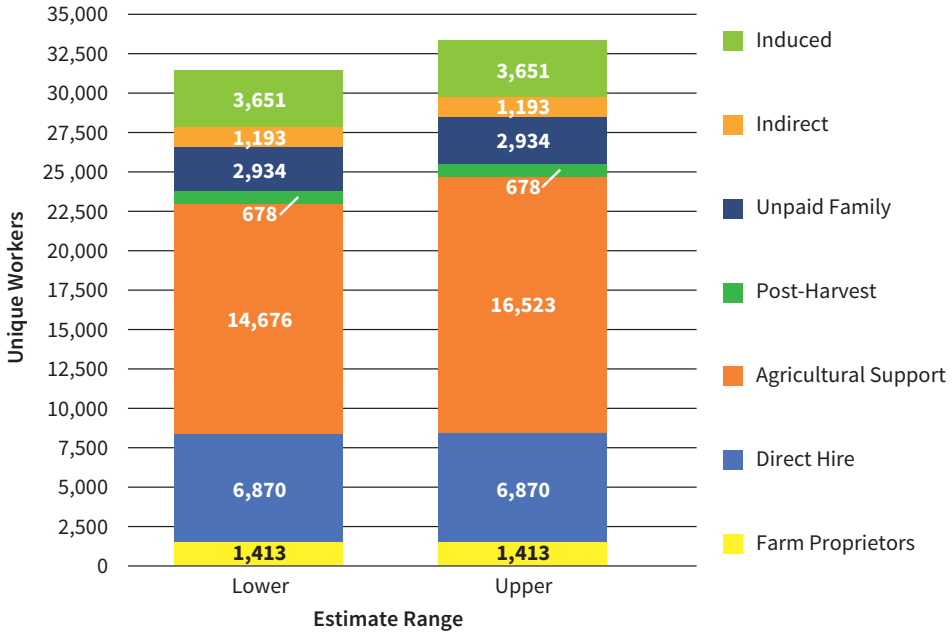


Source: Authors' estimates using Bureau of Labor Statistics QCEW and BEA Employment Data, 2014.

Total Vegetable and Melon Cluster Employment

Figure 14 provides a lower and higher estimate of the total number of jobs supported by the vegetable and melon cluster, including indirect and induced effects. The lower estimate is based on unadjusted estimates of agricultural support service jobs based on QCEW and BEA data. The higher estimate converts agricultural support service jobs to 40 hour per week, 50 weeks per year job equivalents. In total, the cluster supported between 17,708 and 18,632 jobs.

Figure 15. Estimated Range of Unique Workers Supported by the Arizona Vegetable and Melon Industry Cluster, 2014



Source: Authors' estimates using Bureau of Labor Statistics QCEW and BEA Employment Data, 2014; Census of Agriculture, 2012; Hooker, et al., 2015.

Unique Workers

The number of unique farm workers employed in vegetable and melon production is significantly greater than the number of jobs. This is for two reasons. First, according to the 2012 Census of Agriculture, Arizona vegetable and melon operations employed 2,934 unpaid (family) workers. Family members drawing salaries are classified as part of hired labor. Although contributing to vegetable and melon farming operations, unpaid workers are not counted in other labor statistics. Because production levels in 2014 were comparable to those in 2012, we assume that the number of unpaid workers were the same as in 2012. We do not convert their contributions to full-time equivalents because wage and hour data are not available. Second, recent research on California agricultural labor markets found there were an average of two unique farm workers or Social Security Numbers reported by farm employers for each year-round equivalent farm job (Hooker, et al., 2015). Their analysis included both directly hired workers and those providing agricultural support services. This two-to-one relationship was stable across 2007 and 2012 Census of Agriculture editions. If one assumes this two-to-one relationship also holds for Arizona—which has similar crops and production systems as California—then the number of unique hired workers (both direct hire and agricultural support service workers) would be in the range of 21,500 to 23,400 workers.

