Arizona Leafy Greens: Economic Contributions of the Industry Cluster

2015 Economic Contribution Analysis

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Executive Summary

What Is the Issue?

- Leafy greens are an important part Arizona's agricultural economy and represent a significant portion of the state's agricultural sales.
- Due to their perishable nature, there is a highly integrated cluster of industries involved in post-harvest activities that ensures the quality and shelf life of leafy green products. These industries are involved in cooling, cutting, washing, packing, processing, storing, and shipping Arizona-grown leafy green products. This requires incredible coordination and logistical efficiency across industries. Therefore, estimating leafy greens' contribution to the Arizona economy warrants an examination of the whole value chain, including economic activity taking place on-farm as well as in post-harvest industries. We call this cluster the **Arizona leafy greens industry cluster**.
- In addition to the industry cluster's ***direct effects*** on the Arizona economy, a "ripple" of economic activity is generated in other Arizona industries to meet the demand for inputs by leafy greens businesses and the demand for consumer goods and services by households employed by businesses within the cluster. Economists call these ***indirect*** and ***induced multiplier effects***.
  - ***Indirect effects*** measure the economic activity generated by the leafy greens industry cluster's demand for inputs. This effect is the result of business-to-business transactions; in this case, these occur primarily in the real estate, agricultural support services, insurance, and fertilizer industries, among others.
  - ***Induced effects*** measure the economic activity generated by households employed by the leafy greens industry cluster spending their earnings at Arizona businesses. This effect is the result of household-to-business transactions which occur in the healthcare, real estate, retail, restaurant, and other industries.
- Yet data specific to this commodity group (a subset of vegetables and melons) are not often reported at the state level in government statistics. Furthermore, economic data that are available, such as commodity cash receipts, do not fully capture the economic contributions of leafy greens to the state economy.
- Estimating the economic contributions, or the economic activity, of industries involved in the production and distribution of leafy greens is challenging. One major issue is that industries involved in farm-level production and post-harvest activities only have data available at an aggregated level not specific to leafy greens. We use a variety of data sources and methods to estimate the economic activity supported by Arizona-grown leafy greens.
- Using estimates for 2015, we use IMPLAN to estimate the total economic contribution of the leafy greens industry cluster, including indirect and induced multiplier effects. Results reported include sales (output), value added (synonymous with Gross State Product [GSP]), incomes, and state and local tax revenues. With limited data, we also estimate employment supported by Arizona's leafy greens industry cluster.

What Did the Study Find?

Arizona is a national leader in the production of leafy greens.

- In 2015, **Arizona ranked second in the nation for the production of lettuce (head [iceberg], leaf, and Romaine) and spinach** by weight, and eighth in the nation for cabbage by weight.
- Arizona-grown leafy greens accounted for about one-fifth of national production by weight in 2015. By commodity, Arizona was responsible for 24% of the nation's production of head lettuce, 19% of leaf lettuce production, 26% of Romaine lettuce production, 21% of spinach production, and 4% of cabbage production.
- Compared to other U.S. counties producing lettuce and spinach in 2012, Yuma County, Arizona, ranked second out of 429 counties for lettuce acreage harvested and second out of 119 counties for spinach acreage harvested. Of 202 U.S. counties producing kale, Maricopa County, Arizona ranked seventh in the nation for acreage harvested.
- Compared to other regions producing leafy greens, Arizona has relatively high yields per acre. Cabbage, typically Arizona's highest-yielding leafy green commodity, has led the nation in hundredweight produced per acre in four of the last six years, but dropped off in 2015. Over the last six years, Arizona has also had higher yields per acre for Romaine lettuce than California, the other leading state.

Arizona plays a critical role in the year-round supply of lettuce for domestic consumption.

- Year-round availability of lettuce is facilitated by a seasonal rotation of production between major growing regions in Arizona and California. According to USDA Agricultural Marketing Service statistics, from mid-April to late October, California's Central Valley ships an average of more than 1.1 billion pounds of lettuce per month. From late November to mid-March, western Arizona ships an average of 1.0 billion pounds of lettuce per month.
- At its most productive point in the season, **from the first week of December 2014 through the first week of March 2015, Arizona supplied an average of 82% of the nation's lettuce.** Over this same period, 16% was supplied by California and 2% was supplied by Florida.
- The peak in weekly lettuce shipments occurred on December 6, 2014, where Arizona accounted for 92% of the nation's lettuce shipments.

Leafy greens are an important commodity in Arizona's agricultural economy.

- Since 2010, on average, leafy greens have accounted for 17% of the state's total agricultural cash receipts (crops + livestock). However, the value of production for leafy greens is heavily dependent on prices received. In 2014, a low-price year for leafy greens, cash receipts for Arizona's largest leafy green commodities (cabbage, spinach, and lettuce) were $468 million and accounted for only 11% of Arizona's total agricultural cash receipts. **In 2015, leafy greens cash receipts rose to $779 million and accounted for 19% of the state's total agricultural receipts.**

Arizona's leading leafy green commodity is lettuce.

- In 2015, Romaine lettuce accounted for the largest proportion of Arizona leafy greens cash receipts (39%). This was followed by head lettuce (33%), leaf lettuce (19%), spinach (7%), and cabbage (2%).
- Head lettuce consistently accounts for the majority of leafy greens acreage harvested in Arizona. In 2015, Arizona harvested 32,500 acres of head lettuce, 20,900 acres of Romaine lettuce, 10,300 acres of spinach, 9,300 acres of leaf lettuce, and 2,600 acres of cabbage.

Yuma County produces a large majority of Arizona's leafy greens.

- County-level data from the 2012 Census of Agriculture report that Yuma County accounted for 97% of the state's harvested acreage of lettuce and 90% of the state's harvested acreage of spinach.
- Maricopa County accounted for 97% of the state's harvested acreage of kale.

The contribution of leafy greens to the state economy extends beyond on-farm production.

- **In 2015, the leafy greens industry cluster's total sales contribution to the Arizona economy was an estimated $2.0 billion.** Direct sales (cash receipts) from on-farm production of Arizona's major leafy greens commodities (cabbage; spinach; and head, leaf, and Romaine lettuce) and forward-linked cluster industries accounted for approximately $931.5 million in sales, while indirect and induced multiplier effects accounted for more than $1.0 billion in sales.
- Based on these 2015 production-level estimates, the leafy greens industry cluster's total contribution to Arizona's gross state product (GSP) was nearly $1.2 billion. This included approximately $950 million in wages, salaries, and proprietor income.
- Total state and local tax contributions from Arizona's leafy greens industry cluster for 2015, including multiplier effects, were an estimated $64 million.

Arizona's leafy greens industry cluster supports a host of different jobs in the state, both directly and indirectly.

- **In 2015, Arizona leafy greens production required more than 16.9 million hours of hired on-farm labor.** This included directly hired, contract, and other agricultural support service workers employed on-farm. The vast majority of these labor hours are required during the November-to-March harvesting season.
- There were more than 18,000 full- and part-time jobs directly and indirectly supported by the leafy greens industry cluster in Arizona on an annualized basis. More than 60% 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.
- **In 2015, 2,266 jobs in lettuce and spinach production were certified under the H-2A visa program** for seasonal agricultural workers. The H-2A nonimmigrant program provides Arizona (and other) farms with short-term agricultural labor when the number of available domestic workers is determined by the U.S. Department of Labor to be insufficient. For lettuce, H-2A certified positions rose from 1,676 in 2010 to 2,066 in 2015.

- The number of unique farm workers employed in leafy greens production is greater than the number of jobs. Recent research from California found an average of two unique farm workers reported for each year-round, full-time equivalent farm job. Assuming this relationship holds for Arizona—with similar production systems—**this suggests there are nearly 27,000 individuals working in jobs directly or indirectly supported by the Arizona leafy greens industry cluster.**

How Was the Study Conducted?

- We use a variety of data sources and methods to estimate the economic activity supported by Arizona-grown leafy greens. The chosen method for the economic contribution analysis uses agricultural cash receipts for on-farm production and cost-and-return farm budgets to estimate the economic activity in post-harvest industries.
- The economic contribution analysis was conducted using input-output modeling and the premier software for this type of analysis, IMPLAN Version 3.1. IMPLAN is a regional economic modeling system based on national average production conditions. The model was refined based on best available, recent data to more accurately reflect economic conditions and agricultural practices in Arizona.
- Because economic contribution analyses provide estimates for a snapshot in time and agricultural commodities often experience inter-annual fluctuations in price and production, we conduct two economic contribution analyses: one for 2014 and one for 2015. We only report the results for 2015 as this is the year of interest. The first analysis, 2014, was conducted because it accords with the data available from the IMPLAN modeling software. We use the 2014 IMPLAN model as a baseline for the 2015 analysis and account for price and production-level differences between 2014 and 2015.
- Results of the economic contribution analysis are reported through the following metrics: sales (output), value added, labor income, and state and local taxes.
- Finally, the study also estimates employment supported by Arizona's leafy greens industry cluster. A "bottom up" approach was used to derive hours of work required on farm, based on crop enterprise budgets and acreage data. Hours worked were then converted to on-farm job equivalents following methods employed in previous farm labor studies (Martin, 2014). IMPLAN was used to estimate employment supported in leafy greens post-harvest industries and in industries affected by indirect and induced effects.

Introduction

Leafy greens,[1] a broad term used to describe vegetable crops with edible leaves, are an important crop group in Arizona. Arizona plays a key role in the country's production of leafy greens, particularly lettuce varieties and spinach. Together, Arizona and California account for nearly 90% of all leafy greens produced (by weight) in the United States (USDA NASS Quickstats, 2015). In winter months, leafy greens are sourced almost exclusively from Arizona and California counties straddling the Colorado River. Considering the state's role in national production, leafy greens are also an important part of Arizona's agricultural economy. Since 2010, the state's major leafy green commodities (lettuce, spinach, and cabbage) have accounted for approximately one-fifth of all agricultural sales (crops and livestock) in Arizona and have represented a large majority of vegetable and melon sales (USDA ERS Farm Income and Wealth Statistics, 2016). Sales of leafy greens contribute to the state economy, providing incomes and jobs for people working on Arizona farms. These contributions to the state economy, however, are not limited to on-farm activities. They extend to an entire cluster of industries that are involved in essential post-harvest activities that ensure the quality and shelf life of leafy greens products. The **leafy greens industry cluster**, therefore, includes farms producing leafy greens as well as post-harvest industries such as refrigerated warehousing, transportation, and wholesale services.

The first section of this report provides an overview of the U.S. leafy greens industry. This includes trends in the demand for leafy greens, a description of production regions across the nation, the marketing and distribution channels used to deliver leafy green products, and the shifts that have occurred in the industry within the last 20 to 30 years.

The second section of this report focuses specifically on Arizona leafy greens. We present information on the volume of production, acreage harvested, value of production, price received, and yield for the major leafy green commodities produced in the state. While the focus of this analysis is 2015, we also present earlier data to highlight recent trends in the state's production.

The final section of the report estimates the total economic contributions of the leafy greens industry cluster to Arizona's economy based on 2015 production, including multiplier effects. To estimate the contribution of leafy greens to the state economy, this study analyzes the interconnectedness of industries involved in producing, marketing, and delivering Arizona-grown leafy green products to consumers, and the diversity and complexity of those supply chain relationships. ***Indirect multiplier effects*** measure the economic activity supported through business-to-business transactions providing inputs to leafy greens production. ***Induced multiplier effects*** measure the economic activity supported by household spending from individuals employed by the leafy greens industry cluster. Contributions are presented in terms of sales (output), value added (gross state product-GSP), labor income, and state and local taxes. Finally, estimates of on-farm labor requirements (in hours) and employment are presented and discussed.

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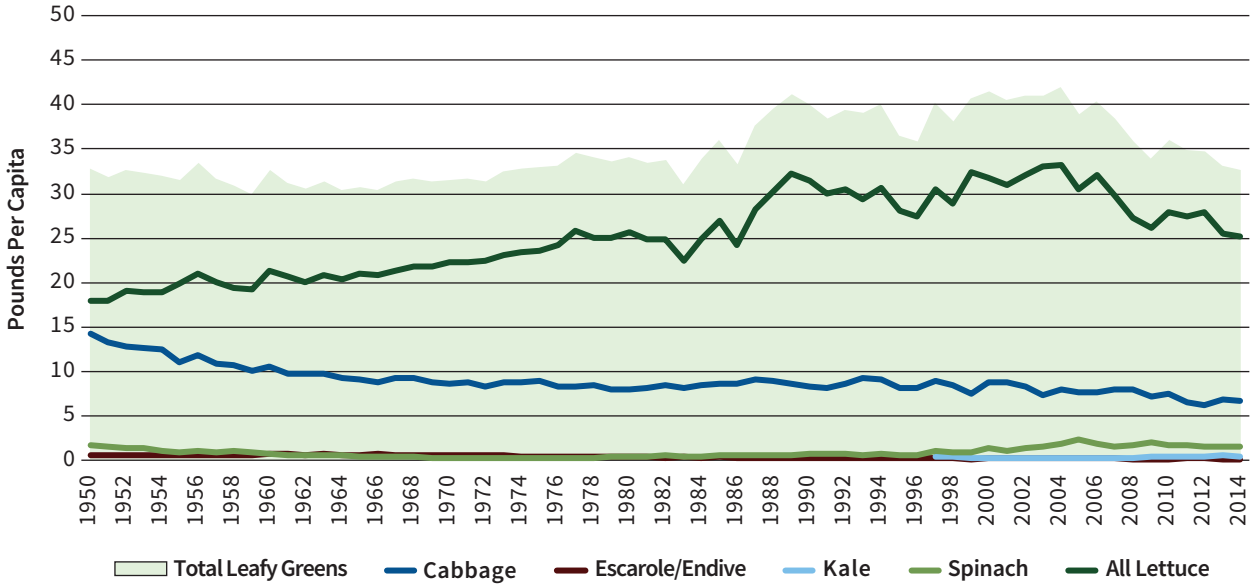
1 Leafy greens include a wide range of agricultural commodities (Kaiser and Ernst, 2011). The most common leafy green products (and consequently the commodities with the most data available) are cabbage, lettuce (head, red and green leaf, and Romaine), and spinach. Other leafy greens covered by the Arizona Leafy Greens Marketing Agreement include arugula, baby leaf lettuce, butter lettuce, chard, endive, escarole, kale, radicchio, and spring mix (Arizona Leafy Green Products Shipper Marketing Agreement, 2015).

Overview of the Leafy Greens Industry

Demand for Leafy Greens

From the 1950s to the mid-1980s, total demand[2] for fresh-market leafy greens remained relatively stable, with total demand fluctuating between 30 and 35 pounds per capita per year. Since the mid-1980s, demand has ranged from 34 to 42 pounds per capita per year. Lettuce has consistently been the highest-demanded leafy green commodity in the United States, with an average per capita demand of 25 pounds per year from 1950 to 2014 (Figure 1). Cabbage has been the second highest demanded leafy green commodity in the U.S., with an average per capita demand of 9 pounds per year over the 65-year period. The average per capita demand for another popular leafy green, spinach, hovers around 1 pound per year, with increased demand over the last 15 years. Other leafy greens such as kale, escarole, and endive have average per capita demand of less than one pound per year.

Figure 1. U.S. Per Capita Availability and Demand for Select Leafy Greens by Farm Weight, 1950–2014

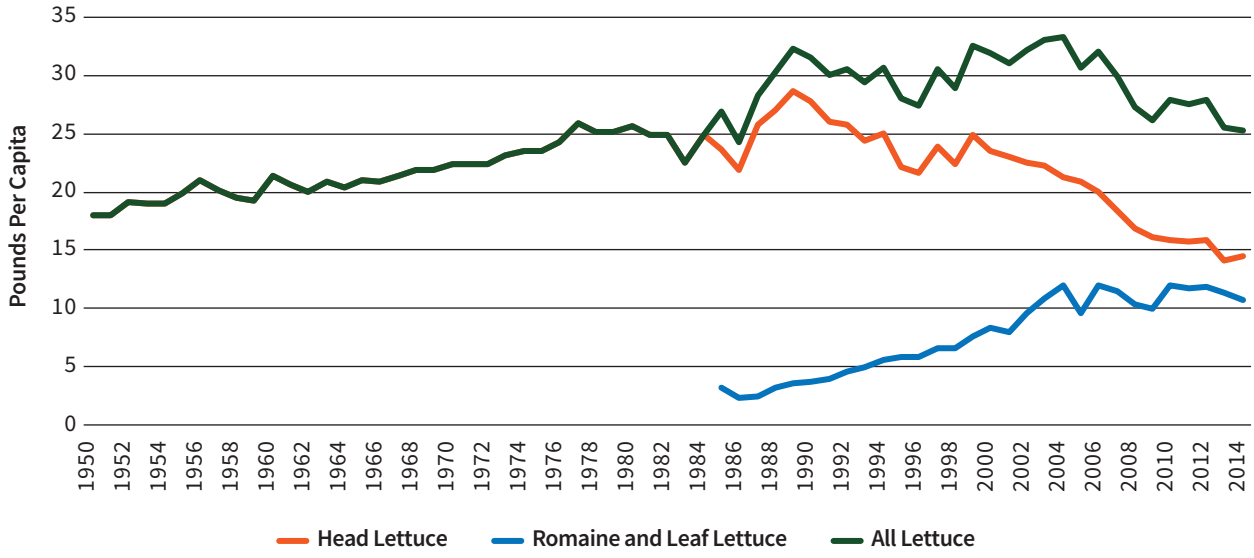


Source: USDA ERS Food Availability (Per Capita) Data System (FADS), 2016.

