The Contribution of Small Grains Production to Arizona's Economy

Dari Duval
Economic Impact Analyst

Ashley Kerna
Economic Impact Analyst

George Frisvold
Professor and Extension Specialist

Chris Avery
Graduate Research Assistant

October 2016

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Agricultural & Resource Economics

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Jeffrey C. Silvertooth, Associate Dean & Director, Extension & Economic Development, College of Agriculture Life Sciences, The University of Arizona.

Contents

List of Figures

List of Tables

Executive Summary

What Is the Issue?

Small grains, in particular wheat and barley, are an important part of Arizona's agricultural economy. Durum wheat, the most common type of wheat produced in Arizona, is grown for a wide variety of domestic and foreign customers. Small grains, especially barley, have long served as a source of feed for the state's large cattle feedlot and dairy industries as well as its hog, sheep, and poultry industries. Small grains play a critical role in maintaining soil and crop health for Arizona farms because other key agricultural crop sectors, such as those growing fresh produce and cotton, use small grains as important components of their crop rotations. Finally, Arizona mills, bakeries, food manufacturers, breweries, and distilleries also use small grains in a small, but growing local foods movement.

The contribution of small grains production to Arizona's economy goes beyond the **direct effect** of the dollar value of grain harvested from the fields. Grain production requires inputs of goods and services, many of which are supplied by local businesses. These local businesses in turn require their own production inputs. These rounds of business-to-business transactions providing inputs are known as **indirect effects**. Incomes generated in small grains production (farm profits, wages, and salaries) are also spent by households for expenses such as rent or mortgages, doctor visits, and groceries, which produce more rounds of household-to-business transactions, known as **induced effects**. Because of these **indirect** and **induced multiplier effects**, the economic contribution of small grains in Arizona is considerably greater than indicated by farm gate sales figures.

What Did the Study Find?

- In 2014, Arizona's small grains industry had direct sales (output) of $103 million. Including indirect and induced multiplier effects, the small grains industry had a total economic contribution of $206 million in sales to the state economy.
- The industry supported a total of 1,485 jobs in 2014. This included 814 jobs directly related to small grains production and an additional 671 jobs supported in other industries.
- Because agricultural production and prices are highly variable, estimates of direct effects and total agribusiness economic contributions can fluctuate significantly from year to year. In 2015, both total small grains production and prices increased to above 2014 levels. Direct sales rose from $103 million in 2014 to more than $150 million in 2015. The model used in this study (calibrated to represent Arizona's economy as of 2014) was also used to estimate the multiplier effects of the 2015 small grains crop. Accounting for multiplier effects (based on 2014 relationships), the total contribution of small grains production to Arizona's economy in 2015 was $300 million in sales (see report Addendum).
- The predominant forms of organization of Arizona small grains farms are family-based operations and partnerships. Family/individual operations and partnerships account for 71% of wheat-producing farms, while 22% of wheat-producing farms are organized as family-held corporations. Among barley-producing farms, 80% are family/individual operations or partnerships, with 13% organized as family-held corporations. Only 6 of 225 wheat-producing farms are organized as non-family held corporations, while only one out of a total of 177 barley-producing farms is organized as a non-family held corporation.

- Arizona small grains, particularly barley, are a source of feed for Arizona's animal products industries, which had more than $2.3 billion in direct sales in 2014. Maricopa and Pinal Counties rank within or near the top 1% of all U.S. counties in measures of milk and feedlot-based production. The state's feed requirements exceed state production, so producers rely heavily on feed grains shipped from the Midwest. Nevertheless, Arizona barley production fulfills several desirable features as a rotational crop and provides the state's animal products industries with an additional, local source of feed.
- Arizona small grains are used by in-state mills, food manufacturers, restaurants, breweries, and distilleries for the production of local food products. If these grains were not produced locally, some businesses producing for "local foods" niche markets would be required to significantly change their business model and product lines.
- The study also considered the economic value of changes in small grains yields or prices. Assuming acreage and prices held at 2014 levels, a 5% increase in barley yields would produce a total annual sales contribution of about $1.8 million, while a 5% increase in wheat yields would produce an annual sales gain of $7.6 million. Assuming acreage and yields held at 2014 levels, a 10% barley price increase would contribute an additional $3.4 million in sales per year to the state, while a 10% wheat price increase would contribute $14.7 million in sales per year.

How Was the Study Done?

- The economic contribution analysis was conducted using input-output analysis and the premiere modeling software for this type of analysis, IMPLAN Version 3.1. IMPLAN is a modeling system for regional economies based on national average production conditions. The model was refined based on best available recent data to more accurately reflect economic conditions and agricultural production practices in Arizona.
- The contribution of the small grains industry to the Arizona economy was modeled in IMPLAN and measured through the following metrics: sales (output), value added (GDP), labor income, jobs, and state and local taxes.
- A number of Arizona-based businesses directly source Arizona small grains for their production. These include flour mills, food manufacturers, restaurants, breweries, and distilleries. These businesses were interviewed to determine the role of locally-produced grain products in their production, branding, and marketing decisions.

Introduction

Small grains,[1] in particular wheat and barley, are an important part of Arizona's agricultural economy. Wheat, particularly durum wheat is grown for a wide variety of domestic and foreign customers. Small grains, especially barley, have long served as a source of feed for the state's large cattle feedlot and dairy industries as well as its hog, sheep, and poultry industries. Small grains play a critical role in maintaining soil and crop health for Arizona farms, because other key agricultural crop sectors, such as those growing fresh produce and cotton, use small grains as important components of their crop rotations. Finally, Arizona mills, bakeries, food manufacturers, breweries, and distilleries also use small grains in a small, but growing local foods movement.

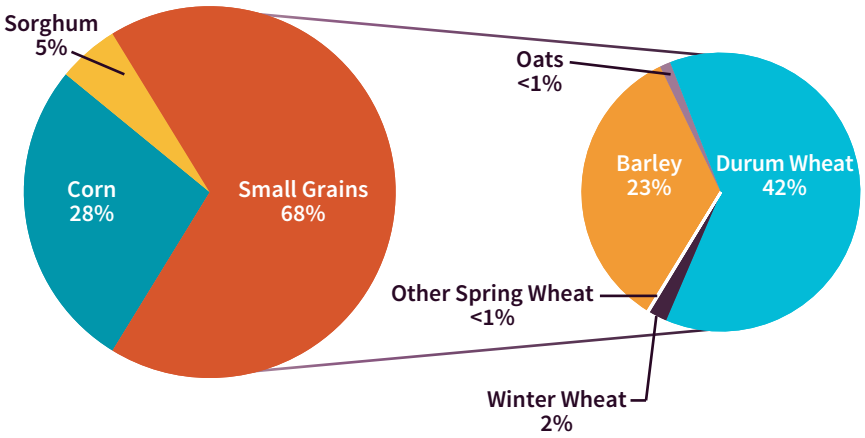
In this report we consider wheat and barley, Arizona's two main small grain crops, and the economic contribution of their supply chains and labor force to the state economy. A profile of the small grains industry is presented to understand the structure and composition of the industry, and recent trends in production. In addition, downstream businesses that use Arizona small grains in producing food and beverages were interviewed to understand how their businesses depend on Arizona small grains production. Finally, in order to understand how small changes in yield and price affect the state economy, economic impact analyses of a 5% increase in yield and a 10% increase in price were performed for both wheat and barley.