A more accurate measure of the number of unique workers in the vegetable and melon cluster as a whole would account both for unpaid family workers and adjust for the number of workers per year-round equivalent job. Combining these effects, the number of unique workers in the whole Arizona vegetable and melon cluster would be the in range of 31,400 to 33,300 workers (Figure 15).

Summary and Discussion

The vegetable and melon industry cluster is a highly integrated system comprised of a variety of industries that work in tandem with one another to get fresh, as well as processed, vegetable and melon produce and products to consumers. This cluster includes industries involved in all aspects of the vegetable and melon value chain, including those that perform activities on-farm as well as those that perform essential post-harvest activities. The industry cluster includes the vegetable and melon farming industry (growing and harvesting activities), the refrigerated warehousing industry (packing, cooling, and storing activities), the vegetable and melon processing industry (processing activities), the transportation industry (trucking activities), and the vegetable and melon wholesaling industry (distributing and marketing activities).

Recall that indirect effects measure the economic activity associated with the industry's demand for inputs and induced effects measure the economic activity associated with industry employees' demand for consumer goods. A majority of these multiplier effects are supported in the agricultural support industry, an industry that provides a critical component in the vegetable and melon industry cluster value chain. The agricultural support industry provides one of the most important (and costly) inputs to vegetable and melon production: contract farm labor. Of total indirect and induced multiplier effects, the agricultural support industry accounts for approximately 35% of sales, 45% of value added, 57% of income, and 45% of jobs.

In conclusion, when accounting for economic activity supported in industries providing goods and services as inputs to producers and as consumer goods for households, the total economic contribution of the vegetable and melon industry cluster in 2014 was nearly $1.9 billion in sales, $946 million in value added, $745 million in incomes (wages and salaries of employees and business-owner income), and $59.2 million in state and local taxes.

There were between 17,700 and 18,600 jobs directly and indirectly supported by the vegetable and melon industry cluster in Arizona on an annualized basis. Between 12,100 and 13,100 of these jobs were on-farm jobs, which included farm proprietor jobs, directly hired farm labor, and agricultural support service workers (primarily hired through farm labor contractors). Other jobs supported were those in industries providing inputs to the cluster, those providing post-harvest transportation and processing services, and consumer goods and services to workers and proprietors in the industry cluster.

The number of unique farm workers employed in vegetable and melon production is significantly greater than the number of jobs. First, there are more than 2,900 unpaid (family) workers working on vegetable and melon farms. Second, recent research on California agricultural labor markets found there were an average of two unique farm workers or Social Security Numbers reported by farm employers for each year-round equivalent farm job. If one assumes this relationship also holds for Arizona and if one includes unpaid family workers, there would be closer to 31,400 to 33,300 individuals supported directly or indirectly (through multiplier effects) by the Arizona vegetable and melon cluster.

In 2014, Arizona vegetable and melon production required more than 26.7 million hours of hired on-farm labor. This included directly hired, contract, and other agricultural support service workers employed on-farm. Monthly on-farm labor demand fluctuated from lows of less than 1.5 million hours per month in slack months to highs above 3.5 million hours per month in peak winter months.

Appendix

Defining Arizona's Vegetable and Melon Industry Cluster

This analysis examines the contribution of the vegetable and melon industry from the whole-supply chain perspective. This includes estimating the economic contribution not only of the production of vegetable and melons on Arizona farms, but also the economic contribution of the cluster of industries involved in post-harvest activities that ensure that high-quality vegetables and melons reach consumers. The vegetable and melon industry cluster, therefore, includes the vegetable and melon farming industry as well as the refrigerated warehousing industry (packing, cooling, and storing activities), the vegetable and melon processing industry (processing activities), specialized trucking, and vegetable and melon wholesaling (distributing and marketing activities). The industries included in this analysis (and their respective NAICS and IMPLAN codes) are listed in Table 5. Sales for each industry within the cluster were estimated based on Arizona vegetable and melon production and parsed out from their larger industry aggregation. Research methods are presented in the next two sections.