2 Demand is estimated by the USDA Economic Research Service (ERS)'s Food Availability (Per Capita) Data System (FADS). The FADS estimates the amount of food that is available for domestic consumption for more than 200 agricultural commodities, including leafy greens, and is commonly used as a proxy for food consumption. Although these data may overstate the amount of food actually consumed (due to nonedible portions and food lost through waste and spoilage), it allows for the assessment of long-term consumption trends. (USDA ERS FADS Documentation, 2016).

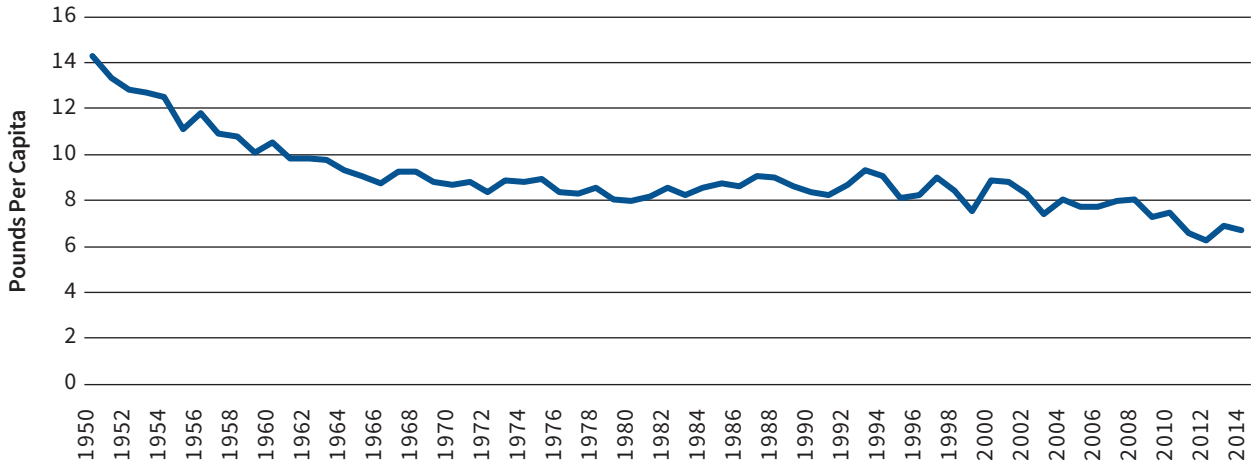
Looking more closely at individual leafy green commodities, some trends become more evident. Since 1950, there has been significant growth in the demand for lettuce. Average per capita demand rose from 18 pounds per year in 1950 to a peak of 33.2 pounds in 2004. Average per capita demand has since declined to 25.2 pounds in 2014 (Figure 2). There also have been major shifts in the types of lettuce demanded. In 1990, per capita demand for lettuce (all varieties) was about 31.5 pounds per year, with head (iceberg) lettuce accounting for 27.7 pounds or 88% of all lettuce consumed. In the early 2000s, demand for head lettuce began to decrease and its dominance waned. In 2000, the U.S. per capita demand for lettuce was 31.8 pounds, with head lettuce at 23.5 pounds or 74% of all lettuce consumed. This trend has continued with head lettuce only accounting for 57% of all lettuce consumed as of 2014.

Figure 2. U.S. Per Capita Availability and Demand for Lettuce by Farm Weight, 1950–2014



Source: USDA ERS Food Availability (Per Capita) Data System (FADS), 2016.

Figure 3. U.S. Per Capita Availability and Demand for Cabbage by Farm Weight, 1950–2014

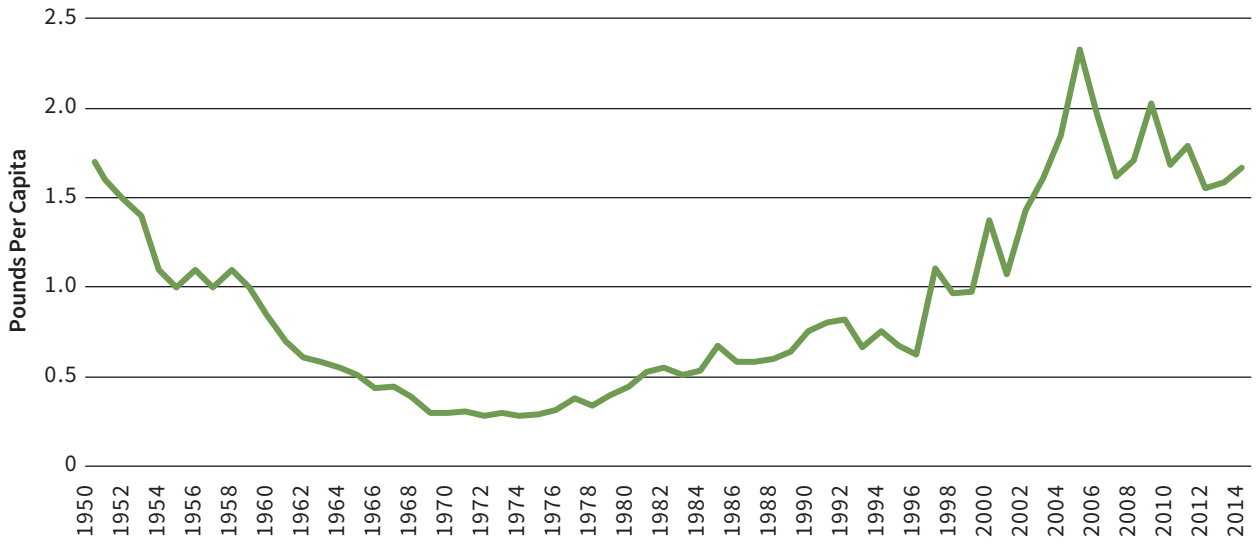


Source: USDA ERS Food Availability (Per Capita) Data System (FADS), 2016.

Cabbage, the second highest demanded leafy green commodity, has experienced decreasing demand (Figure 3). In 1950, the U.S. per capita demand for fresh cabbage was about 14.3 pounds per year, while in 2014, the U.S. per capita demand was 6.7 pounds per year, falling by more than half. In 2002, Romaine and leaf lettuce varieties surpassed the demand for cabbage.

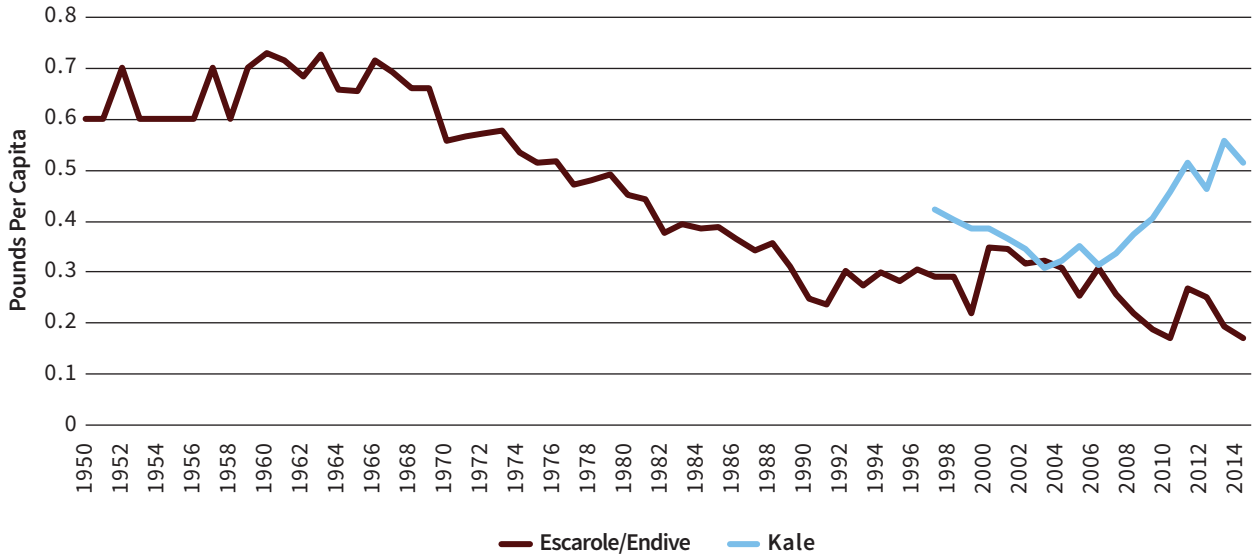
The third-highest demanded leafy green commodity, spinach, exhibits roughly the same level of demand in 2014 as it had in 1950 at 1.7 pounds per year (Figure 4). However, while the U.S. per capita demand is the same from the beginning of the time frame to the end, the demand for spinach has not remained constant over the 65-year period, falling from 1.7 pounds per capita to below 0.5 pounds per capita in 1970. Since the early 1980s, however, the demand for spinach has consistently increased, with a dramatic increase in the early 2000s, peaking at 2.3 pounds per year in 2005.

Figure 4. U.S. Per Capita Availability and Demand for Spinach by Farm Weight, 1950–2014



Source: USDA ERS Food Availability (Per Capita) Data System (FADS), 2016.

Figure 5. U.S. Per Capita Availability and Demand for Escarole, Endive, and Kale by Farm Weight, 1950–2014



Source: USDA ERS Food Availability (Per Capita) Data System (FADS), 2016.

Finally, demands for less common leafy green commodities, such as kale, escarole, and endive, have trended in different directions (Figure 5). The U.S. per capita demand for escarole and endive has decreased from 0.6 pounds in 1950 to 0.2 pounds in 2014, with a relatively consistent decline across time. Kale, on the other hand, has exhibited an overall increase in demand since statistics were first reported for this commodity in 1997, when U.S. per capita demand for kale was about 0.4 pounds. In the early 2000s demand for kale decreased to 0.3 pounds per capita, but has since increased, reaching its peak in 2013 at 0.6 pounds per capita. In 2014, U.S. per capita demand for kale was 0.5 pounds.

Production Regions

To meet this growing demand for leafy greens, the United States produces a majority of its leafy greens domestically. In 2014, nearly 92% of leafy greens[3] consumed in the U.S. were produced domestically (USDA ERS FADS, 2016). By satisfying its own demand, the United States is the eighth largest producer of cabbage in the world, the second largest producer of all lettuce in the world, and the second largest producer of spinach in the world (FAO Stat, 2013).

While there are several states that produce leafy green commodities, approximately 87% of all leafy greens produced in the United States (as measured by hundredweight [cwt])[4] are produced in two states: Arizona and California (USDA NASS Quickstats, 2015). Acreage harvested and production, however, depend on the region and the commodity grown. The following section discusses production regions based on (1) harvested acreage and (2) production as measured by hundredweight (cwt). County-level harvested acreage data were obtained from the 2012 Census of Agriculture, and more recent 2015 state-level harvested acreage and production data were obtained from USDA NASS statistics.

3 This leafy greens statistic includes cabbage, escarole, head lettuce, kale, Romaine lettuce, and spinach.

4 A hundredweight is a unit of measurement for weight and is equal to 100 pounds.

Cabbage

Cabbage is grown on more than 4,000 farms across the country (2012 Census of Agriculture, 2014). In terms of acreage, in 2012, these farms harvested a total of 66,035 acres of cabbage for both the fresh market and for processing. Only 12 states, however, had harvested acreage of more than 1,000 acres. California and Arizona accounted for nearly 20% of all cabbage acreage harvested (2012 Census of Agriculture, 2014). The top 3 U.S. counties for cabbage acreage harvested in 2012 were Hidalgo County in Texas, Colquitt County in Georgia, and Ventura County in California.

As of 2015, California and Arizona accounted for 29% of all cabbage acreage harvested and one-third (33%) of the nation's production (cwt) of fresh-market cabbage (USDA NASS Quickstats, 2015).

Spinach

In 2012, there were nearly 1,600 farms across the country that harvested 46,377 acres of spinach for both the fresh market and for processing. Six states (Arizona, California, Colorado, New Jersey, Oklahoma, and Texas) harvested acreage of more than 1,000 acres. California and Arizona accounted for about 75% of all spinach acreage harvested in the United States (2012 Census of Agriculture, 2014). In 2012, the top 3 U.S. counties for spinach acreage harvested were Monterey County in California, Yuma County in Arizona, and Imperial County in California.

As of 2015, California and Arizona accounted for 76% of all spinach acreage harvested in the United States. Based on 2015 production-level data (in terms of cwt), however, Arizona and California accounted for 92% of the nation's production of spinach (USDA NASS Quickstats, 2015).

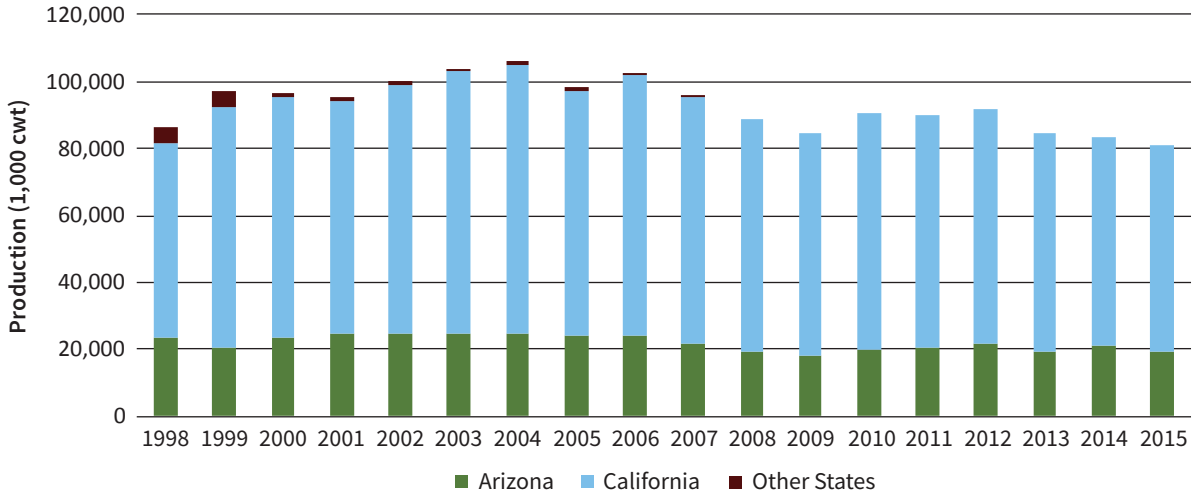
Lettuce

Lettuce (of any variety), is almost exclusively produced in Arizona and California. According to the 2012 Census of Agriculture, Arizona and California accounted for approximately 94% of lettuce acreage harvested in the U.S. Other states with harvested acreage of more than 1,000 acres include Florida, New Jersey, and New York, but combined these states only accounted for about 4% of the nation's harvested acreage of lettuce (2012 Census of Agriculture, 2014). The top 3 U.S. counties for lettuce acreage harvested in 2012 were Monterey County in California, Yuma County in Arizona, and Imperial County in California.

In 2015, Arizona and California accounted for 100% of harvested acreage of lettuce and 100% of the nation's commercial production (cwt) of head, leaf, and Romaine lettuce[5] (USDA NASS Quickstats, 2014).

5 A few other states produce lettuce, but annual lettuce estimates were discontinued from government statistics in 2000. These data are only available from the Census of Agriculture, conducted every five years..