1 According to the USDA Small Grains 2015 Summary, small grains includes oats, barley, wheat, and rye (USDA, 2015).

Arizona Small Grains Production

Arizona has a long tradition of producing small grains. Cultivation of wheat and barley in Arizona first started in the 17th century through their introduction by Spanish missionaries (Ottman, 2001). In particular, White Sonora wheat was well suited to the arid climate given its resistance to drought and quickly became a staple of diets in what are now Southern Arizona and Sonora, Mexico (Native Seeds/SEARCH, 2016). Today, small grains production is an important part of Arizona's agricultural economy. With some of the highest yields in the nation, Arizona ranked 6th nationally in 2014 in terms of the value of production for barley and 29th for wheat. In terms of quantity of production, Arizona ranked 3rd nationally in 2014 for production of durum wheat, a market class of wheat utilized around the world for pasta making.

Figure 1. Arizona Grain Production by Commodity (Percentage of Bushels), 2012



** Percentages calculated based upon bushels of production.*
*** Excludes production of commodities for silage or greenchop.*
Source: 2012 Census of Agriculture, Arizona Table 37: Specified Crops by Acres Harvested.

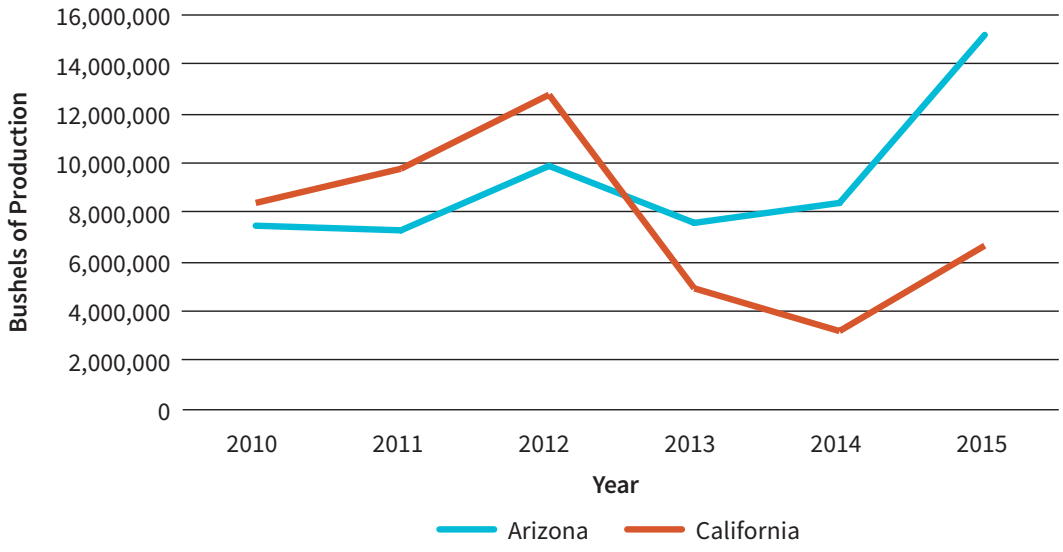
Of all grain kinds produced in Arizona in 2012, small grains accounted for nearly 68% of total bushels of production (Figure 1). Arizona's production of small grains is primarily limited to wheat and barley (Figure 1). In 2012, production of oats accounted for less than one percent of grain production. More recent data (2014) indicate that no oats were produced in Arizona in 2014. Therefore, the focus of this analysis will be on Arizona's wheat and barley production. Wheat represented the majority of small grains production. Wheat classes produced include durum wheat and common wheat. Of total wheat produced in 2012, durum wheat represented almost all of the state's production.

Top states for durum wheat production in 2014 were North Dakota (52%), Montana (25%), Arizona (16%), California (6%), Idaho (1%), and South Dakota (<1%) (USDA, 2015). Arizona and California crops represented just over 21% of national production of all durum wheat in 2014. Figure 2 presents recent trends in spring durum wheat production in Arizona and California, the two states that produce Desert Durum®.

Arizona's wheat producers specialize in growing durum wheat grain now widely known as "desert durum," a description that has been awarded a certification mark protection by the U.S. Patent and Trademark Office (California Wheat Commission & Arizona Grain Research and Promotion Council, 2014). Consequently, only durum wheat grain produced under irrigation in the desert valleys and lowlands of Arizona and California may be called "Desert Durum®" and grain of this origin must constitute at least 90% of any quantity described as Desert Durum®. The joint owners of the mark are the Arizona Grain Research and Promotion Council and the California Wheat Commission. These entities license commercial entities to identify grain as Desert Durum® only if it meets those production conditions. The intrinsic

2 Allan Simons, personal communication.

Figure 2. Durum Spring Wheat Production for California and Arizona (Bushels), 2010–2015



Source: USDA NASS Quickstats Database.

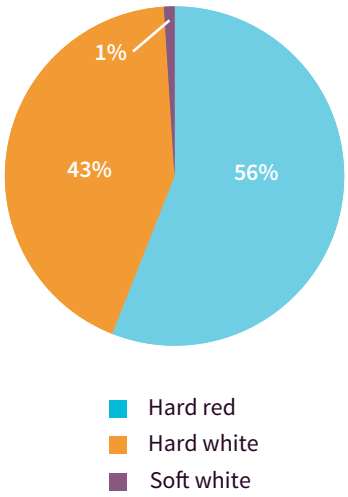
grain and semolina flour qualities of Desert Durum® render it attractive to millers because of its low moisture content and high extraction rates and to pasta makers as an "improver" semolina flour with strong gluten for blending with variable-quality semolina of other origins to make a consistent pasta product. Approximately half of the annual Desert Durum® grain crop has been exported in recent years, with Italy as a prime destination.[2] Durum production volume in the desert southwest varies with competitive market conditions as influenced by much larger durum crops in Canada and the northern United States.

The durum and barley varieties grown in Arizona are largely developed by Arizona-based private plant breeding firms and are specifically adapted to the local growing conditions. The varieties usually receive the intellectual property protection that is available in the U.S. Plant Variety Protection Act, in which unauthorized production and sale of protected-variety seed is an infringement of the act. Significant portions of the annual durum crop are pre-contracted with major handlers and most of the volume is grown, harvested, and stored separately by variety in a process known as "identity preservation." Foreign buyers may specify their variety of choice as well as their preferred shipping schedule. The majority of the barley crop is sold to Arizona-based dairies and feedlots.

In addition to durum wheat, Arizona also produces several varieties of common wheat, officially classified in USDA production statistics as "winter wheat." In 2014, 700,000 bushels of winter wheat were produced in Arizona. That same year, Arizona's production of winter wheat was split almost evenly between hard red wheat and hard white wheat. However, there was a small portion of soft white wheat produced (Figure 3).

Some of Arizona's soft white wheat is purchased by customers in New York who use the wheat for production of matzo for Passover in Orthodox bakeries (Santos, 2013). Another portion of Arizona's soft white wheat is White Sonora wheat, a heritage grain gaining popularity within the local foods movement (Machelor, 2015).

Figure 3. Arizona Winter Wheat Production Distribution by Class, 2014



Source: USDA, NASS: Small Grains 2015 Summary.