Table 5. Vegetable and Melon Industry Cluster IMPLAN and NAICS Codes

NAICS Codes	IMPLAN Code	Industry
11211; 112119	3	Vegetable and melon farming
311421	81	Canned fruits and vegetables manufacturing
424480	395	Fruit and vegetable merchant wholesaler
484220	411	Local specialized trucking
493120	416	Refrigerated warehousing

IMPLAN Modifications

The economic contribution of the vegetable and melon industry cluster was estimated using the 2014 IMPLAN Version 3.1 input-output model. While IMPLAN has data built into the model, modifications were made to the IMPLAN data to more accurately capture the economic contribution of the vegetable and melon industry cluster.

First, modifications were made to the baseline IMPLAN data for the vegetable and melon farming industry in an effort to more accurately represent the economic conditions and agricultural practices in Arizona. Modifications were made to the baseline IMPLAN data to better reflect state-level output, and value added: employee compensation of hired farm labor,[13] farm proprietor income,[14] and agricultural taxes on production and imports.[15] This 2014 state-level data were distributed among agricultural industries based upon their shares reported by the 2012 Census of Agriculture. Additional modifications to the IMPLAN data include revising the production function (also known as industry spending pattern) for the vegetable and melon farming industry. These modifications are necessary because the default IMPLAN industry production functions are based on a national average spending pattern which may not represent vegetable and melon farming spending patterns in Arizona. Farm expense data were obtained from the 2012 Census of Agriculture and the vegetable and melon farming industry spending pattern was modified to reflect the reported shares of input expenditures for Arizona.

As harvest expenses (typically garnered in the agricultural support industry through farm labor contracting services) are such a large portion of vegetable and melon farm input expenses, a more thorough examination of the agricultural support industry was required. The value of agricultural support services necessary for harvesting Arizona-produced vegetables and melons industry was estimated based on data from a mathematical programming model exercise carried out by Wishon et al. (2015). That study provided estimates of per acre labor requirements for major crops grown in Yuma County.

13 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment: Farm Income and Expenses.
14 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment: Farm Income and Expenses.
15 Data from U.S. Department of Agriculture (USDA), Economic Research Service, U.S. and State-Level Farm Income and Wealth Statistics: Value Added to the U.S. Economy by the Agricultural Sector.

These labor requirements were used to estimate statewide sales of agricultural support services for vegetable and melon production, as well as employment in that industry. A more thorough explanation of employment estimates is provided in subsequent sections.

The vegetable and melon farming spending pattern was then updated to reflect the expenses necessary to harvest all vegetables and melons in the state. As farm labor contracting is most notably a local service, we kept IMPLAN's regional purchase coefficient as 98% in-state purchases. However, when modeling the contribution of the vegetable and melon industry cluster, we account for the fact that many farm labor contractors in Yuma (where most vegetable and melons are harvested) are migrant farm labor, either crossing the border from Mexico or coming from California. See the section below for additional details on the economic contribution analysis.

Additionally, as one of the primary objectives of this project is to include critical downstream support industries of vegetable and melon production and distribution, we use a variety of data sources to estimate the economic activity in these industries that is attributable to vegetables and melons produced in the state. Estimation is required because IMPLAN reports their data at an aggregated level. For example, IMPLAN has data available that estimates the sales and employment in the *warehousing and storage industry* (IMPLAN sector 416; NAICS 493). We are only interested in a subset of that, the segment of the *refrigerated warehousing and storage industry* (NAICS 493120) that can be attributed to Arizona vegetable and melon production. We, therefore, use fixed share and scaling estimation techniques to estimate the economic activity in post-harvest vegetable and melon industries.