Figure 6. U.S. Lettuce Production by State, 1998–2015

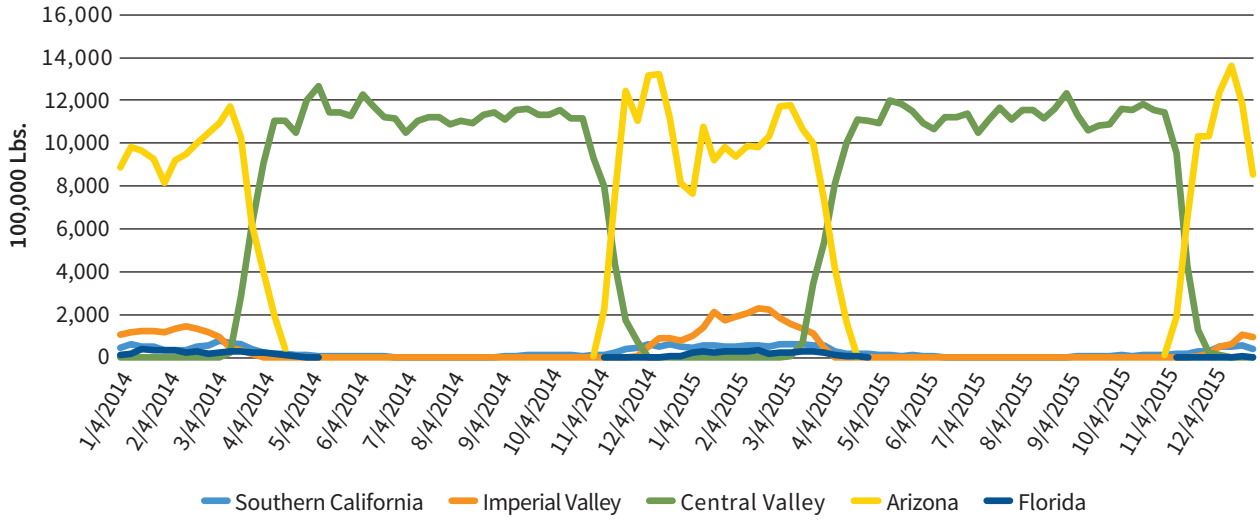


Source: USDA ERS Lettuce Statistics, 2011; USDA NASS Quickstats, 2016.

Arizona and California have long dominated the production of lettuce, but it is only within the last decade that U.S. commercial production has been concentrated almost exclusively in these two states. According to government statistics, in 1998, Arizona and California accounted for about 94% of the nation's production of lettuce (Figure 6). Since 2008, however, government statistics report that Arizona and California are responsible for 100% of the nation's commercial production of lettuce. A few other states, such as Florida, also produce lettuce, but government-reported annual lettuce estimates were discontinued in 2000.

Lettuce production is year round, with a combination of growing regions in Arizona and California producing at different times of the year. From April through October most lettuce is harvested in the Central Valley of California. During the winter, from November through March, most lettuce is harvested either in Yuma County, Arizona, or Imperial and Riverside counties in California. During the fall, a time of transition between these major regions, lettuce is harvested in the San Joaquin Valley of California, in the counties of Fresno, Kings, and Kern (USDA NASS, 2007).

Figure 7. U.S. Weekly Lettuce Shipments by Production Region, 2014–2015



Source: USDA AMS Specialty Crop Movement Custom Report, 2016.

These production trends of cycling growing regions are evident when examining weekly shipments of lettuce (Figure 7). According to USDA Agricultural Marketing Service shipment data, there are three states that ship lettuce: Arizona, California, and Florida. Within these states, the Central Valley of California (Salinas-Watsonville, Central San Joaquin, and Santa Maria districts) and western Arizona (particularly Yuma County) dominate lettuce shipments. During the Central Valley's most productive part of the season, from mid-April to late October, the region ships an average of more than 1.1 billion pounds of lettuce per month. As production and shipments cease in the Central Valley, Arizona ramps up production. During Arizona's most productive part of the season, late November to mid-March, the region ships an average of 1 billion pounds of lettuce per month. During the same winter-months period, other locations in California (the Imperial Valley and other regions in Southern California) and Florida produce and ship lettuce, but at lower levels. Combined, this amounts to a nearly constant weekly supply produced across all regions over the course of the calendar year (Figure 7).

Kale, Escarole, and Endive

Other less common leafy greens, such as kale, escarole, and endive, are primarily produced in California. In 2012, California had the highest harvested acreage of kale of any state, with 1,680 kale acres harvested. This was followed by New Jersey and Texas with 537 acres and 524 acres, respectively. Arizona chipped in with 121 harvested acres of kale. Most of Arizona's kale acreage was in central Arizona. In fact, Arizona's Maricopa County was ranked in the top 10 kale-producing U.S. counties in terms of acreage harvested (2012 Census of Agriculture, 2014). The top 3 U.S. counties for kale acres harvested in 2012 were Monterey County, California, Ventura County, California, and Hidalgo County, Texas. Finally, more than 60% of the nation's harvested acreage of escarole and endive in 2012 was from California. In 2012, California harvested 1,258 acres of escarole and endive. This was followed by New Jersey with 404 harvested acres. The top 3 U.S. counties for escarole and endive acreage harvested in 2012 were Monterey County, California, San Luis Obispo County, California, and Cumberland County, New

Jersey. There were no counties in Arizona with escarole and endive acreage harvested data disclosed.

From Farm to Market

Distribution Channels and Value Chain

As demonstrated in the previous section, the nation's supply of leafy greens (particularly lettuce) is concentrated in the western United States—in Arizona and California. After being harvested, leafy greens can follow a variety of production tracks. Leafy green products are marketed in four broad categories: raw agricultural commodities, value-added products, fresh-cut or fresh-processed products, or processed goods (Glaser et al., 2001).

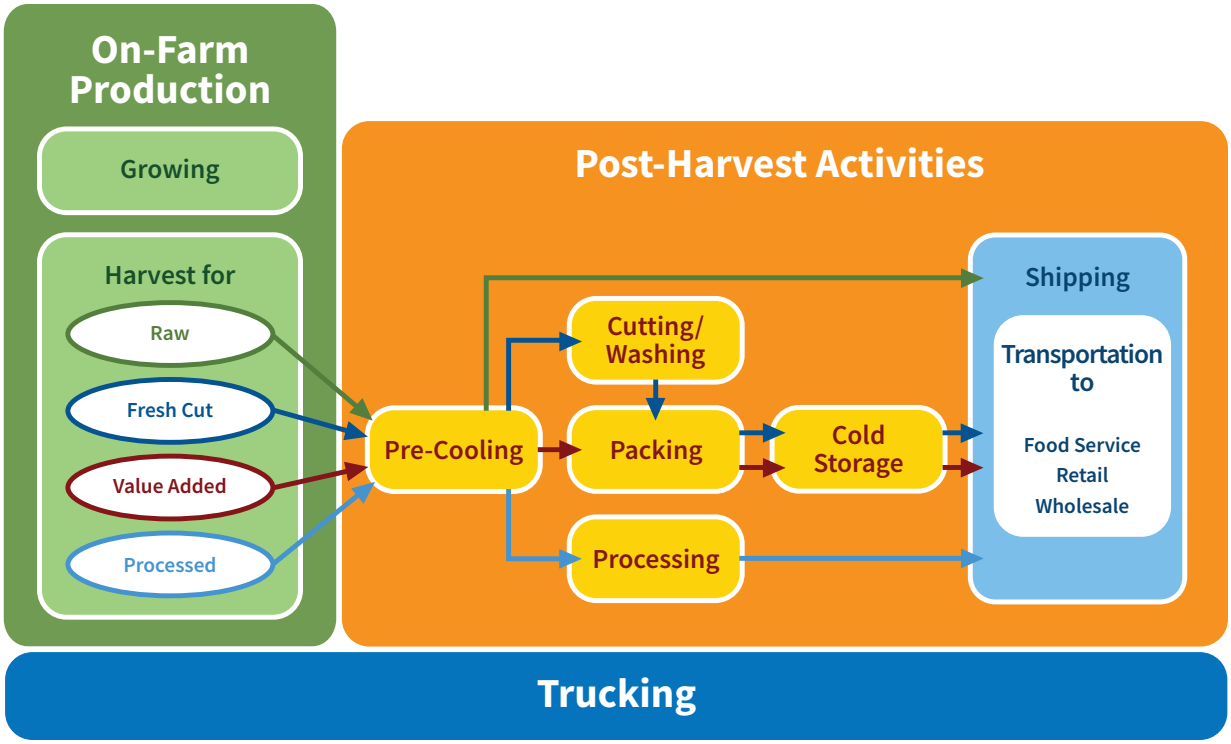
Leafy greens marketed as raw agricultural commodities are typically field packed, marketed in bulk, and require little to no processing. Field packing is when the "grading, sorting, sizing, packing, and palletizing" takes place in the field (Gorny et al., 2006). While these products may be packed in protective films, they are considered raw agricultural commodities due to the field packing process.

Leafy greens marketed as value-added products have slightly higher levels of processing, where the product is typically bagged in cello packs (Glaser et al., 2001). Value-added products are often shed packed. Shed packing takes place in a "facility where raw agricultural commodities are washed, trimmed or sorted and packed in commercial containers, e.g. cartons or totes" (Gorny et al., 2006). While value-added products often require a packing facility, they do not require large investments in expensive processing equipment.

Fresh-cut or fresh-processed products have the highest level of processing for fresh-market produce. Fresh-cut products require significant investment in processing equipment, manufacturing infrastructure, and sophisticated packaging films. Processing plants can require an investment of more than $20 million (Glaser et al., 2001). These fresh-cut products, like bagged salads, are considered "ready-to-eat" due to the cleaning process and protective packaging used (Gorny et al., 2006). Due to the high level of manufacturing, bagged salads act more like packaged goods than produce (Glaser et al., 2001). However, they are not considered processed foods when compared to other food categories (Parrish, 2014).

Traditionally, processed foods are those that have been "canned, concentrated, cooked, dried, frozen, jellied, juiced, pickled, pureed, segmented or sliced" (USDA, 2012). Another distinguishing mark for processed foods is that they are typically heated when processed. Leafy greens can be marketed as a processed good, but the leafy green commodities most likely bound for the processed market are limited to cabbage and spinach, where cabbage is used to produce sauerkraut and spinach can be frozen or canned (Naeve, 2015).

Figure 8. Leafy Greens Value Chain



Source: Authors' interpretation adapted from Gorny, et al., 2006; Fernandez-Stark et al., 2011.

Figure 8 presents a simplified illustration of the leafy greens value chain. Two primary components comprise the value chain: on-farm production and post-harvest activities. On-farm production involves growing leafy green commodities and harvesting the crops to be marketed through one of four channels: as a raw agricultural commodity, a value-added product, a fresh-cut or fresh-processed product, or a processed good. The second component, post-harvest activities, includes (1) pre-cooling the product to preserve the quality and prevent wilting, (2) transforming the raw product into a saleable product by cutting, washing, packing, and labeling the product, (3) ensuring the quality and extending the shelf life of the produce by maintaining climate-controlled environments, (4) processing the product if not going to the fresh market, and (5) distributing and marketing the product for final consumption. Transportation, particularly refrigerated trucking, is critical throughout this entire process.

Market Participants

Because leafy greens destined for the fresh market are highly perishable, the leafy greens industry has "evolved in order to move product quickly and efficiently from the major production areas to the retail markets" (Kaufman et al., 2000). It has developed a highly-integrated industry cluster that works together to deliver fresh-market leafy greens produce to consumers. This cluster, or group of interconnected firms, suppliers, and related industries, support each other to ensure the quality of their product and gain competitive advantage (Porter, 1990). Businesses within the cluster can operate independently, conducting only one of the activities in the value chain, or they can be vertically integrated, serving many roles along it.

Growers and Packers

Growers are responsible for the on-farm production of leafy greens. Growers plant, irrigate, weed, and in some cases harvest leafy green crops. Alternatively, harvesting can occur through shippers, the market participant that facilitates the sale (Kaufman et al., 2000). As harvesting leafy greens is extremely labor intensive, and there is very high demand for labor during the harvest season, many growers/shippers use farm labor contracting services. Once the leafy greens are harvested they are packed. Packers "transform the loose product into a saleable product by packing it into cartons, boxes, or bags as appropriate" (Gunderson, et al., 2009). Packers may also wash, cut, and label the produce. As mentioned previously, leafy greens may be field packed, shed packed, or packed as fresh-cut or fresh-processed goods.

Coolers and Cold Storage Operations

An unbroken cold chain from farm to market is essential to maintaining the quality and shelf life of leafy greens. This includes harvesting the crop when it is cool in the field, precooling the product immediately after harvest, keeping the product in a cold environment during packing, and transporting the product in refrigerated vehicles (Ezeike and Hung, 2009; Gorny et al., 2006). The process begins with harvesting during the cool hours of the day and precooling the product right after harvest. There are different cooling requirements depending on the commodity produced and the production track followed. For example, for leafy greens with very high respiration rates, such as leaf lettuce and spinach, cooling should occur within 90 minutes of harvest. Other leafy greens, such as head lettuce, should be cooled within three hours of harvest (Ezeike and Hung, 2009). Lettuce marketed as a raw agricultural commodity requires thorough precooling (either through forced-air cooling, vacuum cooling, or spray-vacuum cooling) because refrigerated trucks do not have enough cooling capacity to cool warm lettuce during transit (Gorny et al., 2006). Coolers and cold storage operations are refrigerated warehouses that can be owned and operated by a grower-shipper or as an independent business.

Shippers

Shippers have an incredibly important role in the marketing and distribution of leafy greens. Shippers are responsible for connecting buyers (retail markets, foodservice firms, and wholesale markets) to the sellers (growers). As one industry expert so aptly described them, shippers are the "name on the box." These shippers "can be very large, vertically integrated growers, a cooperative of growers, or an independent business" (Gunderson, et al., 2009). For example, a shipper may have their own farming operation (a grower-shipper) or they may source from multiple, independent growers. The role of the shipper is to consolidate produce and market it in large enough quantities for distribution to some of the largest retail, foodservice, and wholesale companies. Consolidation of product is important because of the different production regions. For example, while most major lettuce shippers are based in Salinas, California, these shippers have arrangements with growers in Arizona that allow them to market Arizona-grown lettuce—offering year-round availability for buyers. Most leafy greens shippers also offer a wide variety of other vegetables. In fact, one report states that most lettuce shippers have product lines of as many as 75 commodities (Glaser et al., 2001). Shippers may also be involved in other aspects of the value chain, such as owning and operating a cooler (refrigerated warehouse), operating a fresh-cut processing plant, or having their own refrigerated trucks to transport products. Other shippers may contract with independent businesses for post-harvest handling.

Processors

Processors are involved in transforming leafy greens produce into a new product. Many of the largest leafy greens shippers are also processors and are involved in the production of fresh-processed products, such as bagged salads. These bagged salads are "ready-to-eat" and are marketed directly to retail and foodservice markets. Fresh processing requires significant investment in processing equipment, manufacturing infrastructure, and sophisticated packaging films. Some leafy greens, such as cabbage and spinach, may also be further processed, either by freezing or canning (Naeve, 2015).

Wholesalers and Brokers

Wholesalers buy produce from growers, shippers, or grower-shippers, take the title the product, and market to retailers, foodservice firms, and exporters. Brokers, on the other hand, do not take title to the product and only mediate the sale between the buyer and the seller. Wholesalers and brokers deliver leafy green products to a variety of market channels, but are increasingly being cut out of transactions with retailers. Many retail firms are now so large that they are buying produce directly from grower-shippers rather than through wholesalers.

Shifts in the Leafy Greens Industry

Over the last 30 years, the leafy greens industry has evolved significantly. These changes have been precipitated by shifts in consumer demand, the development of new technology, and retail consolidation. These factors have led to "major internal shifts in the product form, mix, and the relative roles of industry players" (Cook, 2012).

First and foremost, the industry has experienced a change in the product mix. Once dominated by head lettuce, the leafy greens industry has responded to shifts in consumer demand and is producing more Romaine and leaf lettuce. Not only are consumers demanding more variety, they are also demanding more convenient product forms such as bagged salads.

The industry has also experienced a major shift in the role of market participants. In the past, sales were between growers and wholesalers, where wholesalers would then market the product to retailers and foodservice firms. Today, sales are increasingly from grower-shippers directly to retailers. Large retailers are now performing "wholesaling activities such as purchasing goods from suppliers, arranging for shipment to distribution warehouses, and replenishing store-level inventory" (Dimitri et al., 2003). Furthermore, retailers are increasing efficiencies by consolidating. ERS reports that in 1987, the largest 20 retailers accounted for 36.5% of total grocery sales and by 2000, the same retailers accounted for 52% (Dimitri et al., 2003).