Table 1. Ranking of Cash Receipts for Arizona Agricultural Products Sold, 2014

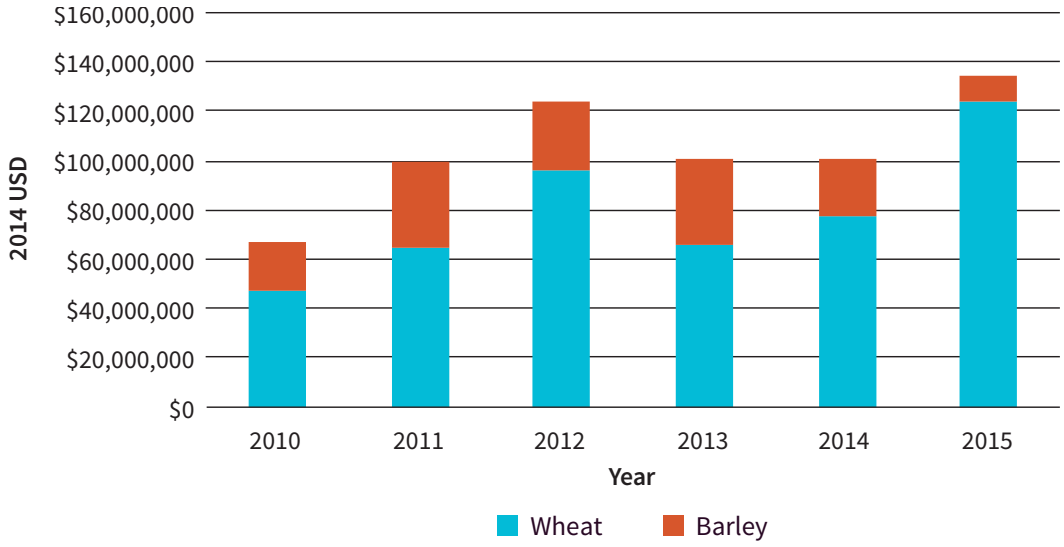
		State Cash Receipts	Share of Cash Receipts
Rank	*Commodity*	*$1,000*	*Percentage*
1	Cattle and Calves	1,165,143	25.9
2	Dairy Products, Milk	1,087,152	24.2
3	Miscellaneous Crops	525,929	11.7
4	Lettuce	377,183	8.4
5	Hay	288,076	6.4
6	Cotton Lint, Upland	196,815	4.4
7	Lemons	136,914	3.0
8	Cantaloupes	93,312	2.1
9	**Wheat**	**77,811**	**1.7**
…	…	…	…
21	**Barley**	**22,704**	**0.5**

Source: ERS, USDA, 2014. Cash receipts by state, commodity ranking and share of U.S. total, 2014.

In 2014, cash receipts for Arizona's two small grains crops totaled roughly $100 million, with wheat constituting approximately four-fifths of cash receipts and barley the remaining one-fifth. Among Arizona agricultural products sold in 2014, wheat ranked 9th for cash receipts with nearly $78 million in sales. Barley ranked 21st with roughly $23 million in sales (Table 1).

Small grains cash receipts for the 2010–2015 period were highest in 2015, surpassing 2012 levels after two years of lower cash receipts in 2013 and 2014 (Figure 4).

Figure 4. Arizona Small Grains Cash Receipts, 2010–2015



Source: USDA, ERS, Farm Income and Wealth Statistics. BLS, 2016.

Structure of the Arizona Small Grains Industry

Arizona's small grains industry consists of on-farm production, including growing, harvest, and storage, both on and off farm. In addition to primary production, other downstream industries are involved in getting raw products from producers to customers (Figure 5). Grain handlers are involved in storage, marketing and wholesale of small grains. Arizona small grains, particularly barley, supply feed for the state's animal products industries. Major sources of demand are feedlot and dairy operations, but small grains feed also supplies hog and poultry production. There is also a growing interest by Arizona-based manufacturers of food and beverage products and restaurants in developing small grains products to supply small but growing "local food" market niches. The following section examines these three components of the small grain value chain in depth.

Growers

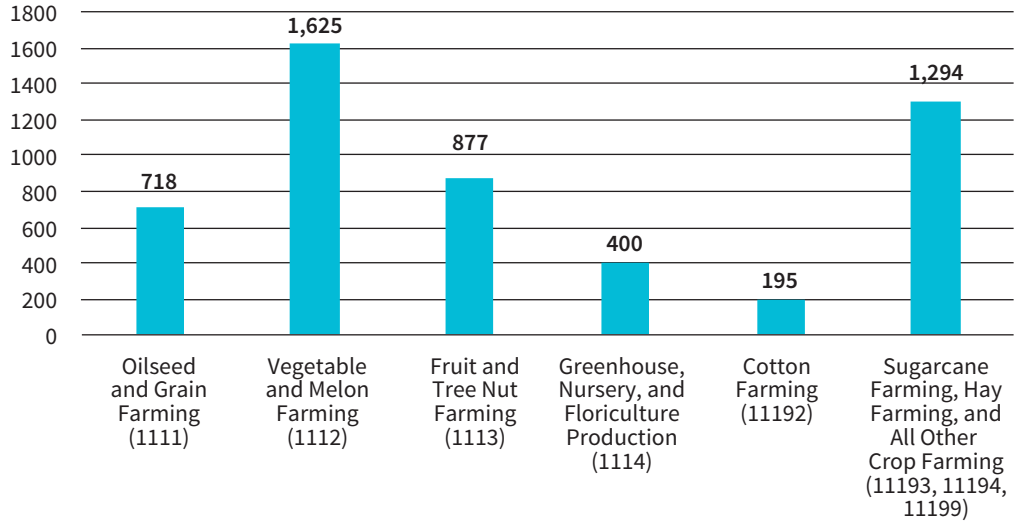
Number of Operations

According to the 2012 Census of Agriculture, there were a total of 2,015 farms with sales of grains, oilseeds, dry beans, and dry peas in Arizona. Focusing only on small grains, there were 225 farms that had sales of wheat and 177 farms that had sales of barley.

In Arizona, small grains are produced by a wide variety of farms, including farms specializing in grains and oilseed production, farms specializing in vegetable and melon production that use grains as a rotational crop, and other farms that specialize in the production of cotton, hay, and other field crops. Specialization is defined as having sales of 50% or greater of a particular commodity. According to the 2012 Census of Agriculture, there were 718 farms in Arizona specialized in the cultivation of oilseeds and grains, of which small grains would be a subset (Figure 6).

Figure 5. Arizona Small Grains Industry Value Chain

Figure 6. Number of Arizona Agricultural Operations by Specialization (as defined by the North American Industry Classification System [NAICS]), 2012



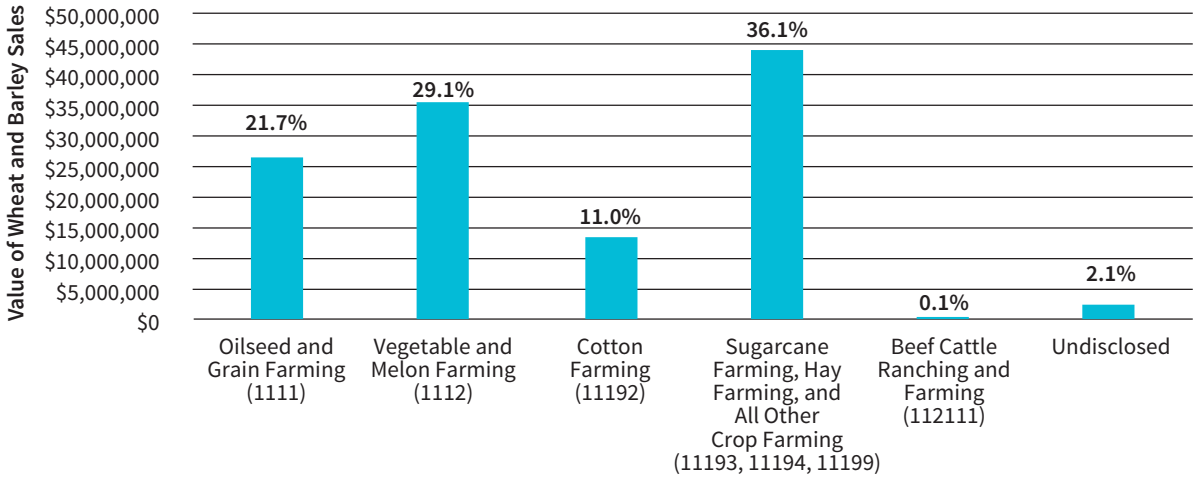
Source: USDA, 2012 Census of Agriculture: Arizona State and County Data: Table 68. (Numbers in parentheses are NAICS Codes).