These methods produce reasonable estimates, thanks in large part, to the concentration of vegetable and melon production in Yuma County. For several post-harvest industries, we use employment data[16] in Yuma to estimate the share of employment in the subsector of interest. We use this data to then estimate the output of the subsector of interest in Yuma basing our calculation off of the reported 2014 IMPLAN output data for Yuma. These results are then scaled up by a factor of 1.32[17] to estimate the state-level output of the sector of interest. Additionally, in some cases, vegetables and melons needed to be parsed out from fruits. We parsed out vegetables and melons by applying the ratio of vegetable and melon sales to total fruit, vegetable, and melon sales in Arizona. Data are also used from the Arizona Department of Agriculture's *Citrus, Fruit, and Vegetable Standardization Annual Report* and the U.S. Census Bureau Economic Census to estimate economic activity related to vegetable and melon transportation.

Selecting Yuma County as a basis for our estimations was a critical decision point in our research methods, allowing us to conservatively estimate the economic contribution of industries involved in post-harvest activities of Arizona vegetables and melons. It was important not to include economic activity of post-harvest industries (refrigerated warehousing, trucking, and distribution) in Santa Cruz County (primarily in Nogales) because previous research has demonstrated that most of the fresh produce-related economic activity that occurs in Santa Cruz County derives from the import of fresh produce from Mexico in to Arizona, and does not occur as a result of the production of vegetables and melons within Arizona.[17]

16 Data from Department of Labor, Bureau of Labor Statistics, Quarterly Census of Employment and Wages.
17 This is the ratio of state-level vegetable and melon sales to Yuma vegetable and melon sales from the 2012 Census of Agriculture..

Economic Contribution Analysis

When conducting the economic contribution analysis, the model was customized to ensure that state-level economic output was not overstated and that there was no double counting. We utilized IMPLAN's multi-contribution analysis method and created new sectors in IMPLAN (using industries that do not exist in the study area) that refer only to vegetable and melon production.

As mentioned in the previous section, when modeling, we also accounted for the fact that many farm labor contract employees in Yuma County are cross-border commuters from Mexico and/or California. We account for this by reducing employee compensation in the agricultural support industry by 25%. According to QCEW data from Yuma and our calculated labor requirements for Yuma, there were an annual average of 8,904 of on-farm jobs. Yet, according to 2014 American Community Survey data, there were only 4,752 permanent Yuma residents employed in farming occupations. If the difference is assumed to be made up by agricultural service workers supplied by farm labor contractors and commuting from Mexico, this brings the annual average to 4,152 jobs. This is half of the 8,262 year-round equivalent support service jobs in vegetable and melon production in the state. So, we assume that cross-border commuters account for half of the total full-time equivalent agricultural service jobs in vegetables and melons in the state. We also examined the spending pattern of a typical household making $10,000-$15,000 a year. According to IMPLAN, approximately half of all annual household expenses are related to housing and healthcare, both of which a cross-border commuter farm worker would not spend in Arizona. Therefore, we estimate that 25% of agricultural support industry employee compensation is leaked out of the state to neighboring regions (50% leakage from 50% of the agricultural support service workers).

Agricultural Support Services Employment

As mentioned previously, we used hour per acre labor requirements reported by Wishon et al. (2015) to derive employment estimates of agricultural support service workers employed in vegetable and melon production. First, for major crop categories in Yuma, hours per acre were multiplied by acreage estimates from the 2012 Census of Agriculture to obtain the total labor required for each crop grown in the county. Labor requirements for each crop category i were divided by the sum of county labor requirements to derive the share S_i of the county's total crop labor required by crop i. For each crop, this S_i was assumed to be the sum of directly hired labor's contribution d_i and agricultural support service labor s_i such that $S_i = d_i + s_i$. Data to calculate d_i were obtained from Yuma County estimates of direct-hire jobs in vegetable and melon production from the Quarterly Census of Employment and Wages (QCEW). The QCEW reports total crop service sector jobs by county, but does not identify what crops these jobs are applied to. The total number of support service jobs were allocated to each crop s_i so that crop shares of total on-farm employment matched S_i, the shares implied by estimated per acre labor requirements and acreage estimates. This procedure was then repeated for acreage outside Yuma County across the rest of Arizona to allocate support service workers to vegetable and melon production outside of Yuma.