Arizona's Leafy Greens Industry

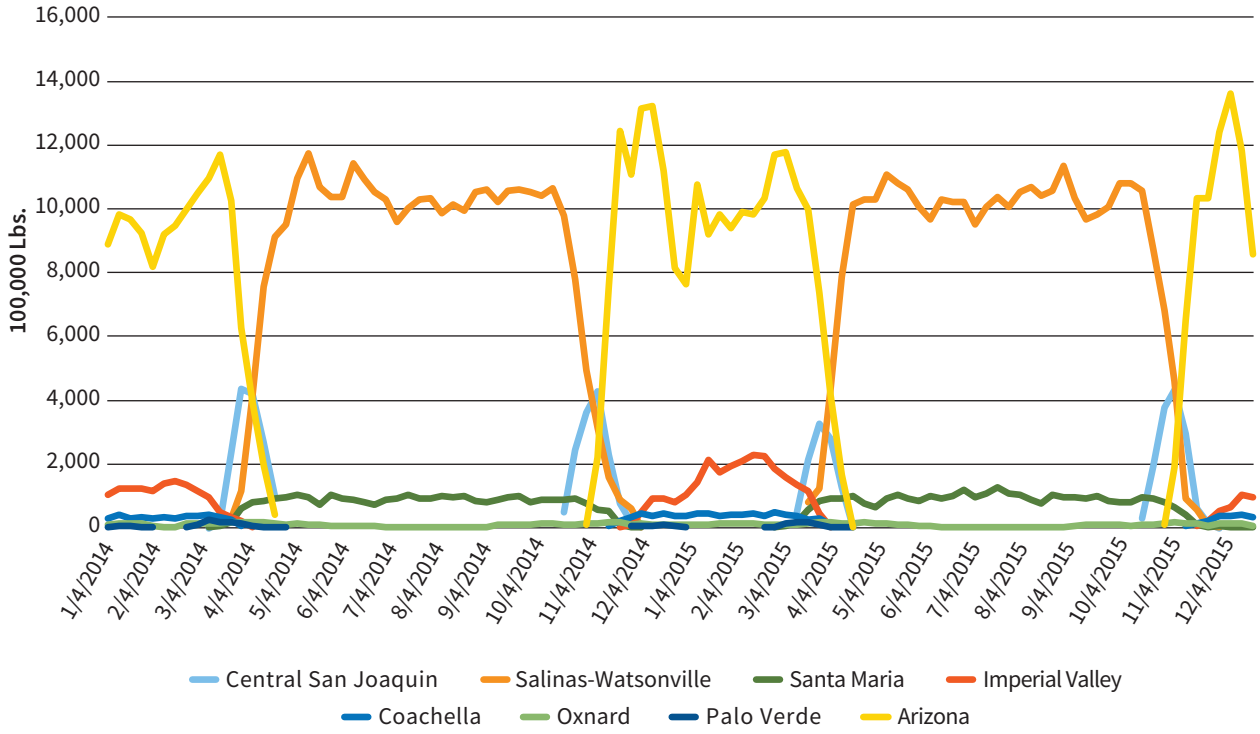
Arizona is a national leader in the production of fresh-market vegetables, with leafy greens making up the majority of vegetable sales. In 2015, Arizona ranked third nationally in area harvested, third in production (in terms of hundredweight [cwt]), and third in value of production for fresh-market vegetables (USDA Vegetables 2015 Annual Summary, 2016). Focusing only on major leafy green commodities, in the same year, Arizona ranked second nationally (only behind California) in the production of lettuce (head, leaf, and Romaine), second in the production of spinach, and eighth in the production of cabbage (Table 1). Furthermore, Arizona-grown leafy greens accounted for an average of 20% of total national leafy greens production. Focusing on lettuce, Arizona accounted for 24% of the nation's production of head lettuce, 19% of the nation's production of leaf lettuce, and 26% of the nation's production of Romaine lettuce. Additionally, in 2015, Arizona-grown cabbage and spinach accounted for roughly 4% and 21% of the nation's production, respectively (Table 1).

Table 1. National Rank of Arizona Leafy Greens Production, 2015

Leafy Green Commodity	Arizona			Leading State		National
	National Rank	*Production (1,000 cwt)*	*Percentage of National Production*	*State*	*Production (1,000 cwt)*	*Production (1,000 cwt)*
Cabbage (fresh market)	8	819	4%	California	5,865	20,113
Lettuce, Head	2	10,238	24%	California	32,870	43,108
Lettuce, Leaf	2	2,325	19%	California	10,010	12,335
Lettuce, Romaine	2	6,688	26%	California	18,733	25,421
Spinach	2	1,288	21%	California	4,272	6,076

Sources: USDA, NASS Quick Stats Annual Survey, 2015; USDA Vegetables 2015 Annual Summary, 2016.

Figure 9. Weekly Lettuce Shipments by Arizona and California Production Regions, 2014–2015



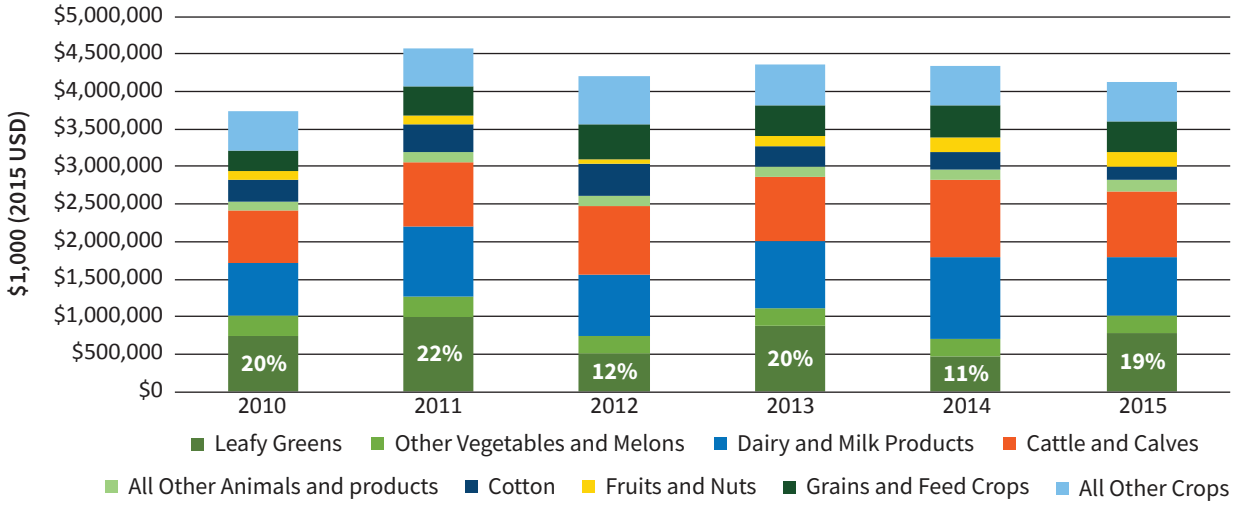
Source: USDA AMS Specialty Crop Movement Report, 2016.

As mentioned previously, one reason why Arizona-grown leafy greens are important to national production is the timing of production. Arizona leafy greens are harvested in the winter, when other major production regions have ceased due to low temperatures. This is particularly the case for lettuce, where production shifts seasonally between California and Arizona. Figure 9 shows the movement of lettuce from California and Arizona lettuce-producing districts. California's Salinas-Watsonville district and Arizona's western district are the major producers and shippers of lettuce. Production shifts seasonally from one region to the other, allowing for year-round availability of lettuce. Spring and summer lettuce production occurs in the Salinas-Watsonville and Santa Maria districts of California and winter lettuce production occurs in western Arizona and California's Imperial, Coachella, and Oxnard districts (Figure 9). According to these data, between the first week of December 2014 and the first week of March 2015, Arizona produced an average of 82% of the nation's lettuce. Arizona's peak week for lettuce shipments occurred on December 6, 2014, where Arizona-grown lettuce accounted for 92% of the nation's shipments. Over this same period, 16% was supplied by California and 2% was supplied by Florida. California's Central San Joaquin Valley and Palo Verde districts ship lettuce during the transition between the two major harvest seasons.

Value of Production

Leafy greens represent a significant portion of Arizona's agricultural economy. Since 2010, leafy greens, on average, have accounted for approximately 17% of annual agricultural sales (cash receipts) in Arizona. However, year-to-year market fluctuations affect leafy greens' share of total agricultural cash

Figure 10. Arizona Cash Receipts by Agricultural Commodity Group, 2010–2015

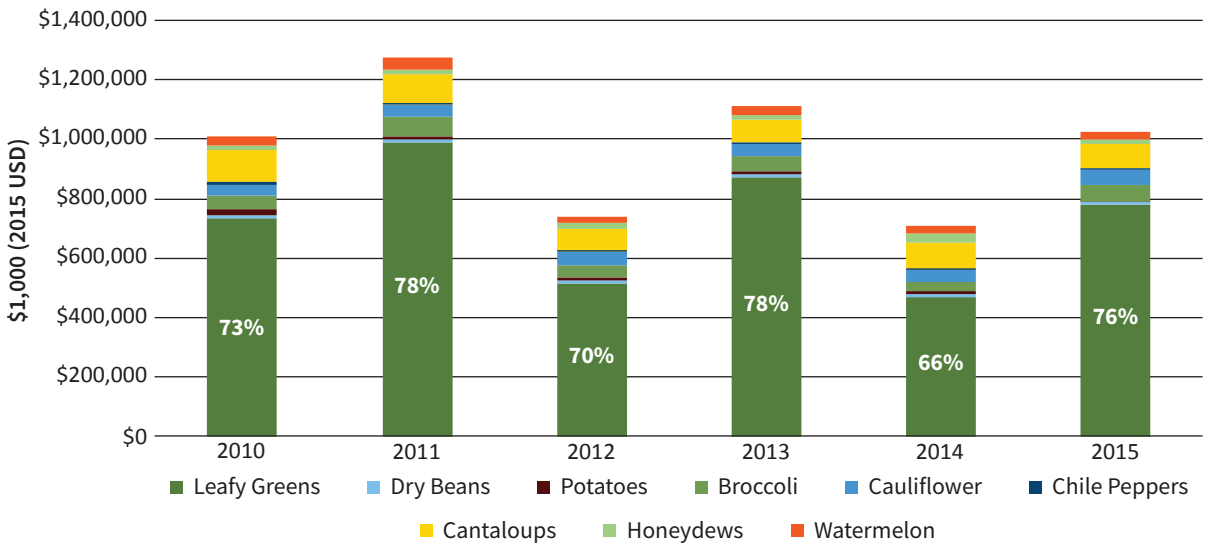


Source: USDA, ERS Farm Income and Wealth Statistics, 2015; Bureau of Labor Statistics.

receipts (Figure 10). For example, in 2011, leafy greens accounted for 22% of Arizona's total agricultural cash receipts, but in 2014, leafy greens only accounted for 11% of total cash receipts, the lowest share over the six-year period. In 2015, that rose back to 19% of state cash receipts.

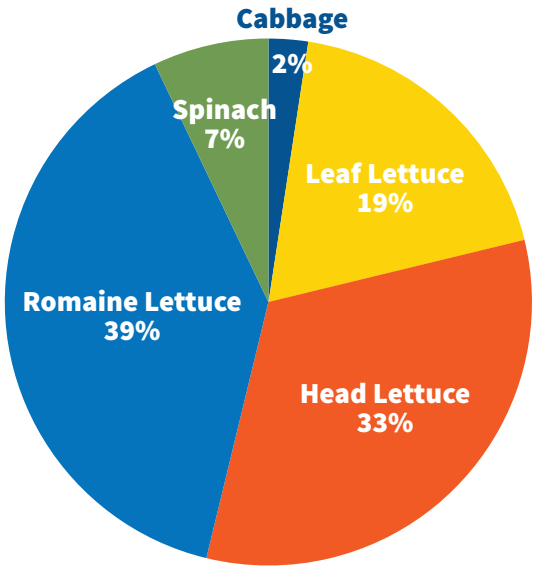
Leafy greens, as a commodity group, are not categorized in agricultural statistics. Rather, they are a subset of vegetable and melon production. For Arizona, the production of leafy greens—in particular head, leaf, and Romaine lettuce—accounts for a majority of the state's vegetable and melon production. Over a six-year period, leafy greens have accounted for an average of more than 70% of the state's vegetable and melon cash receipts. In 2014, leafy greens accounted for 66% of Arizona's vegetable and melon cash receipts. That figure rose to roughly 76% in 2015 (Figure 11). Figure 11 suggests that

Figure 11. Arizona Real Cash Receipts for Vegetables and Melons by Broad Commodity Group, 2010–2015



Source: USDA, ERS Farm Income and Wealth Statistics, 2015.

Figure 12. Arizona Leafy Greens Cash Receipts by Commodity, 2015



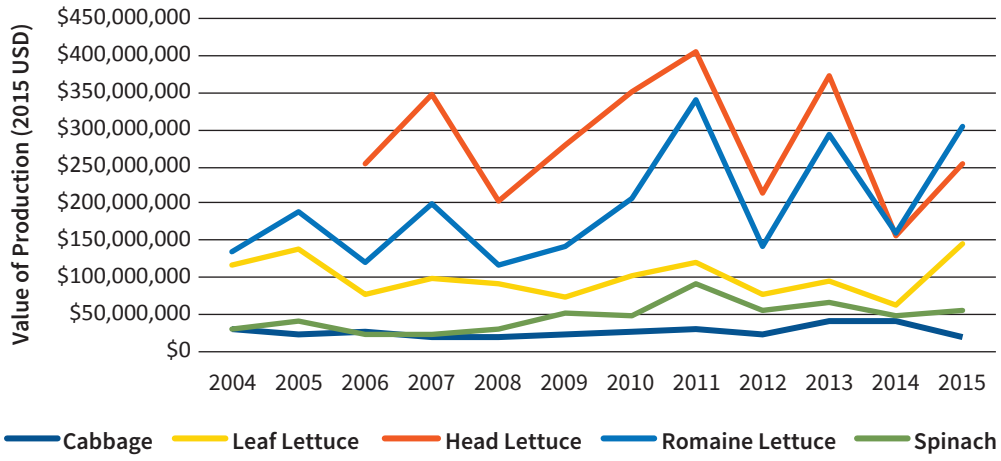
Source: USDA, NASS Quick Stats Annual Survey, 2015.

when cash receipts for leafy greens are high, vegetable and melon sales as a whole are typically high for the state.

Focusing individually on the major leafy green commodities produced in Arizona, lettuce accounts for a large majority of the cash receipts received. In 2015, all varieties of lettuce accounted for more than 90% of Arizona's leafy greens cash receipts. By lettuce variety, Romaine and head lettuce each accounted for about one-third of total leafy greens cash receipts and leaf lettuce accounted for about 19%. Other Arizona-grown leafy green commodities, spinach and cabbage, accounted for about 7% and 2%, respectively (Figure 12).

While Romaine lettuce accounted for the largest share of Arizona's leafy greens cash receipts in 2015, this hasn't always been the case. Only in recent years has Romaine lettuce's value of production surpassed head lettuce's value of production. Prior to 2014, head lettuce had a higher value of production than Romaine lettuce and accounted for a larger share of the state's leafy greens cash receipts (Figure 13). In fact, in 2006, head lettuce accounted for more than 50% of Arizona's leafy greens cash receipts while Romaine only accounted for about one-quarter. This accords with trends in national demand for different varieties of lettuce.

Figure 13. Value of Production for Arizona Leafy Greens by Commodity, 2004–2015

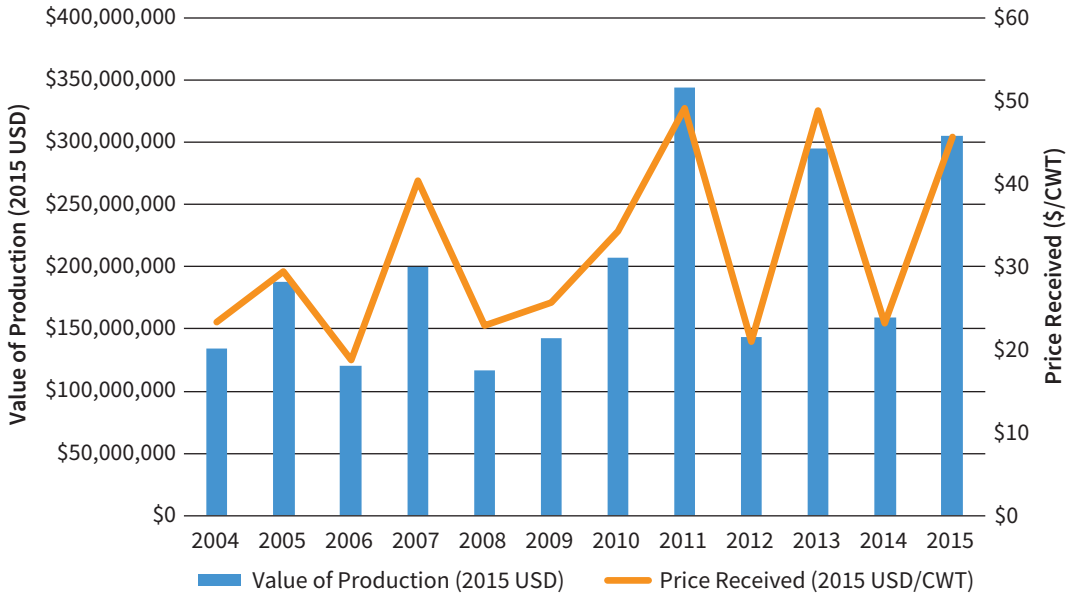


Source: USDA, NASS Quick Stats Annual Survey, 2004–2015; Bureau of Labor Statistics.

As mentioned previously, the value of production for leafy greens can vary significantly from year to year. For example, in 2011 the value of production for head lettuce was more than $400 million. The next year, in 2012, the value of production for head lettuce was just approximately $215 million, a decrease of nearly 50%. During the same time frame, production (measured by cwt) actually increased. This illustrates that the value of production is heavily dependent on prices received. In years where prices are high, the value of production is also high. In years where prices are low, the value of production is also low. While there may be some variation in the volume produced from year to year, most of the variation in the value of production from year to year is due to a change in prices received. The following section examines the intersection of prices received and value of production for the five major leafy green commodities produced in Arizona.