Sizes and Types of Operations

Sales

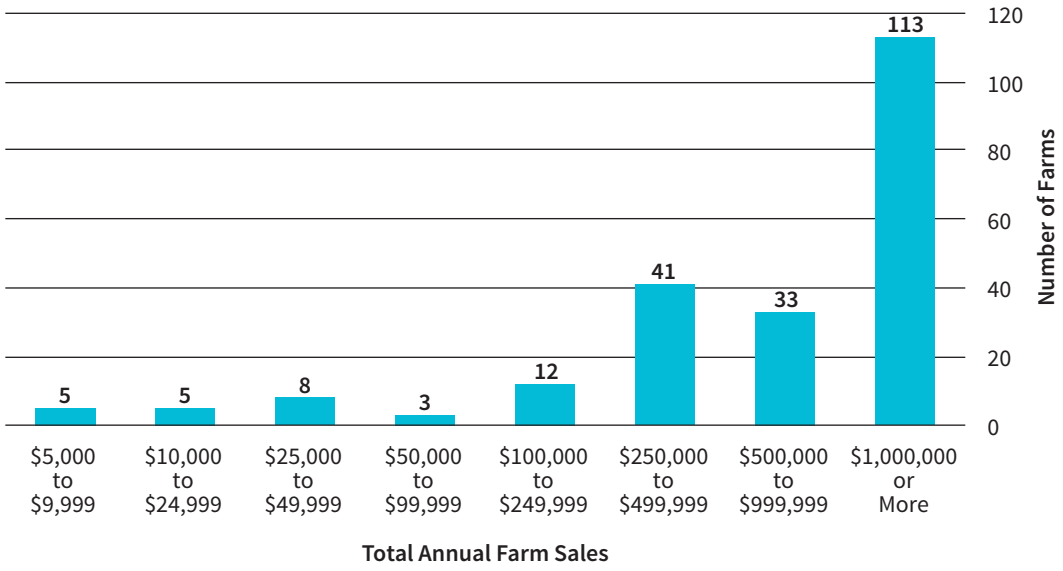
Farms specializing in oilseed and grain production only accounted for a portion of Arizona small grains sales in 2012 (roughly 22% of combined wheat and barley sales) (Figure 7). In fact, farms specializing in vegetable and melon farming and farms of all other crop specializations (including cotton and hay) represented a larger portion of small grains sales, with their small grains sales representing 29.1% and 47.1% of sales, respectively. This is a result of using small grains in crop rotations. This statistic underlines the diversity of farms producing small grains in Arizona.

Figure 7. Sales of Small Grains (Wheat and Barley) by Farm Specialization (as defined by NAICS), 2012



Source: USDA, 2012 Census of Agriculture: Arizona State and County Data: Table 68. (Numbers in parentheses are NAICS Codes).

Figure 8. Arizona Farms with Sales of Wheat by Market Value of All Agricultural Sales, 2012

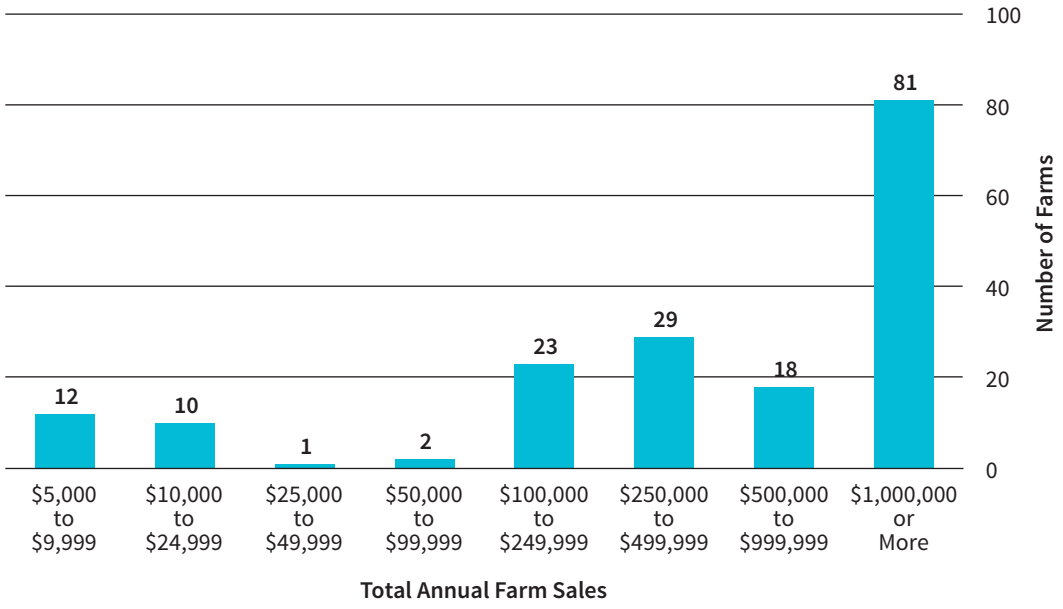


Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 65.

In Arizona, farms that produce small grains tend to be relatively large, with a majority of farms having more than $1,000,000 in total annual sales for all commodities combined. Farms producing wheat with total annual sales over $1,000,000 (for all commodities) account for 85% of sales of wheat-producing farms and 50% of farms by number (Figure 8). This once again reflects the common practice among large vegetable and melon farms of using small grains as rotational crops.

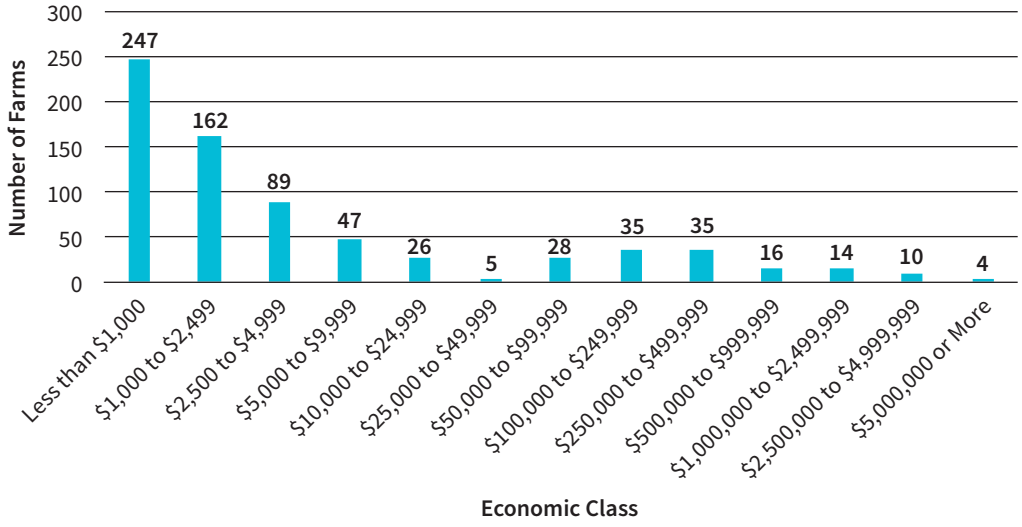
Farms producing barley with total annual sales over $1,000,000 (from all commodities) account for 72% of sales of barley-producing farms and 46% of farms by number (Figure 9).