17 Pavlakovich-Kochi and Thompson, 2013.

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Addendum: 2015 Price Effects

This study utilizes data on Arizona vegetable and melon production from 2014 as it accords with the base year of the most recent IMPLAN model and, therefore, provides the most accurate estimate possible of the vegetable and melon industry cluster's economic contribution statewide. The inter-annual fluctuations in price and production of agricultural commodities, however, can lead to estimates of economic contributions that vary significantly from one year to the next. In the case of vegetable and melon production, changes in both price and production led to an overall higher value of production in 2015 compared to 2014. In this addendum, we examine the changes from 2014 to 2015 and estimate the economic contribution of 2015 production as if it had occurred in Arizona in 2014.

To illustrate the production and market trends for Arizona vegetables and melons, Table 6 provides a comparison of acres harvested, production by hundredweight, and production by value of sales for the 34 major fresh-market vegetables produced between 2014 and 2015. While the value of production increased significantly from 2014 to 2015, the volume of vegetables and melons produced (measured in cwt) actually decreased over the same timeframe.

Table 6. Acres Harvested, Production (in Cwt), and Production (in $) for Arizona's 34 Major Fresh Market Vegetable and Melon Commodities, 2014–2015

	2014	2015	Percentage Change
Acres Harvested	110,000	110,200	0.18%
Production, In Cwt	31,816,000	28,848,000	-9.33%
Production, In $*	$685,608,000	$1,011,551,000	47.54%

**Value of production is presented in current dollars and refers to ERS cash receipts. There was less than 1% inflation between 2014 and 2015.*

Source: USDA, NASS Quick Stats Annual Survey, 2014–2015; USDA, ERS Farm Income and Wealth Statistics.

While this trend may not hold true for individual vegetable and melon commodities (for example, leaf lettuce increased in acres harvested, volume produced, and total value of production), the aggregate effects for the vegetable and melon industry suggest that the change in the total value of production from 2014 to 2015 is primarily attributable to an increase in prices received. Using these data as an indicator of production and market trends, we are able to estimate the economic contribution of 2015 production as if it had occurred in Arizona in 2014, accounting for the increase in value of production by modeling price effects through a farm proprietor income change.

In 2015, the reported total value of production for all Arizona-produced vegetables and melons (fresh-market and harvested for processing) in Arizona was $1.02 billion (USDA Economic Research Service, 2015). Including a small margin to account for other farm-related income, the total economic output (sales) for the vegetable and melon farming industry was an estimated $1.05 billion. If that level of sales were to occur in the 2014 Arizona economy, the economic contribution would be as follows (Table 7).

Table 7. Estimated Economic Contribution of 2015 Vegetable and Melon Production in 2014 Arizona Economy

Impact Type	Labor Income	Value Added	Sales
Total Direct Effects	$556,000,000	$587,000,000	$1,168,000,000
Vegetable and Melon Farming Industry	$518,000,000	$535,000,000	$1,054,000,000
Vegetable and Melon Post-Harvest Industries	$38,000,000	$52,000,000	$114,000,000
Indirect and Induced Effects	$617,000,000	$861,000,000	$1,356,000,000
Total Effects	$1,173,000,000	$1,448,000,000	$2,524,000,000

Source: Authors' calculations using IMPLAN 2014.

Direct sales from the vegetable and melon farming industry ($1.05 billion) and the supporting vegetable and melon post-harvest industries ($114 million) results in a total economic contribution of more than $2.5 billion in sales, $1.4 billion in value added, and approximately $1.2 billion in labor income for the Arizona economy. Note that the total economic output (sales) for vegetable and melon post-harvest industries remained unchanged from the previous analysis. This is due to the proposition that the overall production of vegetables and melons (in cwt) did not increase from 2014 to 2015 and therefore the post-harvest industries did not experience an increase in overall economic activity.