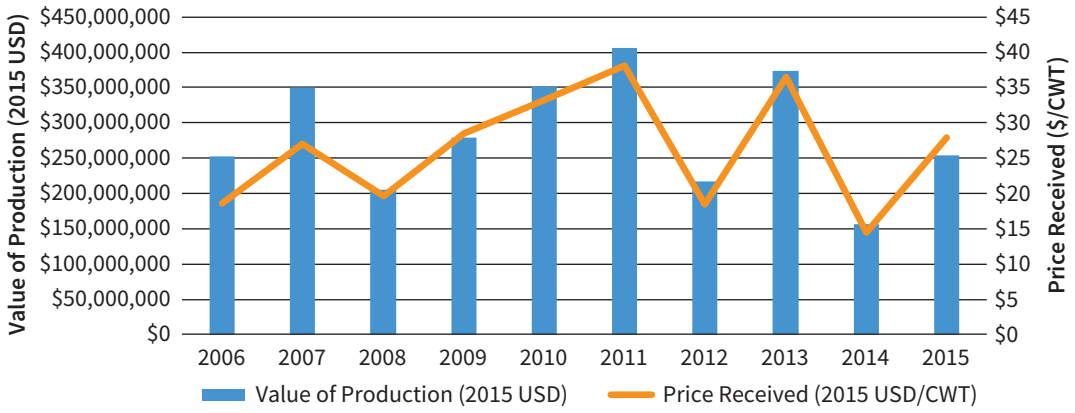
Prices received for Romaine have fluctuated significantly since 2004, with lows of about $20/cwt to highs of nearly $50/cwt. Romaine cash receipts have also fluctuated, in accordance with prices received (Figure 14). In 2014 and 2015, the value of production for Romaine lettuce was approximately $160 million and $305 million, respectively.

Figure 14. Value of Production and Price Received for Arizona Romaine Lettuce, 2004–2015



Source: USDA, NASS Quick Stats Annual Survey, 2004–2015; Bureau of Labor Statistics.

Figure 15. Value of Production and Price Received for Arizona Head Lettuce, 2006–2015

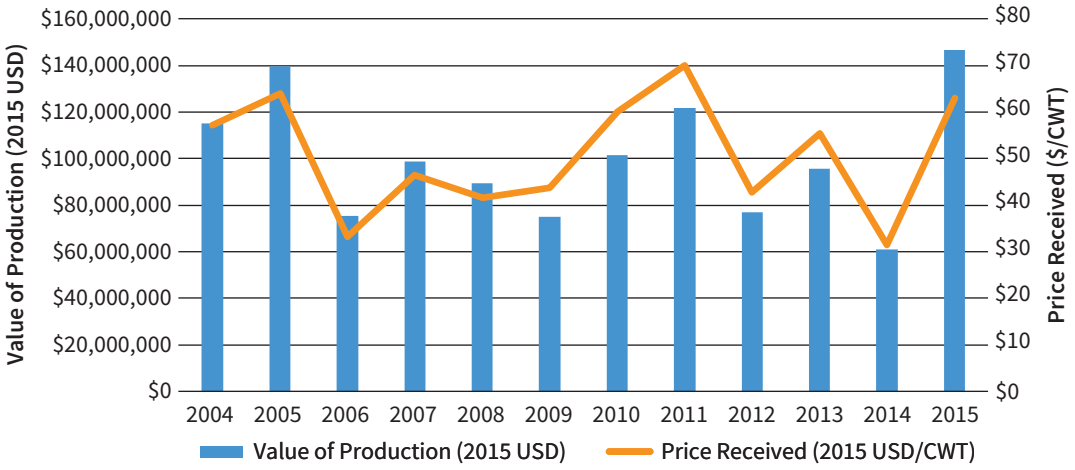


Source: USDA, NASS Quick Stats Annual Survey, 2006–2015; Bureau of Labor Statistics.

The value of production of head lettuce in Arizona varies significantly from year to year and closely mirrors trends in price received. Prices received for head lettuce fluctuated between 2011 and 2015, reaching a low of $12.80 per cwt in 2014, when adjusted for inflation, then again regaining value in 2015 (Figure 15).

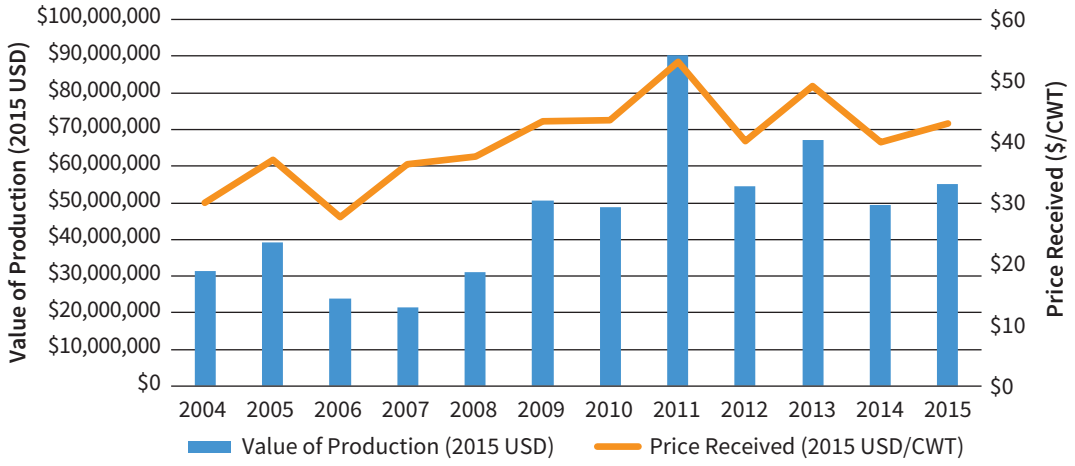
Leaf lettuce cash receipts have also fluctuated from year to year, achieving a low point in 2014 at $61 million, then climbing sharply in 2015 to $146 million. Similarly, prices received were at a low in 2014 when adjusted for inflation, followed by an increase in 2015 (Figure 16). Prices received for Romaine lettuce, head lettuce, and leaf lettuce exhibit the same general trend between 2011 and 2015, with alternating years of high and low prices.

Figure 16. Value of Production and Price Received for Arizona Leaf Lettuce, 2004–2015



Source: USDA, NASS Quick Stats Annual Survey, 2004–2015; Bureau of Labor Statistics.

Figure 17. Value of Production and Price Received for Arizona Spinach, 2004–2015

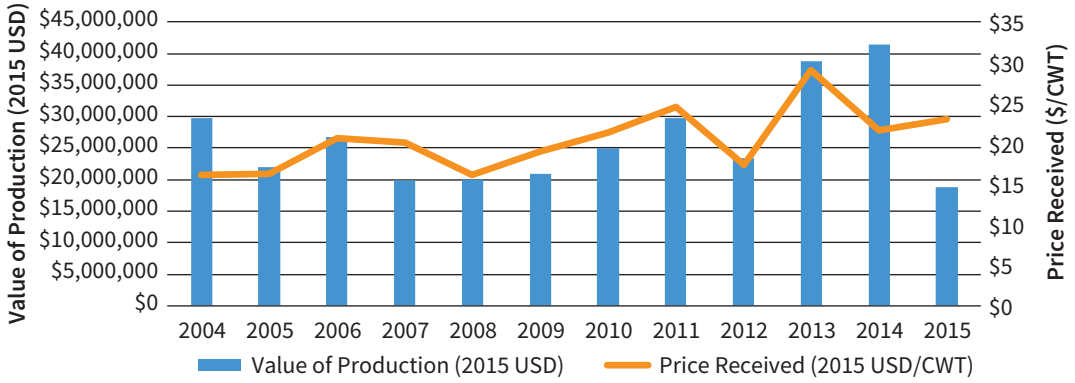


Source: USDA, NASS Quick Stats Annual Survey, 2004–2015; Bureau of Labor Statistics.

The value of production for spinach also closely reflects trends in prices received (Figure 17). With a received price of about $43/cwt, spinach cash receipts were about $55 million in 2015, an increase from 2014.

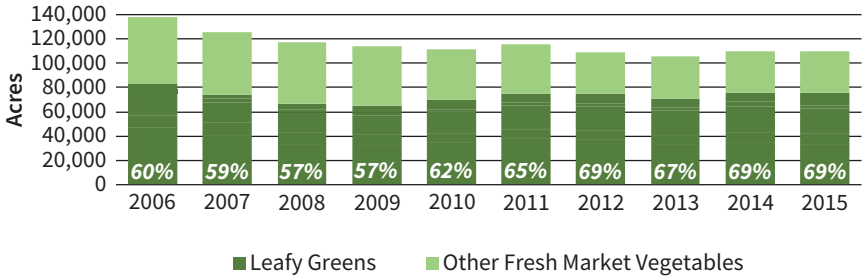
Finally, cash receipts for cabbage saw a slight increase between 2013 and 2014, as a result of a combination of increased production and lower prices received, and then a drop in 2015 due to decreased production (Figure 18).

Figure 18. Value of Production and Price Received for Arizona Cabbage, 2004–2015



Source: USDA, NASS Quick Stats Annual Survey, 2004–2015; Bureau of Labor Statistics.

Figure 19. Arizona Leafy Greens and Other Vegetables Acreage Harvested in Arizona, 2006–2015



Source: USDA, NASS Quick Stats Annual Survey, 2006–2015.

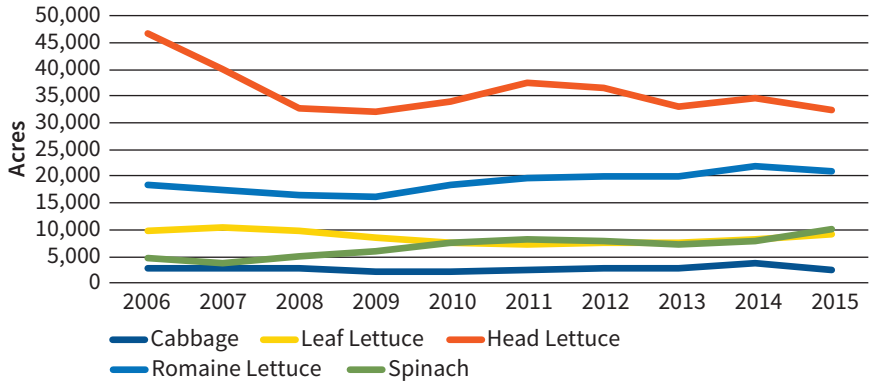
Harvested Acreage

Leafy greens also account for a majority of vegetable and melon harvested acreage in the state. From year to year between 2006 and 2015, leafy greens represented anywhere from 57% to 69% of vegetable and melon acreage (Figure 19). This is slightly lower than the share of cash receipts represented by leafy greens, suggesting that leafy greens are a relatively higher-value agricultural product on a per-acre basis, when compared to other vegetable crops.

Since 2006, harvested acreage of fresh-market vegetables[6] has steadily decreased in Arizona, from nearly 140,000 acres in 2006 to just over 110,000 acres in 2015. Leafy greens' share of vegetable acreage harvested, however, has increased from about 60% of Arizona's total harvested vegetable acreage to nearly 70% of Arizona's total harvested acreage (Figure 19).

Focusing on individual leafy green commodities, head lettuce has consistently accounted for the majority of leafy greens acreage harvested in Arizona (Figure 20). Since 2006, however, head lettuce harvested acreage has decreased. For example, in 2006, Arizona had more than 46,800 acres of head lettuce harvested. This fell to 32,500 acres in 2015. In 2015, Romaine lettuce

Figure 20. Arizona Leafy Greens Acreage Harvested for Fresh Market by Commodity, 2006–2015



Source: USDA, NASS Quick Stats Annual Survey, 2006–2015.

6 Data refer to the 34 major fresh-market vegetables reported by USDA, NASS Quick Stats Annual Survey.

was ranked second in the state in terms of acreage harvested, with total harvested acreage of 20,900 acres and has generally increased over time. In recent years, spinach has surpassed leaf lettuce in terms of harvested acreage with 10,300 acres and 9,300 acres in 2015, respectively. Finally, cabbage has the fewest acres harvested with about 2,600 acres in 2015.

While acreage data for individual commodities are not disclosed for most Arizona counties in the 2012 Census of Agriculture, there are some data to suggest where most of this leafy greens production is occurring within the state. In 2012, Yuma County accounted for 96.7% of the state's harvested acreage of all lettuce. Interestingly, Yuma County only accounted for about 30% of the state's lettuce operations, suggesting that farms in Yuma are generally large-scale producers.

Compared to other U.S. counties that produce lettuce and have acreage data disclosed, Yuma County was ranked second nationally, with 69,748 acres in 2012. Monterey County, California, was ranked first with more than 130,000 acres, and Imperial County, California (Yuma's western neighbor), was ranked third (Table 2).

Unfortunately, harvested acreage data for Romaine and head lettuce are not disclosed for Yuma County. However, data are disclosed for leaf lettuce. In 2012, Yuma County accounted for 94.7% of leaf lettuce acreage harvested in the state. Maricopa County, in Central Arizona, accounted for 5.1% of the state's leaf lettuce acreage and the remaining Arizona counties accounted about 0.2%. Because these data are disclosed at the county level, we are able to compare Arizona counties to other U.S. counties producing leaf lettuce.

In 2012, Yuma County ranked 3rd among U.S. counties that produce leaf lettuce and have acreage data disclosed. Maricopa County ranked 10th in the nation with 479 acres. Yuma's western neighbor, Imperial County, California, ranked second with 9,847 acres and Monterey, California, ranked first with 28,977 acres of leaf lettuce harvested in 2012 (Table 3).

Similar to lettuce, a majority of the spinach acreage harvested in Arizona is in Yuma County. In 2012, Yuma County had 8 farms with 7,160 acres harvested (about 90% of the state's harvested spinach acreage). Other counties in Arizona with spinach acreage harvested were Pima, Maricopa, Coconino, and Pinal.

Table 2. Lettuce Acreage Harvested—Top U.S. Counties by Acreage, 2012

State	County	Acres
California	Monterey	134,662
Arizona	Yuma	69,748
California	Imperial	41,739
California	Santa Barbara	15,755
California	Santa Cruz	9,770
California	Fresno	8,567
California	Riverside	7,478
California	San Luis Obispo	4,635
California	Ventura	3,681

Source: 2012 Census of Agriculture, 2014.

Table 3. Leaf Lettuce Acreage Harvested —Top U.S. Counties by Acreage, 2012

State	County	Acres
California	Monterey	28,977
California	Imperial	9,847
Arizona	Yuma	8,895
California	Riverside	2,323
California	Santa Barbara	2,006
California	Ventura	1,423
California	Santa Cruz	1,248
California	Fresno	955
California	San Luis Obispo	593
Arizona	Maricopa	479

Source: 2012 Census of Agriculture, 2014.

Table 4. Spinach Acreage Harvested—Top U.S. Counties by Acreage, 2012

State	County	Acres
California	Monterey	14,834
Arizona	Yuma	7,160
California	Imperial	4,624
California	Ventura	1,679
California	San Benito	1,536
California	Santa Barbara	1,129

Source: 2012 Census of Agriculture, 2014.

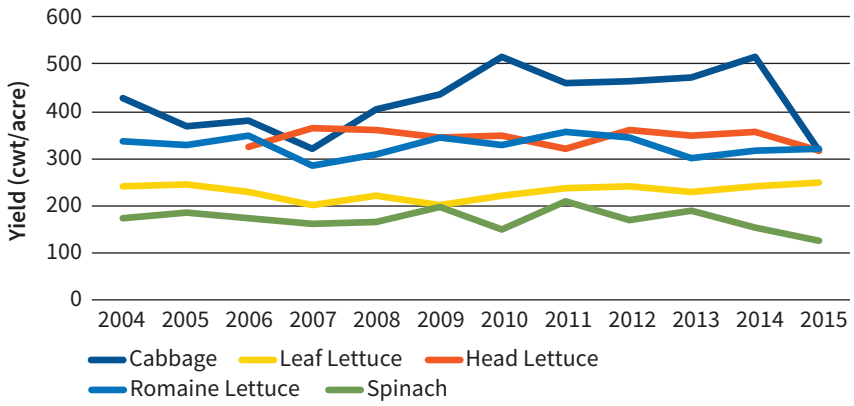
Compared to other U.S. counties that produce spinach and have acreage data disclosed, in 2012, Yuma County ranked second in the nation for acreage harvested with 7,160 acres. Monterey County, California, ranked first with 14,834 harvested acres and Imperial County, California, ranked third with 4,624 harvested acres (Table 4).

For cabbage, only one Arizona county had harvested acreage disclosed. This was Apache County in Northern Arizona, which only accounted for about 0.5% of the state's cabbage acreage harvested.