Figure 9. Arizona Farms with Sales of Barley by Market Value of All Agricultural Sales, 2012



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

Figure 10. Arizona Farms Specializing in Grains Production by Economic Class, 2012



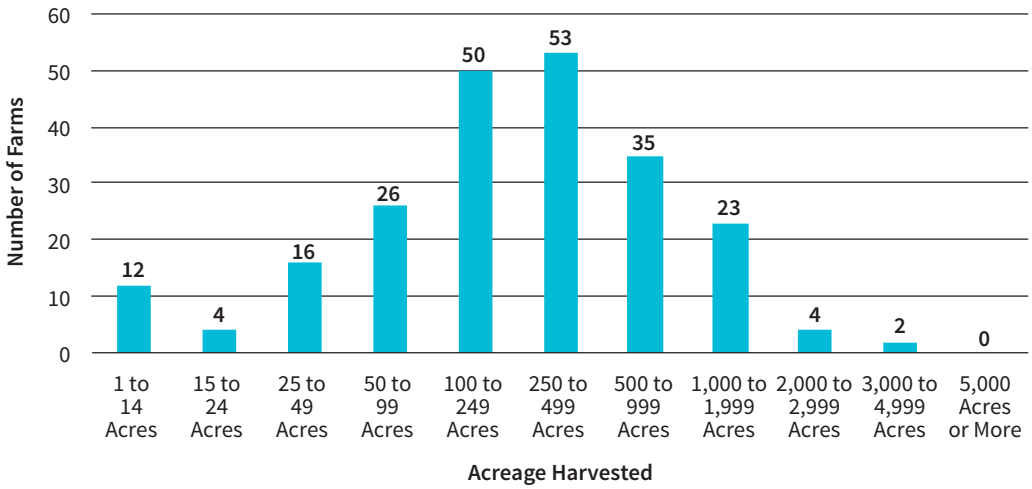
Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 68.

This, however, is not reflective of farms ***specialized*** in grains production. In fact, of the 718 farms specialized in grains production (small grains and all other grains), most farms are small, with nearly 70% of farms having less than $5,000 in annual sales (Figure 10). Many of these farms are operated by Native Americans. More than 62% of all grain farms are located in Apache and Navajo counties, where more than 93% of farms have Native American operators (USDA, 2012 Census of Agriculture, Volume 1, Chapter 2: County Level Data).

Acreage

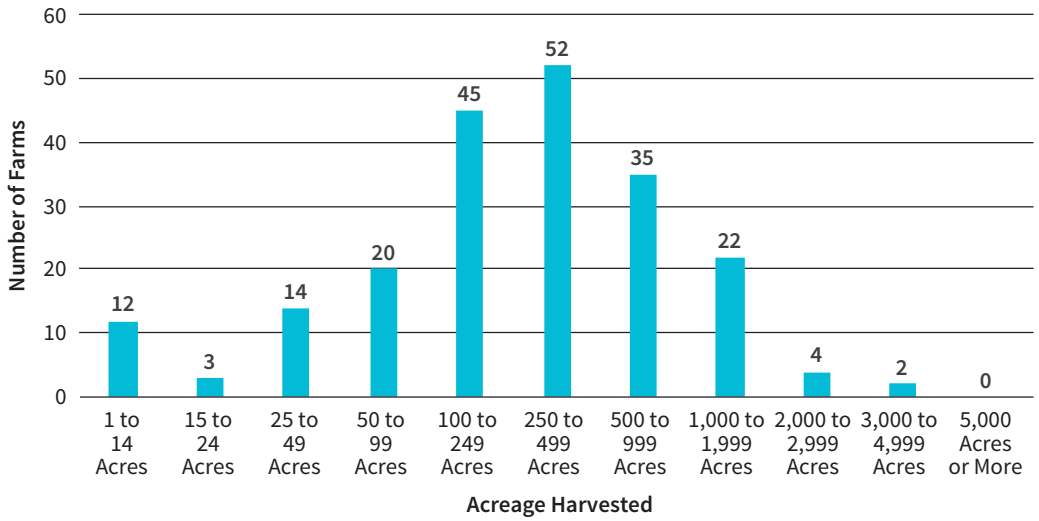
In terms of acreage, 75% of Arizona wheat-producing farms harvest more than 100 acres of wheat, though only 13% harvest more than 1,000 acres. Just under half of farms producing wheat (46%) harvest between 100 and 500 acres (Figure 11).

Figure 11. Arizona Farms with Sales of All Wheat Varieties by Wheat Acreage Harvested, 2012



Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 37.

Figure 12. Arizona Farms with Sales of Durum Wheat by Durum Wheat Acreage Harvested, 2012

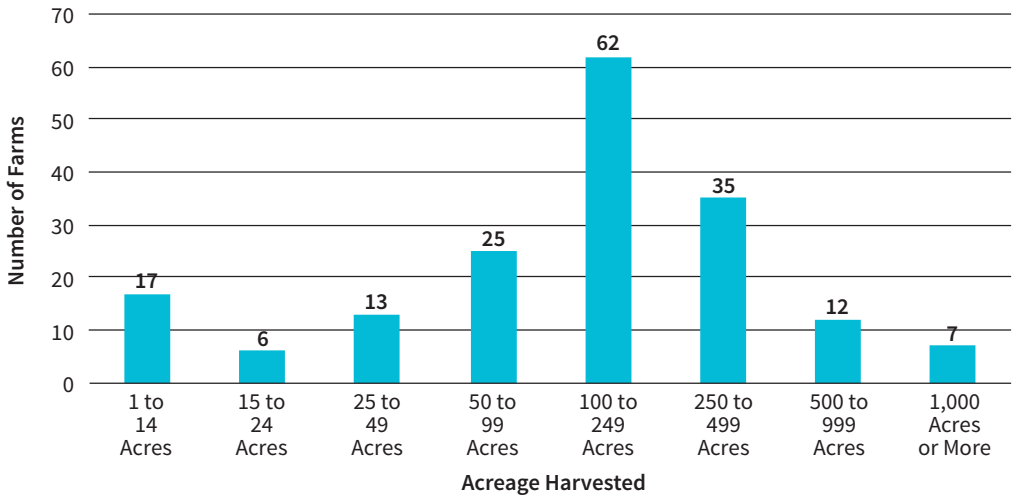


Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 37.

For durum wheat, a large subset of all wheat produced in Arizona, the same pattern holds with 46% of farms having harvested between 100 and 500 acres of durum wheat (Figure 12).

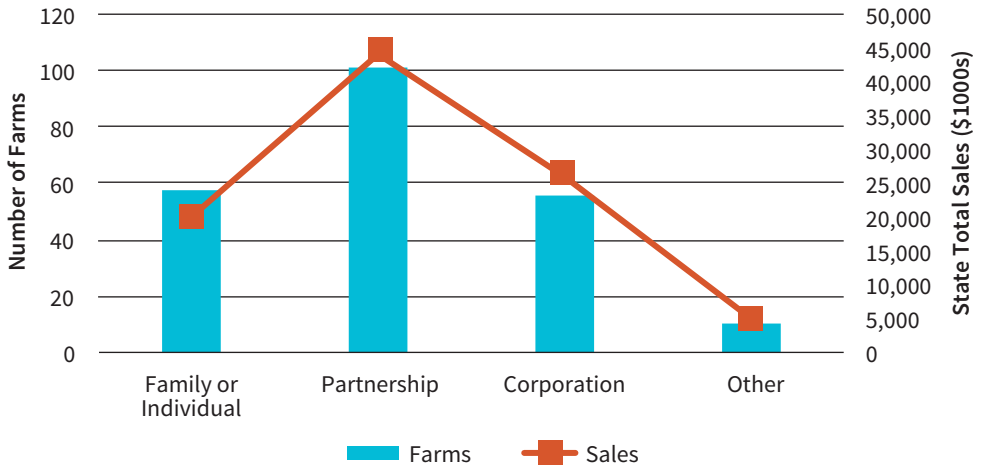
Nearly 70% of all barley-producing farms harvest between 50 and 499 acres of barley, with 35% harvesting between 100 and 249 acres (Figure 13).

Figure 13. Arizona Farms with Sales of Barley by Barley Acreage Harvested, 2012



Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 37.

Figure 14. Arizona Wheat-Producing Farms and Sales by Legal Status for Tax Purposes, 2012



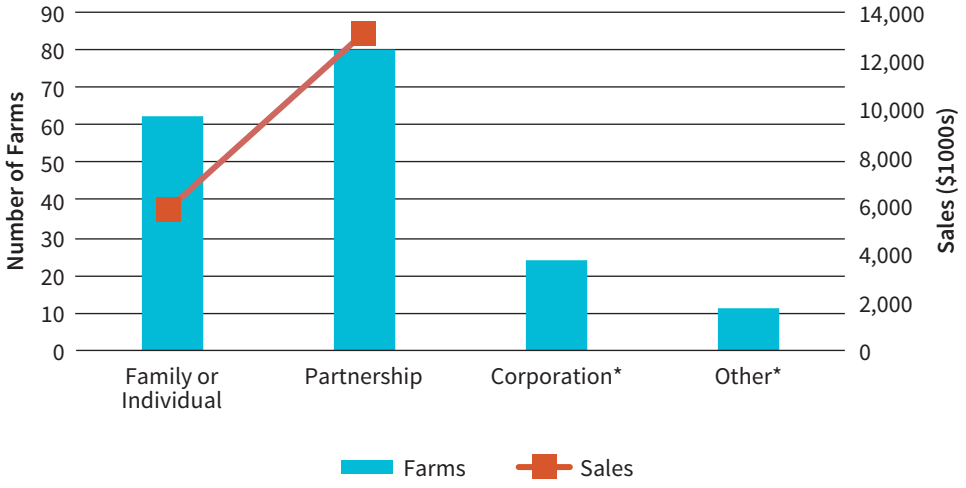
Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 67.

Farm Business Type

The most common business type for Arizona farms with sales of wheat is a partnership, followed by family or individual business, and then corporations. Partnerships represented 47% of wheat sales in 2012, family or individual businesses 21%, corporations 27%, and all other business types 5% (Figure 14). Of wheat-producing farms in Arizona organized as corporations, 50 of 56 are family-held corporations. Of those 50 family-held corporations, 45 have ten or fewer stockholders. There are 6 wheat-producing farms organized as corporations that are not family held, of which 4 have ten or fewer stockholders.

Similarly, Arizona farms that produce barley are dominated by partnerships, followed by family or individual businesses, which represented 48% and 22% of sales in 2012, respectively (Figure 15). There were 24 farms organized as corporations, and 11 farms with other business types. Sales of barley from

Figure 15. Arizona Barley-Producing Farms and Sales by Legal Status for Tax Purposes, 2012



** Sales of corporations and other farm types not disclosed*
Source: USDA, 2012 Census of Agriculture: Arizona State Data: Table 67

family or individual farms totaled $6 million for 2012, while sales totaled $13 million for partnerships. Farm sales for all other barley-producing farms (corporations and other) were suppressed for farm confidentiality; however, they totaled $7.9 million when combined. Of Arizona farms producing barley organized as corporations, 23 out of 24 were family-held corporations, and all had 10 or fewer stockholders.

Geography

Small grains production in Arizona is clustered in central and southwestern Arizona. Figures 16 and 17 present the number of wheat and barley-producing farms in Arizona by county with counties with a higher number of farms in darker shades. In 2012, Yuma County produced 48.5% of the state's wheat with 85 farms, Pinal County produced 20.8% with 59 farms, and Maricopa County produced 17.1% with 44 farms. These counties represented 37.8%, 26.2%, and 19.6% of wheat-producing farms, respectively.

In 2012, 82 farms in Pinal County produced 49.0% of the state's barley and 60 farms in Maricopa County produced 33.8%. These counties represented 46.3% and 33.9% of barley-producing farms, respectively.

County Rankings for 2012

USDA's 2012 Census of Agriculture data provides rankings of counties by acreage. Yuma County ranks in the top 9% of all U.S. counties with durum wheat acreage and in the top 10% for all wheat acreage (Table 2). Pinal County ranks in the top 3% of all U.S. counties with barley acreage. In terms of wheat acreage, Maricopa County is in the top 20% for durum and all wheat acreage, while La Paz County is in the top 30% in both categories. Even urbanized Pima County is in the top 44% of acreage among all U.S. wheat-growing counties.

Table 2. Rankings of Arizona Counties in Small Grains Acreage among All U.S. Counties That Produce the Grain

County	Durum Wheat	All Wheat	Barley
La Paz	Top 26%	Top 28%	—*
Maricopa	Top 18%	Top 19%	—
Pima	—	Top 44%	—
Pinal	—	—	Top 3%
Yuma	Top 9%	Top 10%	—

** — ranking not reported by USDA*

Figure 16. Number of Wheat Farms by County, 2012

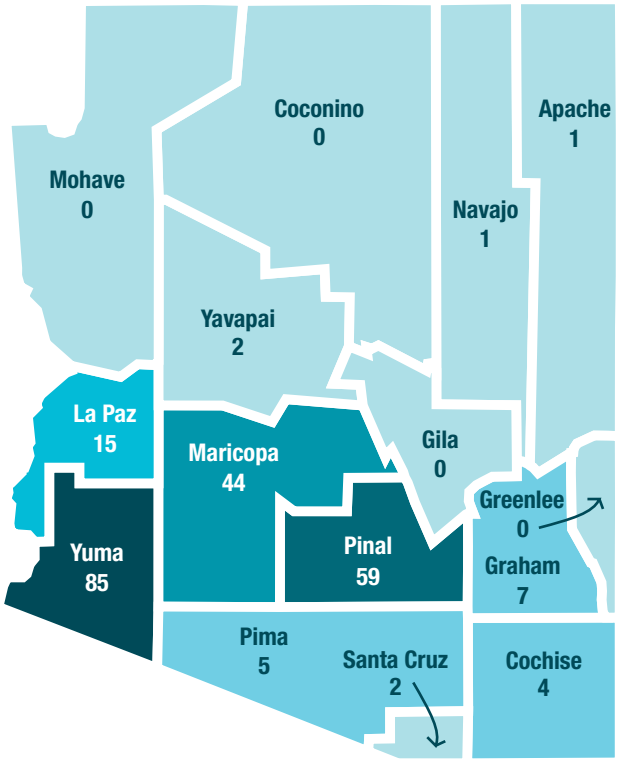
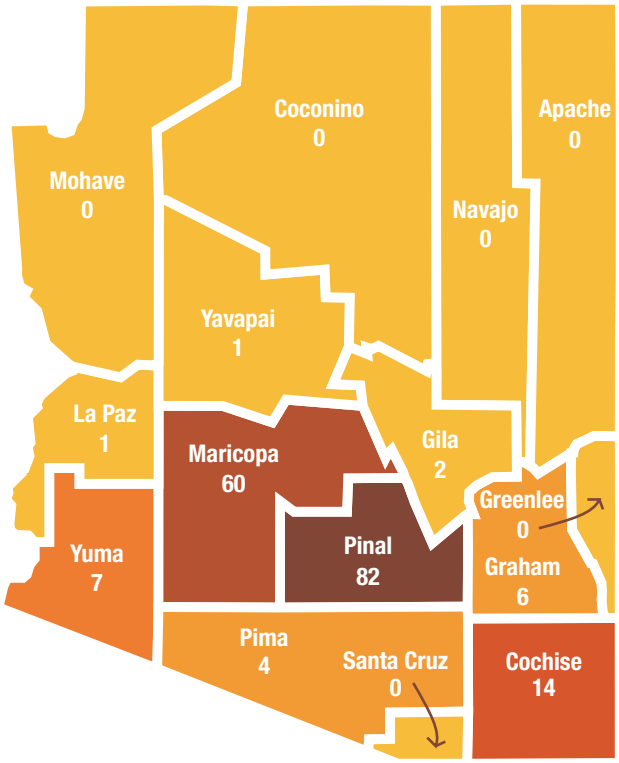