Other less prominent leafy greens produced in Arizona are kale, escarole, and endive. In 2012, there were a total of 20 farms with 121 acres harvested of kale. Maricopa County, in Central Arizona, had 117 of these acres, accounting for 97% of the state's harvested kale acreage.

Compared to other U.S. counties that produce kale and have acreage data disclosed, Maricopa County ranked seventh in the nation in terms of acres harvested. Monterey County, California, was ranked first with 382 acres of kale harvested and Ventura, California, was ranked second with 310 acres of kale acres harvested (2012 Census of Agriculture, 2014). No acreage data are disclosed for endive and escarole.

Figure 21. Arizona Yields by Leafy Green Commodity, 2004–2015



Source: USDA, NASS Quick Stats Annual Survey, 2004–2015.

Table 5. Arizona's Cabbage Yield and National Rank, 2010–2015

Year	National Rank	Cwt/Acre
2010	1	515
2011	1	460
2012	2	465
2013	1	470
2014	1	515
2015	9	315

Source: USDA, NASS Quick Stats Annual Survey, 2010–2015.

Yield

Finally, when examining yields of individual leafy green commodities in Arizona, in 2015, Romaine lettuce had the highest yield per acre with yields of 320 cwt/acre. This was followed by head lettuce (315 cwt/acre), cabbage (315 cwt/acre), leaf lettuce (250 cwt/acre), and spinach (125 cwt/acre) (Figure 21).

Compared to other leafy greens producing regions, Arizona has relatively high yields per acre. Cabbage, typically Arizona's highest-yielding leafy green commodity, has led the nation in hundredweight produced per acre in four of the last six years. However, in the most recent year, cabbage yields in Arizona fell to ninth nationally with a yield of 315 cwt/acre (Table 5).

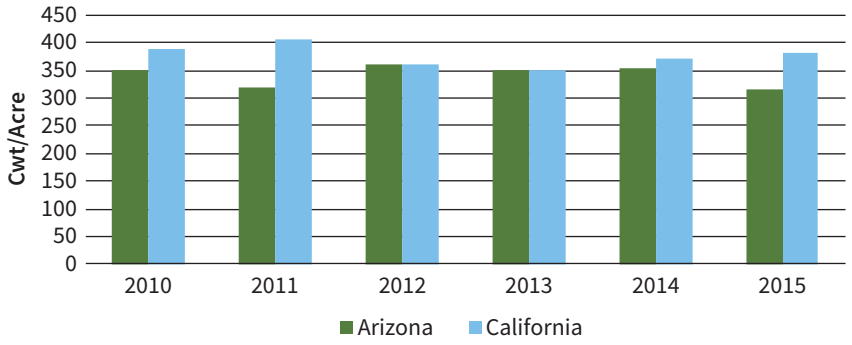
For lettuce, Arizona and California have relatively similar yields per acre, though fluctuations occur from year to year and yields vary by lettuce variety. Over the last six years, California has tended to have higher head lettuce yields than Arizona. In 2015, Arizona had a yield of 315 cwt/acre versus California's 380 cwt/acre for head lettuce (Figure 22).

For Romaine lettuce, however, Arizona has exhibited higher yields over the last six years. In 2015, Arizona had a yield of 320 cwt/acre versus California's 295 cwt/acre (Figure 23).

Finally, although leaf lettuce yields have historically been higher in California than Arizona, Arizona has seen increasing yields per acre, increasing from 220 cwt/acre in 2010 to 250 cwt/acre in 2015. In comparison, California had a yield of 260 cwt/acre in 2015 (Figure 24).

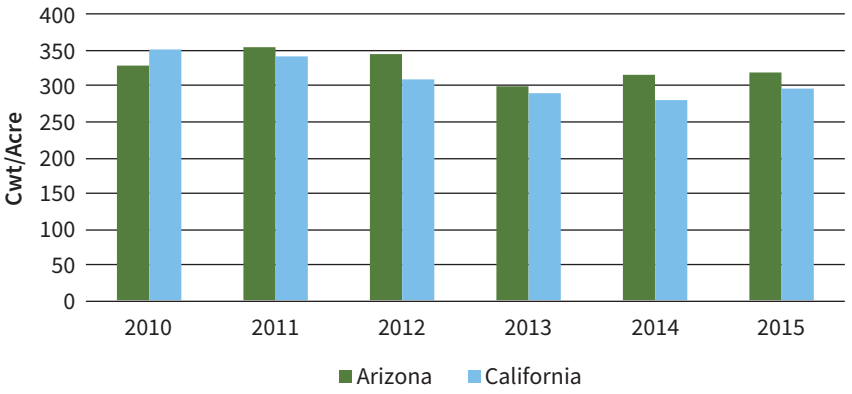
Of the four major spinach-producing states in the nation, Arizona has consistently ranked in the top 3 in terms of yield per acre since 2010. In 2015, Arizona had the third highest yield in the nation (equal to Texas), after California and New Jersey, with a yield of 125 cwt per acre in 2015 (Table 6).

Figure 22. Head Lettuce Yield in Arizona and California, 2010–2015



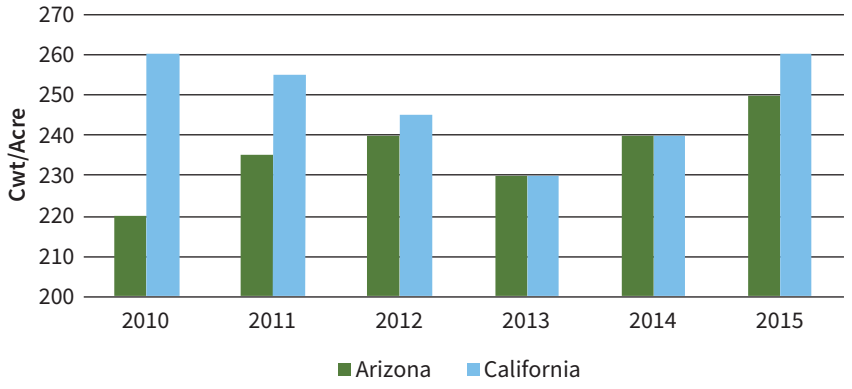
Source: USDA, NASS Quick Stats Annual Survey, 2010–2015.

Figure 23. Romaine Lettuce Yield in Arizona and California, 2010–2015



Source: USDA, NASS Quick Stats Annual Survey, 2010–2015.

Figure 24. Leaf Lettuce Yield in Arizona and California, 2010–2015



Source: USDA, NASS Quick Stats Annual Survey, 2010–2015.

Table 6. Spinach Yield per Acre—Top U.S. States, 2015

State	Yield (Cwt/Acre)
California	160
New Jersey	150
Arizona	125
Texas	125
Other States	62

Source: USDA, NASS Quick Stats Annual Survey, 2015.

Marketing Arizona-Grown Leafy Greens

Most Arizona-grown leafy greens are marketed for the fresh market. In fact, according to the 2012 Census of Agriculture, there were only three leafy green commodities produced in Arizona that were harvested for processing. These leafy green commodities were cabbage, Chinese (Napa) cabbage, and spinach (Table 7).

Table 7. Number of Arizona Farms Producing Leafy Greens for Processing and Acreage Harvested for Processing, 2012

Leafy Green Commodity	Total Number of Farms	Number of Farms that Harvested for Processing	Acreage Harvested for Processing
Cabbage	23	1	(D)
Chinese cabbage	9	7	5
Spinach	24	5	(D)

(D): Data are not disclosed when such reporting will allow for identification of individual operations.
Source: 2012 Census of Agriculture, 2014.

In Arizona, there were a total of 23 cabbage-producing farms in 2012. However, there was only 1 farm in Arizona that harvested cabbage for processing. This farm was in Yuma County and the Census of Agriculture did not disclose harvested acreage for privacy concerns. Of the 9 farms in Arizona that harvested Chinese cabbage, 7 farms harvested for processing. These farms were located in Pima County (4 farms), Yuma County (2 farms), and Maricopa County (1 farm). The total Chinese cabbage acreage harvested for processing in Arizona was approximately 5 acres. Finally, in 2012, there were a total of 24 farms in Arizona that harvested spinach. Of these, 5 farms harvested spinach for processing. These farms were located in Yuma County (4 farms) and Maricopa County (1 farm). Again, the total acreage of spinach harvested for processing was not disclosed to prevent identification of individual operations.

While there is not a large processing presence in Arizona, there is a fair amount of fresh-cut processing taking place in western Arizona. According to USDA Agricultural Marketing Service statistics, during the lettuce harvest season, processed lettuce accounts for anywhere from 10% to 20% of the monthly volume of lettuce shipped from Arizona. In fact, from January 2014 to December 2015, processed lettuce accounted for an average of 20% of the total lettuce shipped from Arizona, or about 38 million pounds per month (USDA AMS Specialty Crop Programs Market News Division, 2015 and 2016).

As mentioned previously, processing plants require extremely expensive, highly specialized heavy equipment and manufacturing infrastructure. Due to the seasonal nature of lettuce production, some processing plants "follow the product," moving from one production region to another (usually between Salinas and Yuma). While the physical buildings stay put, all of the specialized processing equipment is cleaned, disassembled, and loaded into trucks and transported and reassembled in a matter of days (Taylor Farms, personal communication, January 25, 2017).

Economic Contributions of the Leafy Greens Industry Cluster

The contribution of leafy greens to the Arizona economy goes beyond leafy greens produced on Arizona farmland. Other industries in Arizona provide essential post-harvest activities to facilitate the delivery of leafy greens product from farm to market. These other industries are part of the leafy greens value chain and are responsible for packing, cooling, storing, processing (if processed), and distributing and marketing leafy greens for final consumption. This cluster directly contributes to the Arizona economy by generating sales and employing workers for the production and distribution of Arizona-grown leafy greens. These are known as the **direct effects** of the leafy greens industry cluster.

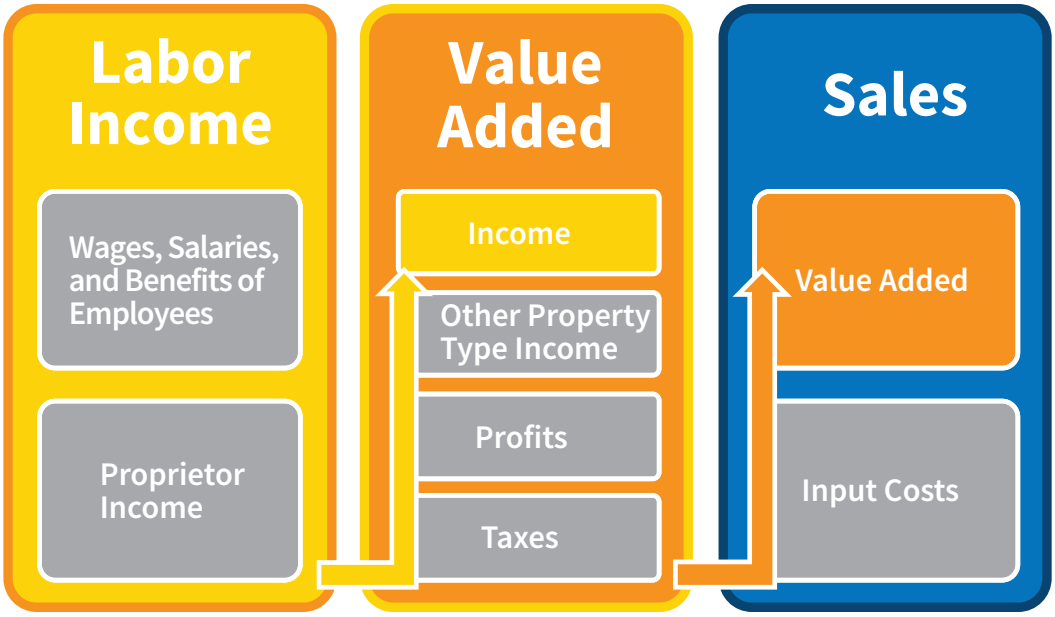
In addition to the direct contributions, the cluster's demand for inputs and labor also supports economic activity in other Arizona industries. A "ripple" of economic activity is generated in Arizona when (1) businesses involved in the production and distribution of leafy greens purchase inputs from other Arizona businesses and (2) when households employed by the industry cluster spend their earnings on consumer goods and services that are purchased from other Arizona businesses. Economists call these **indirect** and **induced multiplier effects**.

Indirect effects measure the economic activity resulting from business-to-business transactions, or the purchasing of inputs to production from other Arizona businesses. When analyzing the contribution of the leafy greens industry cluster, the first round of indirect effects is generated in industries that sell inputs to the cluster. For example, at the farm level, additional economic activity is generated in industries that sell water and supplies for irrigation, fertilizers, farm and processing machinery, labor services, land, electricity, and banking services, among others. Each of these suppliers must also purchase inputs from other businesses, some of which are also located in state, generating additional rounds of economic activity. These rounds of business-to-business transactions capture the indirect effects of the leafy greens industry cluster.

Another component of economic activity supported by the leafy greens industry cluster is the set of effects resulting from salaries and wages paid to people employed by the cluster. When employees of the cluster spend their earnings (salaries and wages) at Arizona businesses for household expenses, additional economic activity is generated in industries that provide those consumer goods and services. For example, additional economic activity is generated in the housing, retail, healthcare, and restaurant industries. These rounds of household-to-business transactions capture the **induced effects** of the leafy greens industry cluster.

Combined, the direct, indirect, and induced effects measure the total contribution of the leafy greens industry cluster to the Arizona economy. These contributions can be measured using a variety of economic metrics. The most common metric, and easiest to understand, is sales. Sales, also known as output, is a gross measure of economic activity. 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 to a particular industry and is composed of the incomes paid to workers, the profits of the industry, and the taxes paid to the government

Figure 25. Illustration of Relationship between Economic Metrics



(IMPLAN Group, LLC). This metric is synonymous with the official measure of gross state product (GSP), the measure that is most often used to measure the size of a state economy. Contributions can also be measured through incomes supported by the industry. Estimates of labor income supported by the industry include the wages, salaries, and benefits of people employed by the industry as well as the income of proprietors, or business owners. Another way to measure the contribution of an industry is through its contributions to state and local tax revenues. Finally, contributions can be measured in terms of the number of jobs supported. When conducting an economic contribution analysis, jobs are typically measured by the annual average number of temporary, part-time, and full-time workers. However, estimating the number of jobs supported by agricultural industries, particularly a commodity group like leafy greens, is extremely challenging. We estimate the number of on-farm jobs based on total hours of on-farm labor required and use IMPLAN to estimate employment supported in leafy greens post-harvest industries and industries affected by indirect and induced effects.

These economic metrics are interconnected and, therefore, cannot be added together. Figure 25 demonstrates the relationships between sales, value added, and labor income.

The following section of the report summarizes the results of the economic contribution analysis for 2015 production.[7] Total contributions were estimated using the input-output modeling software IMPLAN Version 3.1.[8] Estimates of the direct, indirect, and induced contributions of the leafy greens industry cluster are reported in terms of sales, value added, labor income, state and local tax revenues, and employment.

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7 Arizona leafy greens production in 2015 was modeled as if it had occurred in 2014. Research methods for the economic contribution analysis are presented in the Appendix.

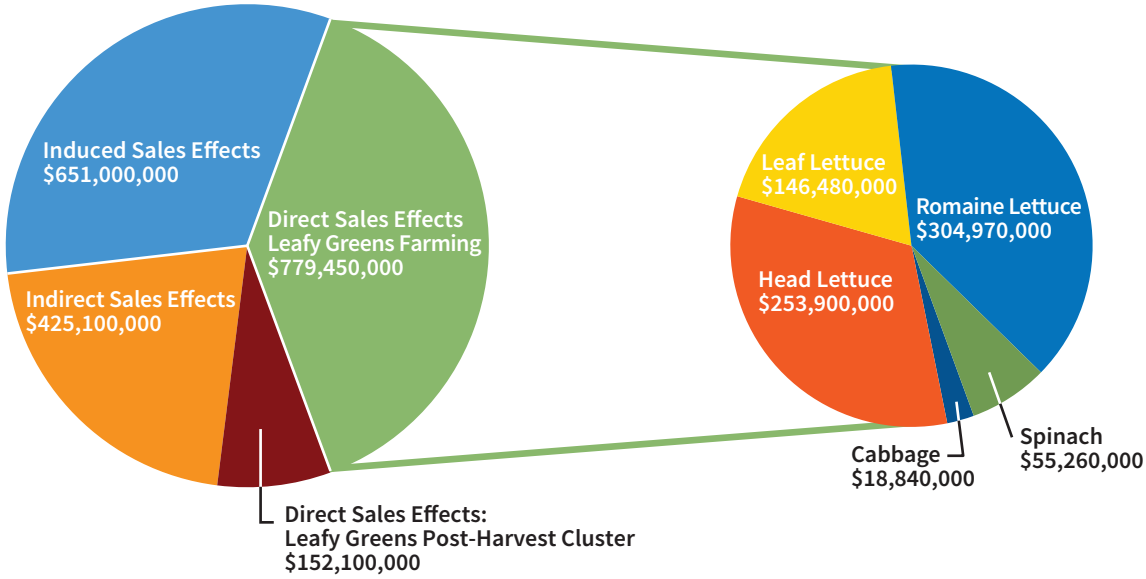
8 IMPLAN is a widely used input-output data and modeling system that provides a detailed account of the Arizona economy; it is used to demonstrate how each industry in the economy is linked to one another and estimate how changes in one industry can affect other industries through backward linkages with suppliers of inputs to production.

Sales Contributions

In 2015, the leafy greens industry cluster directly and indirectly contributed an estimated $2.0 billion in sales to the Arizona economy. This sales contribution included approximately $931.5 million in direct sales from the leafy greens industry cluster and more than $1.0 billion in sales supported through indirect and induced multiplier effects.

Of direct industry cluster sales, approximately $779 million originated from the direct sale of leafy green commodities from Arizona farms. Romaine lettuce accounted for the largest proportion of sales with nearly $305 million in sales, followed by head lettuce with nearly $254 million in sales, leaf lettuce with $146 million in sales, spinach with $55 million in sales, and cabbage with nearly $19 million in sales. Other direct industry cluster sales occurred in industries that provide critical post-harvest services. The sales supported by Arizona leafy greens production in these cluster industries was an estimated $152 million (Figure 26).

Figure 26. Total Sales Contribution of the Leafy Greens Industry Cluster to the Arizona Economy, 2015



Source: Authors' estimates using IMPLAN; USDA, ERS Farm Income and Wealth Statistics, 2015.

Additionally, by purchasing inputs to production, another $425 million in sales were generated through indirect effects. As the cost of labor to harvest leafy greens is often one of the highest input costs to the farmer, much of these indirect sales effects were generated in the agricultural support services industry. This is the industry that provides additional labor for custom work, thinning, weeding, and harvest. Businesses in this industry are often farm labor contractors, or companies that employ temporary agricultural laborers and offer labor services to growers on an as-needed basis. Based on model estimates, roughly 60% of the indirect sales effects were generated in the agricultural support services industry.

Finally, an additional $651 million in sales was supported through induced effects, or when employees of the industry cluster take their earnings and spend them at other Arizona businesses. The industries most affected by induced effects tend to be industries that provide goods and services to households. These industries include the real estate, healthcare, insurance, banking, and restaurant industries, among others.

Value-Added Contributions

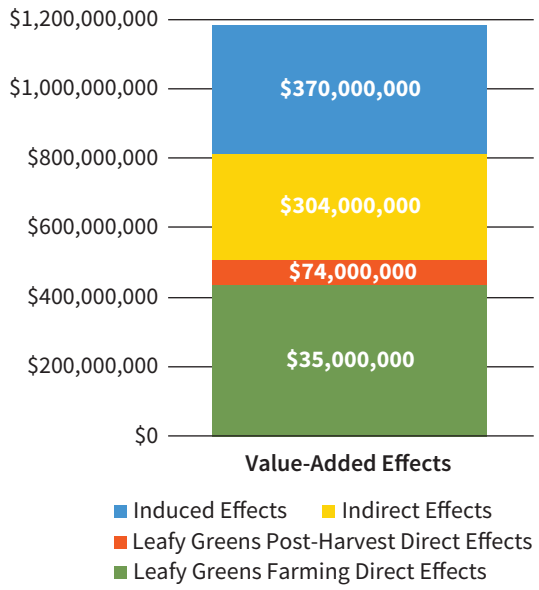
The total estimated value-added contribution from the leafy greens industry cluster for 2015 was nearly $1.2 billion. This contribution includes direct value-added effects of approximately $509 million from the leafy greens industry cluster, $304 million from indirect effects, and $370 million from induced effects (Figure 27). Recall that value added measures the additional gain in economic activity that can be attributed to a particular industry above the cost of inputs to production. This metric is synonymous with the official measure of gross state product (GSP), the measure that is most often used to measure the size of a state economy.

Labor Income Contributions

The leafy greens industry cluster's total contribution to labor income, including multiplier effects, was an estimated $950 million in 2015. The direct contributions to labor income, from on-farm production and post-harvest industries, accounted for $477 million, while income generated by indirect and induced effects was approximately $473 million. Nearly 90% of the income directly supported by the leafy greens industry cluster originated from on-farm production, which accounted for $424 million in income (Figure 28).

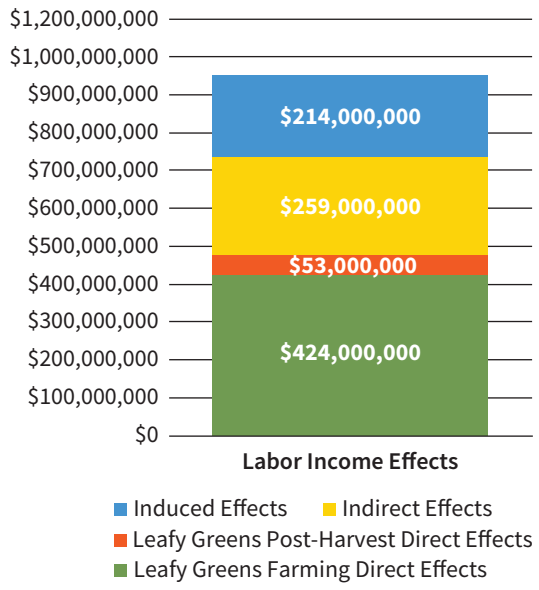
Recall that labor income includes the wages, salaries, and benefits of employees as well as the income earned by proprietors. Of the $424 million in direct labor income effects from on-farm production (leafy greens farming),

Figure 27. Total Value-Added Contribution of the Leafy Greens Industry Cluster to the Arizona Economy, 2015



Source: Authors' estimates using IMPLAN.

Figure 28. Total Labor Income Contribution of the Leafy Greens Industry Cluster to the Arizona Economy, 2015



Source: Authors' estimates using IMPLAN.

it is estimated that more than three-quarters of this income was earned by proprietors. This outcome is the result of our modeling assumption that the price increase from 2014 to 2015 was passed onto the proprietor in the form of increased income and profits.[9]

Tax Contributions

In 2015, the total estimated state and local tax contribution from the leafy greens industry cluster (including multiplier effects) was $64 million. This includes an estimated direct state and local tax contribution of $12.1 million. The leafy greens industry cluster directly contributed an estimated $8.2 million from taxes on production and imports, $3.2 million from personal taxes such as personal income and property taxes, and $0.7 million from corporate profit and social security taxes. Additionally, through indirect and induced effects, the leafy greens industry cluster supported an estimated $51.9 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 leafy greens industry cluster.

Employment Contributions

The final metric that can be used to demonstrate contributions to the state economy is employment, or the number of jobs supported. Arizona's leafy greens industry supports a host of different jobs in the state, both directly and indirectly.

First and foremost, jobs are supported on-farm. Farm operations employ people to work on their operations. This hired on-farm labor includes workers that are hired directly by the farm and workers that are hired through the agricultural support service industry. The agricultural support service industry provides services such as soil preparation, cultivation, and harvesting. In addition to hired workers, there are self-employed farm operators and a substantial number of unpaid family workers that may not draw formal salaries but work on the farm nonetheless. Additionally, beyond the farm gate, there are a number of jobs supported in industries that provide post-harvest services for leafy greens. Finally, as demonstrated above, the leafy greens industry cluster creates demand for jobs in industries supplying goods and services as inputs to leafy greens production and consumer goods and services for households. Employment is supported in these industries through indirect and induced multiplier effects.

There are several challenges to measuring the employment supported by the leafy greens industry cluster. One of the largest issues is the lack of data. Data sources simply do not report specific numbers for workers in the leafy greens industry. With limited availability of data, we estimate on-farm labor requirements (in hours) for leafy greens production and calculate the resulting number of on-farm full-time equivalent jobs. We also estimate post-harvest employment and employment supported through indirect and induced multiplier effects. Finally, as on-farm employment is incredibly seasonal, the number of unique farm workers employed in leafy greens production is significantly greater than the number of jobs. We account for this and estimate the number of unique workers supported by the Arizona leafy greens industry cluster. The following section of the report outlines the data sources and methods used to estimate employment supported by Arizona leafy greens production. A more thorough discussion of the methods used in this section is provided in the Appendix.

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9 Research methods for the economic contribution analysis are presented in the Appendix.

On-Farm Employment

Estimating on-farm employment (farm proprietor jobs, unpaid family labor, directly hired farm labor, and agricultural support service workers) for leafy greens is particularly challenging. First, there is no one single source of data on U.S. hired farm labor. Second, there are no sources that report comprehensive data on labor employed specifically in leafy greens production. Data that are available provide incomplete estimates of on-farm labor requirements and do not separate leafy greens workers from other agricultural workers.

The USDA Census of Agriculture reports the number of hired agricultural laborers employed by vegetable and melon farms (defined as farms that receive most of their gross farm income from vegetable and melon sales). In the most recent, 2012 Census, these Arizona vegetable and melon operations accounted for 97% of the state's vegetable and melon sales. According to the 2012 Census, vegetable and melon operations hired 6,315 workers. Of these, 55% worked less than 150 days out of the year. The Census does not report the number of workers employed through custom work or via farm labor contractors, however. As such it provides an incomplete picture of on-farm labor requirements.

The Department of Labor's Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) reports monthly job and salary data paid out to directly hired workers on vegetable and melon farms (as defined by the North American Industry Classification System—NAICS 1112). Data from QCEW only include data for operations large enough to pay into the unemployment system. QCEW data for 2015 report that there were 3,486 annual average jobs in vegetable and melon farming (NAICS 1112). Subtracting out employment in potato farming (NAICS 111211), an absolute upper bound estimate for directly hired farm labor for leafy greens is 3,353. Accounting for direct hire jobs for other vegetable and melon commodities is difficult as there are no additional disaggregated data from the QCEW. The QCEW also reports on the total number of workers employed in "agricultural support activities for crop production." The largest single category here is workers employed by farm labor contractors. After subtracting out workers employed by cotton gins and post-harvest activities, the total number of agricultural support service workers in Arizona was 9,720 workers. The QCEW data, however, do not indicate how many of these support service workers are working in leafy greens production and how many are working on other crop or livestock operations.

The Department of Labor's Office of Foreign Labor Certification reports on workers employed in Arizona under the H-2A visa program for seasonal agricultural workers (U.S. Department of Labor, 2010; 2015). The H-2A nonimmigrant program provides Arizona (and other) farms with short-term agricultural labor when the number of available domestic workers is determined by the U.S. Department of Labor to be insufficient. The length of employment is usually less than 10 months. In 2015, 2,266 jobs in lettuce and spinach production were certified under the H-2A visa program for seasonal agricultural workers. For lettuce, H-2A certified positions rose from 1,676 in 2010 to 2,066 in 2015. The H-2A data illustrate the growing importance of guest workers in Arizona lettuce production.

In sum, available data sources on hired farm labor provide only incomplete estimates of on-farm labor requirements, while available data sources do not separate leafy greens workers from other agricultural workers. An additional limitation is that 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. Full-time equivalent jobs are often assumed to be 2,000 hours per year (50 weeks x 40 hours per week). 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 (Hooker et al., 2015; Martin, et al., 2017). Measuring labor in FTEs also obscures sharp monthly fluctuations in labor demands. Most hired agricultural workers are employed by a single agricultural operation for less than half the year. Yet, they may piece together multiple jobs across different seasons and locations. Moreover, when people are working, it is often more than 40 hours per week.

Proprietors

In previous work we estimated that there were 1,413 vegetable and melon farm proprietors in Arizona (Kerna et al., 2017). This estimate was based on information available from the 2012 Census of Agriculture. Census of Agriculture data reported that there were 1,413 farms with vegetable and melon sales where farming was the primary occupation of the principal operator.

To obtain an estimate for leafy greens farm proprietors, we use proprietary data from the Arizona Leafy Greens Marketing Agreement (AZ LGMA) regarding the number of unique farms that reported shipments of vegetables and melons and leafy greens products in 2015. These data suggested that approximately 70% of Arizona operations that had shipments of vegetables and melons in 2015 also had shipments of leafy greens. We therefore assume that 70% of estimated vegetable and melon proprietors are leafy greens proprietors, resulting in an estimate of 989 leafy greens proprietors.

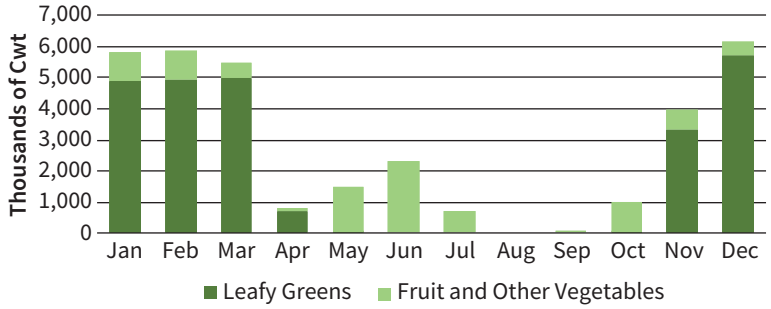
Unpaid Family Labor

Not accounted for in labor statistics, there are also unpaid family workers that contribute to on-farm production. According to the 2012 Census of Agriculture, Arizona vegetable and melon operations (NAICS 1112) employed 2,934 unpaid (family) workers. Analogous to the leafy greens proprietor estimates, we assume that 70% of unpaid labor in vegetable and melon farming was from operations producing leafy greens. This results in an estimate of 2,054 workers.

Hired Labor

To estimate on-farm labor requirements for leafy greens production we employ a "bottom up" approach. Simply put, this approach involves deriving estimates of hours of labor required per acre for on-farm leafy greens production and harvesting. These hour-per-acre estimates are then multiplied by acres harvested of individual leafy greens crops to get hour totals for each crop. Hour totals are then added together to derive a total hours required to plant, grow, and harvest the total Arizona leafy greens crop for 2015 (see Appendix). Estimates of hours of labor required per acre came primarily from University of Arizona Cooperative Extension Arizona Crop Vegetable Budget data files. Supplementary data were also used from University of California, Davis Cost and Returns Studies for vegetable crops. The crop budgets listed hours required for land preparation, planting, and pre-harvest activities. For custom operations, including harvesting, hours were not reported, but expenses for these operations were. Estimates of employee compensation for agricultural support service workers were used to convert total expenses to estimated hours of work per acre (see Appendix).

Figure 29. Monthly Leafy Greens and Other Specialty Crop Shipments from Arizona, 2015



Source: USDA, AMS Specialty Crop Movement Report, 2016.

Following this procedure, it was estimated that leafy greens production required more than 16.9 million hours of on-farm labor. These labor requirements are not distributed evenly across the calendar year. Labor requirements for leafy greens production are highly seasonal. By far, the largest expense is for harvest labor. Figure 29 shows monthly shipping data for leafy greens and other specialty crops for 2015 from USDA's Agricultural Marketing Service. The active shipping months for leafy greens are November to March, with shipments trailing off in April. In 2015, no leafy greens shipments were recorded for May through October. More than 90% of on-farm leafy greens labor hours are devoted to harvest activities, which are concentrated in the November-to-April window. This means that large amounts of seasonal labor must be recruited and deployed each year.

It is possible to convert these 16.9 million hours of work into full-time equivalent (FTE) jobs of 2,000 hours per year (40 hours per week x 50 weeks). A similar approach has been applied by Martin (2014). This translates into a total of 8,463 on-farm hired FTE jobs. If one assumes that the shares of agricultural support service FTE jobs and directly hired jobs are the same as for all vegetable and melon crops (data from Kerna et al., 2017), then 32% of these on-farm jobs are directly hired FTE jobs, while 68% are agricultural support service FTE jobs. This translates into 2,698 directly hired FTE jobs and 5,765 agricultural support service jobs.

Post-Harvest and Other Employment

In addition to supporting jobs on-farm, there are a number of jobs supported in post-harvest industries. Based on the estimate of post-harvest industry sales and IMPLAN industry output-per-worker values, there were a total of 948 full- and part-time jobs supported by Arizona-grown leafy greens production. The leafy greens industry cluster also supported an additional 1,101 full- and part-time jobs in industries supplying inputs to the cluster (indirect effects) and 4,882 full- and part-time jobs in consumer-driven industries that were stimulated via spending of wages and profits from people working within the cluster (induced effects).

Leafy Greens Employment and Unique Workers

In 2015, the leafy greens industry cluster directly and indirectly supported 18,437 Arizona full- and part-time jobs (Table 8). Jobs in agricultural support services—largely harvest workers hired via farm labor contractors—comprised the largest subset of employment. Farm proprietors and their family members also accounted for a significant share of total jobs.