Figure 17. Number of Barley Farms by County, 2012



Grain Handlers

Grain handling operations "receive, handle, store, process and ship raw agricultural commodities" (OSHA, 2016). According to the USDA, there were 22 off-farm grain storage facilities in Arizona with 20,000,000 bushels of capacity in 2014 (NASS, 2014). According to the Quarterly Census of Employment and Wages, there were 8 farm product warehousing and storage establishments[3] in Arizona in 2014, with 72 employees receiving $3,308,362 in annual wages (BLS, 2014). Major grain handling firms in Arizona include Arizona Grain, Inc., Barkley Seed, Inc., and Dunn Grain, Inc. (Costantino, 2015). These largest operations are located in the counties with highest levels of production.

Small Grains for Livestock Feed

The vast bulk of Arizona's barley production goes to supplying feed for the state's animal production industries. To provide context for the discussion of small grains used for animal feeding, we present some statistics regarding livestock production in Arizona.

Animal production represents a significant portion of the state's agricultural economy, regularly accounting for 40% to 55% of the state's total agricultural sales. In 2014, sales of animal products exceeded $2.3 billion. The Central Arizona dairy industry supplies a population of more than 5.5 million people in the Phoenix and Tucson metro areas. The state also has a number of large cattle feedlots and ranks 11th among states in the number of cattle on feed. Animal production is concentrated in Central Arizona, with Maricopa and Pinal counties ranking within or near the top 1% of all U.S. counties in three major production indicators: (1) dollar value of milk sales, (2) dollar value of sales of livestock, poultry and their products, and (3) inventories of cattle on feed (Table 3).

Table 3. Rankings of Maricopa and Pinal Counties in Animal Production Indicators among All U.S. Counties Producing Items or Holding Inventories, 2012

Item	Maricopa County	Pinal County
Value of Livestock, Poultry, and Their Products	Top 1.1%	Top 0.9%
Milk Sales	Top 0.5%	Top 0.8%
Cattle and Calves Inventories	Top 1.4%	Top 0.5%

Source: USDA, 2012 Census of Agriculture.

Despite the economic importance of dairy and cattle production in Central Arizona, Arizona overall is a feed-deficit state. Arizona's production of feed grains (barley, corn, oats, and sorghum) relative to its head of cattle on feed is much lower than the national average (Table 4). While in the United States the average production of feed grains per head of cattle on feed is $4,286, Arizona only produces $212 per head. In terms of physical quantities, the United States produces 1,144 bushels of feed grains per head, while Arizona produces just 10 bushels per head. The United States averages 10.1 tons of corn and sorghum silage per head, while Arizona averages 6.8 tons per head. Arizona's dairies and other animal feeding operations rely on corn from the Midwest as a major source of feed grains, but Arizona-produced feed barley is an important supplement to this supply source.

Table 4. Feed Grain Production per Head of Cattle on Feed, Arizona and U.S. Average Compared, 2014

Item	U.S. Average	Arizona
Feed Grain Production ($ of sales)/Head	$4,286	$212
Corn, Barley, Oats, and Sorghum (Bushels)/Head	1,144	10
Corn and Sorghum Silage (Tons)/Head	10.1	6.8

Source: USDA, NASS and Arizona NASS Field Office.

One benefit of barley's use as a feed grain is that compared to other feed grains produced in Arizona, barley is relatively less water-intensive (USDA, FRIS). Irrigation applications for corn for grain averaged 3 acre-feet of water per acre, 4.1 acre-feet per acre for corn silage, and 3.3 acre-feet per acre for sorghum. In contrast, irrigation applications for Arizona barley only averaged 2.8 acre-feet per acre. This is for 2013, the most recent year of USDA'S Farm and Ranch Irrigation Survey. Irrigation applications for Arizona alfalfa that year averaged 5.4 acre-feet per acre. There is at least one documented case of an

3 Farm product warehousing and storage establishments are classified under NAICS code 493130.

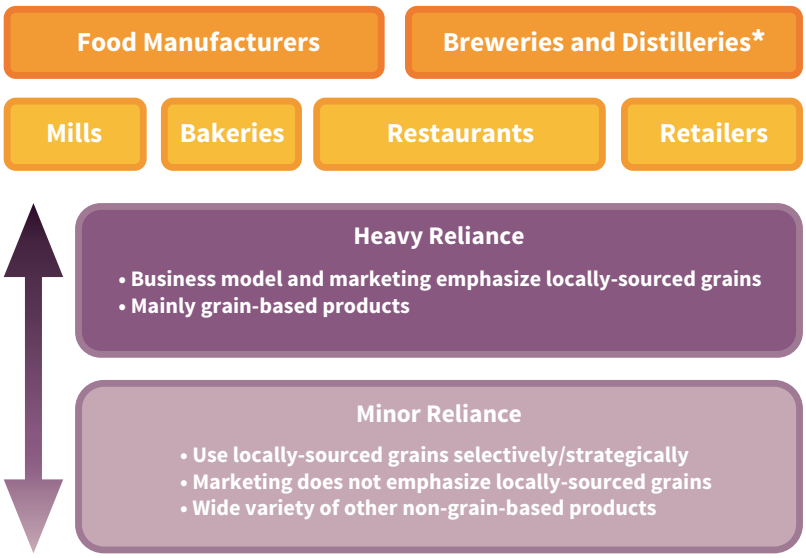
Arizona grower substituting barley for alfalfa in their production systems in the face of water constraints (Murphree, 2015).

Small Grains for Local Food and Beverage Processors, Manufacturers, and Restaurants

In recent years, there has been impressive growth in the demand for local foods, as evidenced by increases in direct-to-consumer marketing and sales, increases in the prevalence of farmers markets, and rising numbers of community-supported agriculture operations, among other indicators (Martinez, et al, 2010). The local foods movement, however, is not limited to direct-to-consumer sales of fresh produce, but also includes locally sourced inputs for use by food and beverage manufacturers and restaurants. It is also characterized by an increasing interest in the revival of heritage crop varieties. A number of Arizona businesses use Arizona-grown small grains and heritage grains to produce foods and beverages around the state. Such businesses include milling operations, food product manufacturers, restaurants, bakeries, distilleries, and breweries. For this study, a sample of Arizona businesses that rely on locally sourced small grains was interviewed to understand the importance of Arizona small grains to their establishments and gauge how they would respond were those grains to become unavailable.

Based upon interviews and communications with these businesses, there was a spectrum of reliance on Arizona small grains (Figure 18). Some companies have built their business models entirely around the use of locally-grown or Arizona-grown small grains, catering to customers interested in locally-sourced food. These businesses stated that in the absence of Arizona small grains, their businesses would cease to operate in their current form and would have to be completely repositioned and reimagined while sourcing their grains from out of state. Other businesses reported partial to minor reliance on Arizona small grains, using locally-sourced grains where feasible or practical, and stated that in the absence of locally-sourced grains, they would substitute grains from out of state. Consistent among responses was the high likelihood of sourcing grains from out of state, should that be necessary. However, the level to which that disrupts business varied considerably.

Figure 18. Arizona Small Grain-Reliant Businesses



★ Barley malting and the production of barley varieties for malting are both very limited in Arizona.