The number of unique farm workers employed in leafy greens production is significantly greater than the number of jobs. 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; Martin 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 on-farm workers (both directly hired and agricultural support service workers) would be 16,926 unique workers. Making such an adjustment, the total number of workers supported by the leafy greens industry cluster is an estimated 26,900 (Table 9).

Table 8. Full- and Part-Time Jobs Supported by the Arizona Leafy Greens Industry Cluster by Job Type

Job Type	Jobs Supported
Direct	
Farm Proprietors	989
On-Farm Directly Hired*	2,698
Agricultural Support Services*	5,765
Post-Harvest	948
Unpaid Family	2,054
Jobs Supported through Multiplier Effects	
Indirect	1,101
Induced	4,882
Total Jobs	**18,437**

** Denotes full-time equivalent (FTE) jobs.*
Source: Authors' estimates.

Table 9. Estimated Number of Unique Workers Supported by the Arizona Leafy Greens Industry Cluster, 2015

Worker Type	Unique Workers
Direct	
Farm Proprietors	989
On-Farm Directly Hired	5,396
Agricultural Support Services	11,530
Post-Harvest	948
Unpaid Family	2,054
Jobs Supported through Multiplier Effects	
Indirect	1,101
Induced	4,882
Total Workers	**26,900**

Source: Authors' estimates.

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Appendix

Estimating Economic Activity Attributable to Arizona-Grown Leafy Greens

The contribution of leafy greens to the Arizona economy extends beyond on-farm production of leafy green agricultural commodities. There is a cluster of industries involved in post-harvest activities that ensure the quality and shelf life of leafy green products. These industries are involved in cooling, cutting, washing, packing, processing, storing, and shipping Arizona-grown leafy green products.

Estimating the economic contributions, or the economic activity, of industries involved in the production and distribution of leafy greens is challenging. One issue is that industries involved in these activities only have data available at an aggregated level. For example, farms that produce leafy greens are classified as the vegetable and melon farming industry by the NAICS economic industry structure and the IMPLAN modeling system (NAICS 112; IMPLAN 3). Leafy greens farming, therefore, is a subset of vegetable and melon farming and must be estimated. Additionally, all post-harvest activities for leafy greens must also be estimated. For example, post-harvest activities such as pre-cooling, cooling, and cold storage are classified as the refrigerated warehousing and storage industry (NAICS 493120). Data are only available for the warehousing and storage industry (IMPLAN 416; NAICS 493), of which refrigerated warehousing and storage industry is a sub-set. Post-harvest economic activity that can be attributable to Arizona leafy greens production is an even smaller subset of the state's refrigerated and warehousing and storage industry.

In order to estimate the economic activity of leafy greens farming, or on-farm production, we use agricultural cash receipt data[10] for Arizona's largest leafy green commodities—cabbage, spinach, and head, Romaine, and leaf lettuce. In 2014, cash receipts for leafy greens were approximately $474 million. In 2015, cash receipts increased dramatically and were approximately $779 million. This is primarily due to an increase in prices received, although the number of leafy greens cartons increased slightly from 2014 to 2015.

To estimate the economic activity in post-harvest industries attributable to Arizona-grown leafy greens, we use a variety of data sources and research methods. First, we use USDA Agricultural Marketing Service shipping point price data and carton shipment data to estimate the maximum level of sales for the Arizona leafy greens industry cluster. For Arizona's largest leafy green commodities—cabbage, spinach, and iceberg, Romaine, and leaf lettuces—we use weekly weighted average price per carton. For other leafy green commodities, we use an annual average shipping point price. These price data are combined with carton shipments, also reported by the USDA Agricultural Marketing Service's Movement Report. Together, this information is used to estimate the total value of sales of Arizona-grown leafy greens. These data help estimate industry cluster sales because shipping point price data are "f.o.b. (free on board) prices that represent open market (spot) sales by first handlers at point of production or port of entry on product of generally good quality and condition" (USDA AMS Specialty Crop Custom Average Pricing Custom Report, 2015). In Arizona, this typically refers to the shipper (first handler) selling the product to foodservice, retail, or wholesale customers. This sale price inherently includes the post-harvest costs of cooling, packing

10 Data from U.S. Department of Agriculture (USDA), Economic Research Service, U.S. and State-Level Farm Income and Wealth Statistics—Annual Cash Receipts by Commodity, U.S. and States.

and palletizing, and transportation from the field. If the product is sold at the point of production, the buyer is responsible for trucking the product to its end destination. If sold at the port of entry, however, this sale price would also include the transportation costs to get to that port. This total sales value estimated through shipping point prices therefore could potentially overstate the economic activity occurring within the state. We use these estimates as an upper bound of Arizona's leafy greens industry cluster.

We also estimate the economic activity in leafy greens post-harvest industries from a bottom up approach. Using cost and return crop farm budgets from the University of Arizona and the University of California, Davis, we estimate the economic value of post-harvest activities. In these grower/shipper crop budgets, total harvest costs represent the costs for cartons, labor, transportation to the cooler, cooling, and palletizing. Harvest costs are reported as costs per carton. These data are used in combination with carton shipment data to estimate the total harvest costs for Arizona-grown leafy greens. Labor and carton costs were removed from total harvest costs because they are captured in the farm industry's production function. The costs to the grower/shipper that are associated with transportation, cooling, and palletizing represent sales for post-harvest industries that provide those services.

Consequently, the estimated post-harvest sales in Arizona attributable to leafy greens were approximately $145 million in 2014 and $152 million in 2015. This increase in economic activity in post-harvest industries from 2014 to 2015 was due to a slight increase in the number of cartons of leafy greens produced in Arizona.

Estimating the total economic contribution of the leafy greens industry cluster, including multiplier effects, requires the use of the IMPLAN input-output model. We use the 2014 IMPLAN Version 3.1 input-output model for our simulations. However, prior to modeling, modifications were made to the baseline 2014 IMPLAN data to more accurately reflect the economic conditions and agricultural practices in Arizona.

IMPLAN Baseline Modifications

Modifications were made to the baseline IMPLAN data to better reflect state-level output, and value added: employee compensation of hired farm labor,[11] farm proprietor income,[12] and agricultural taxes on production and imports.[13] These 2014 state-level data were distributed among agricultural industries based upon the shares reported by the 2012 Census of Agriculture. Additional modifications to the IMPLAN data include revising the production functions (also known as industry spending patterns) for all agricultural industries in the state. These modifications were necessary because the default IMPLAN industry production functions are based on a national average spending pattern which may not represent farm spending patterns in Arizona. Farm expense data were obtained from the 2012 Census of Agriculture[14] and farm industry spending patterns were modified to reflect the reported shares of input expenditures.

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11 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment—Farm Income and Expenses.

12 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment—Farm Income and Expenses.

13 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.

14 Data from U.S. Department of Agriculture (USDA), 2012 Census of Agriculture, Table 68.

As expenditures for harvest are such a large portion of farm input expenses for leafy greens producers as well as many other farming industries, we conducted a more thorough examination of this input and the industry that provides this input, IMPLAN sector #19—agricultural support services. Using state-level income and employment data[15] we modified baseline IMPLAN data for sector #19. We then used data from a mathematical programming model exercise carried out by Wishon, et al., (2015)[16] to estimate the labor income for agricultural support services for each agricultural industry. The study by Wishon, et al., provides estimates of per-acre labor requirements for major crops grown in Yuma County. Using crop acreage for the whole state, per-acre labor requirements, and wage rates for agricultural laborers, we estimated the labor income paid to employees working in agricultural support services for each Arizona agricultural industry. These estimates were combined with data reflecting proprietor income, intermediate expenditures, and other property-type income to obtain estimates of agricultural support services sales to each agricultural industry.

These agricultural support services sales (consequently, the costs of agricultural support services to the producer) are used to construct a ratio of agricultural support service expenditures to total input expenditures for each agricultural sector. This ratio was applied to the original industry spending pattern derived from the 2012 Census of Agriculture and input coefficients were re-estimated for new industry farm spending patterns.

Economic Contribution Analysis of Arizona Leafy Greens

After making modifications to the baseline IMPLAN data, additional modifications were made to tease out economic activity related to Arizona-grown leafy greens from their larger industry aggregations. In order to parse out leafy greens-related economic activity, we created new sectors in IMPLAN (using industries that did not exist in the study area previously) and utilized the estimates described above.

We conducted two economic contribution analyses, one for 2014 and one for 2015. The first analysis, 2014, matches the base year of the 2014 IMPLAN model. The results of this analysis are only presented briefly in this appendix. The second analysis, 2015, was conducted because 2014 leafy greens cash receipts were 55% lower than the 6-year average and were not very representative of the industry cluster's contribution to the Arizona economy in recent years. Because economic contribution analyses provide estimates for a snapshot in time and agricultural commodities often experience inter-annual fluctuations in price and production, results can vary significantly from one year to the next. This is particularly the case for 2014 and 2015, where cash receipts for leafy greens were $474 million in 2014 and $779 million in 2015.

Starting with the 2014 analysis, we accounted for other farm-related income by adding a small margin to leafy greens cash receipts. Therefore, the total economic output (sales) for the leafy greens farming industry was an estimated $481 million. The estimated sales for post-harvest industries in 2014 was $145 million, bringing the leafy greens industry cluster direct sales to more than $626 million. When modeling for indirect and induced multiplier effects, we also accounted for the assertion that many farm labor contract

15 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Full-Time and Part-Time Wage and Salary Employment by Industry; Personal Income by Major Component and Earnings by Industry; Compensation of Employees by Industry.

16 Wishon, Villalobos, Mason, Flores, Lujan. (2015). "Use of MIP for Planning Temporary Immigrant Farm Labor Force." *International Journal of Production Economics*, 170, 25–33.

employees in the state's largest leafy greens-producing region (Yuma County) are cross-border commuters from Mexico or California. We accounted for this by reducing employee compensation in the agricultural support services industry by 25%. This is based on QCEW employment data and our calculated labor requirements for Yuma. According to QCEW data from Yuma and our calculated labor requirements for Yuma, there were an annual average of 8,904 on-farm jobs. Yet, according to 2014 American Community Survey data (U.S. Census Bureau, 2014), there were only 4,752 permanent Yuma residents employed in farming occupations. If the difference is assumed to be made up by agricultural support service workers supplied by farm labor contractors and commuting from other regions, this brings the annual average to 4,152 jobs. So, we assumed that cross-border commuters account for half of the on-farm agricultural support services workers. We also examined the typical spending pattern of a household making $10,000–$15,000 a year. According to IMPLAN, approximately half of all annual household expenditures are for housing and healthcare, both of which a cross-border commuter farm worker would not spend in Arizona. Therefore, we estimated that 25% of agricultural support service industry employee compensation is leaked out of the state to neighboring regions (50% leakage from 50% of the agricultural support service workers). The 2014 results suggested that, including indirect and induced effects, the total contribution of the leafy greens industry cluster to Arizona sales was $1.4 billion.

As stated previously, 2014 was an abnormally low year for leafy greens cash receipts, so we examined 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 leafy greens, Table 10 provides a comparison of acreage harvested and production by values of sales for Arizona's major leafy greens commodities: cabbage, spinach, and head, leaf, and Romaine lettuce. While the value of production increased significantly from 2014 to 2015, the acreage harvested of leafy greens actually decreased over the same timeframe.

Table 10. Acreage Harvested and Value of Production (in $) for Arizona's Major Leafy Green Commodities, 2014–2015

Leafy Green Commodity	Acres Harvested			Production, in 2015 $ USD		
	2014	*2015*	*Change*	*2014*	*2015*	*Change*
Cabbage	3,700	2,600	-1,100	$41,409,000	$18,837,000	-$22,572,000
Leaf Lettuce	8,100	9,300	1,200	$61,114,000	$146,475,000	$85,361,000
Head Lettuce	34,500	32,500	-2,000	$156,960,000	$253,902,000	$96,942,000
Romaine Lettuce	21,900	20,900	-1,000	$159,556,000	$304,973,000	$145,417,000
Spinach	8,000	10,300	2,300	$49,534,000	$55,255,000	$5,721,000
Total Leafy Greens	76,200	75,600	-600	$468,574,000	$779,442,000	$310,868,000

Source: USDA, NASS Quick Stats Annual Survey, 2015.

These data suggest that the change in total value of production from 2014 to 2015 was primarily attributable to an increase in prices received. Using these data as an indicator of production and market trends, we estimated the economic contribution of 2015 production as if it had occurred in the 2014 Arizona economy, accounting for the price increases at the farm gate. Beyond on-farm production, carton-level shipment data from the USDA Agricultural Marketing Service, suggest that for the same 5 commodities, the number of leafy greens cartons shipped from Arizona increased by 4% from 2014 to 2015. This small increase is reflected by minor changes in the gross sales in leafy greens post-harvest industries.

For the 2015 analysis, the original leafy greens farming industry value for 2014 ($481 million) was coupled with a farm proprietor income change to reflect an increase in prices received for leafy green commodities ($297 million). Consistent with the methodology for the 2014 analysis, we accounted for the assertion that many farm labor contract employees in the state's largest leafy greens-producing region (Yuma County) are cross-border commuters from Mexico or California. We accounted for this by reducing employee compensation in the agricultural support services industry by 25%. Finally, we modeled the leafy greens post-harvest economic activity using the $152 million estimate provided above. The 2015 results suggest that, including indirect and induced effects, the total contribution of the leafy greens industry cluster to Arizona sales was an estimated $2.0 billion.

Estimating On-Farm Employment

There is no single data source that tracks the number of workers directly engaged in on-farm leafy greens production in Arizona. The USDA Census of Agriculture reports the number of directly hired laborers, unpaid family workers, and principal operators every five years, most recently for 2012. The Census does not report the number of workers doing custom work or hired via farm labor contractors. The Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) reports the number of workers in vegetable and melon production (excluding potatoes) and the number of workers in "agricultural support activities for crop production." These workers include leafy greens harvest laborers hired via farm labor contractors. However, it also includes other workers in support jobs for other crop and livestock operations.

Estimates of the on-farm employment contribution of leafy greens production were derived in three steps. First, the total hours of on-farm labor required was estimated. Next, these labor hours were converted to full-time equivalent jobs. Finally, full-time equivalent jobs were converted to numbers of unique workers. Studies from California have found that there were an average of two unique workers employed for every full-time equivalent job (Hooker et al., 2015; Martin, et al., 2017).

Estimates of hours of labor required per acre came primarily from University of Arizona Cooperative Extension Arizona Crop Vegetable Budget data files. Unpublished, recent crop budgets were used where available. In cases where recent budgets were not available, labor requirements were derived from older budgets.[17] Supplementary data were also used from University of California, Davis Cost and Returns Studies for vegetable crops.[18] The crop budgets listed hours required for land preparation, planting, and pre-harvest

17 https://cals.arizona.edu/arec/publications/budgets

18 https://coststudies.ucdavis.edu/

activities. For custom work, including harvesting, hours were not reported, but expenses for these services were. Estimates of employee compensation for agricultural support service workers were used to convert total expenses to estimated hours of work per acre. In modified IMPLAN baseline figures described in a previous section in the Appendix, employee compensation in agricultural support services comprised 70% of total output. Custom harvesting costs include not only payments to labor (employee compensation), but also the costs of materials such as cartons and payments to farm labor contracting firms. It was assumed, therefore, that 70% of harvesting costs were payments to labor. Following Martin (2014), it was assumed that hours worked could be calculated by dividing payments to labor by the prevailing agricultural wage rate. The wage rate used for agricultural support service hours came from the USDA Farm Labor report.[19] Hired labor wage rates for field workers are reported quarterly for the Mountain III region (which includes Arizona and New Mexico). For custom planting and land preparation activities, the summer wage rate was used. For thinning and weeding the fall wage rate was used, while for custom harvest operations the winter wage rate was used. Per-acre hours required for each leafy green crop were then multiplied by the number of harvested acres to arrive at a total hour estimate of more than 16.9 million hours.

Next, these 16.9 million hours were divided by 2,000 to derive an estimate of on-farm hired full-time equivalent (FTE) jobs. Full-time equivalent jobs are often assumed to be 2,000 hours per year (50 weeks x 40 hours per week). A similar approach has been applied by Martin (2014). This translates into a total of 8,463 on-farm hired FTE labor jobs. If one assumes that the shares of agricultural support service FTE jobs and directly hired jobs are the same as for all vegetables and melons (data from Kerna et al., 2017), then 32% of these on-farm jobs are directly-hired FTE jobs, while 68% are agricultural supports service FTE jobs. This translates into 2,698 directly-hired FTE jobs and 5,765 agricultural support service jobs.

Finally, research on California agricultural labor markets found there were an average of two unique farm workers reported by farm employers for each FTE farm job (Hooker, et al., 2015; Martin et al., 2015). These studies 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. For this study, it was assumed that this two-to-one relationship also holds for Arizona—which has similar crops and production systems as California. The number of unique hired on-farm workers (both directly hired and agricultural support service workers) was estimated to be 16,926 unique workers.

19 http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do;jsessionid=F154BA78C-7C50C021C8CA924EDB72FD5?documentID=1063