Contribution of Small Grains Industry to the Arizona Economy

Economic Contribution Analysis

The contribution of small grains production to Arizona's economy goes beyond the grain harvested from the fields, known as **direct effects**. Production of those grains requires inputs of goods and services, including machinery, fertilizers, water, and labor. Many of those goods and services are supplied by local businesses and in turn require their own inputs to produce. That portion of inputs procured from within the state produces additional rounds of transactions by those supplier companies to purchase inputs of goods and services, some of which also come from in-state. Each additional round of transactions eventually dissipates as money leaks out of the state economy. These rounds of business-to-business transactions of providing inputs to production are known as **indirect effects**. Another critical component of economic activity supported by the small grains industry is the set of effects resulting from salaries and wages paid to people employed by the small grains industry. When these employees spend their paychecks on household expenses such as rent or mortgages, visits to the doctor, or groceries, that produces more rounds of household-to-business transactions, known as **induced effects**. The total economic contribution of an industry is the sum of these three types of effects. (For a detailed explanation of the methods used to calculate the total economic contribution, please see the Data Sources and Research Methods section of the Appendix).

Table 5. Small Grains Economic Contribution Summary, 2014

Impact Type	Employment	Sales (Output)
Direct Effect	814	$103,396,000
Indirect Effect	381	$64,336,400
Induced Effect	290	$38,677,600
Total Effect	1,485	$206,410,100

The direct effect of Arizona small grains on the state economy in terms of sales (output) was $103 million in 2014.[4] These direct sales are measured as the sum of cash receipts for wheat and barley in 2014 (totaling $100,515,000), plus a margin accounting for other farm-related income based upon state averages. That direct economic activity, in turn, supported an additional $103 million in sales through indirect and induced multiplier effects, for a total estimated economic contribution of $206 million in sales (Table 5). The small grains industry directly supported an estimated 814 jobs[5] in 2014. Through indirect and induced multiplier effects, 381 and 290 jobs were supported, respectively, in other industries throughout the state, for a total of 1,485 jobs supported (Table 5).

Sales is an intuitive way to measure and understand economic activity; however, it double counts the value of goods and services sold as they move through the value chain in business-to-business transactions. For example, the cost of a loaf of bread to the consumer includes the cost of processed inputs (flour), which, when purchased by a bakery, includes the cost of raw inputs (wheat) purchased from a farm or grain handler. In such a case, two sales transactions would be captured in the total sales, and the cost of the raw wheat would be included twice. For that reason, we can use **value added** to measure the value created by an industry over and above the cost of inputs, similar to gross domestic product (GDP). Value added includes labor income, other property type income, profits, and taxes. Labor income can further be broken down into wages, salaries, and benefits paid to hired employees, as well as income to proprietors who own

4 This economic contribution analysis only includes the small grains industry and its supply chain and does not incorporate forward-linked industries such as grain handlers or food and beverage manufacturers.
5 Job numbers include hired workers and farm proprietors and are calculated based upon output per employee for an 8-county region of Southern California (a region with similar agricultural production practices) per Vergati & Sumner (2012). For a full explanation of the jobs calculation, please see the Employment section of the Appendix.

businesses. Figure 19 demonstrates the relationship between sales, value added, and labor income.

Arizona small grains production directly supported an estimated $29.5 million in value added in 2014, $23 million of which was labor income, $5.6 million of which was other property type income and profits, and just under $1 million of which was federal, state, and local taxes on production and imports (Table 6). When considering indirect and induced multiplier effects, the small grains industry's total contribution to the state economy totaled $85.3 million in value added, $53.4 million in labor income, $25.5 million in other property type income and profits, and more than $6 million in taxes on production and imports.

Of the $23 million in labor income directly supported by small grains production, an estimated $16 million was income of farm proprietors, and the remaining $7 million was wages, salaries, and benefits of employees. Including indirect and induced effects, a total of $53.4 million in labor income was generated, $32.8 million in employee compensation, and $20.7 million in proprietor income.

Figure 19. Relationship between Components of Economic Output (Sales)

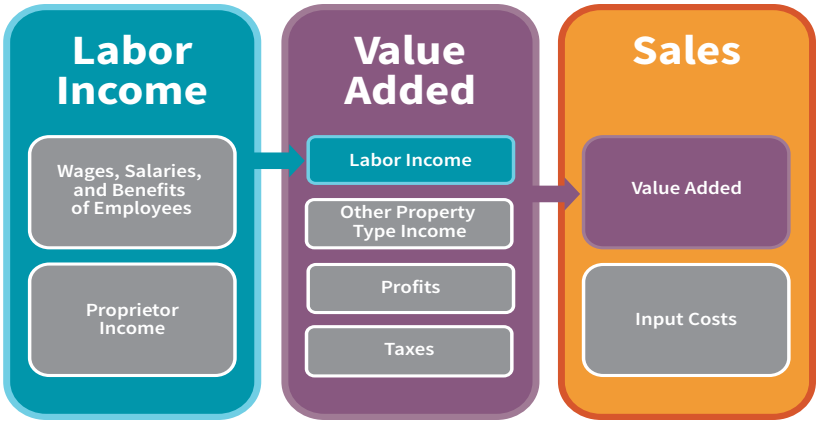


Table 6. Value Added Contribution of Small Grains by Component of Value Added

Impact Type	Labor Income	Other Property Type Income	Taxes on Production & Imports	Total Value Added
Direct Effect	$23,014,600	$5,559,800	$963,700	$29,538,200
Indirect Effect	$17,722,700	$12,756,500	$3,341,600	$33,820,800
Induced Effect	$12,714,500	$7,170,600	$2,082,700	$21,967,800
Total Effect	$53,451,800	$25,486,900	$6,388,100	$85,326,900

Direct, indirect, and induced effects occur across a variety of industries beyond the small grains industry. Indirect effects most heavily affect industries that support small grains production, such as support activities for agriculture and forestry, as well as real estate which captures farm spending on agricultural land leases and other similar expenses. Induced effects most heavily affect industries that supply goods and services to households, or as seen in Table 7, basic household expenses such as mortgage (owner-occupied dwellings) or rent (real estate).

Table 7. Top 10 Industries Affected by Small Grains Production (Sales and Employment Increases)

Industry Affected	Employment	Sales
Small Grains	814	$103,396,000
Real Estate	91	$13,430,200
Electric Power Transmission and Distribution	5	$6,860,600
Wholesale Trade	29	$6,858,300
Retail—Building Material and Garden Equipment And Supplies Stores	68	$6,389,400
Owner-Occupied Dwellings	0	$4,480,400
Insurance Carriers	9	$3,843,700
Other Local Government Enterprises	13	$3,756,100
Monetary Authorities and Depository Credit Intermediation	12	$2,383,600
Local Government Electric Utilities	3	$2,223,900

Economic Impacts of Changes in Yield and Price

The economic contribution of Arizona's small grains industry from one year to the next depends upon the intersection of a variety of factors, including acres planted, acres harvested, yields, grain quality, and prices received. In this section, the impacts of small changes in yield and price are modeled. Increases in yield are modeled as an increase in industry production, requiring additional inputs and labor. Increases in price are modeled simply as an increase in farm operator income without any changes to production. Both types of changes are modeled for both wheat and barley, and both assume acreage harvested is held constant. All yields, production values, acreage harvested, and prices received are based upon 2014 USDA data.

Estimated Gains to Arizona Economy from a 5% Increase in Yield

Arizona's average wheat yield was 110.1 bushels per acre in 2014. An increase of 5% in yield would produce a yield of 115.6 bushels per acre. Assuming constant acreage harvested of 83,000 acres (2014), total yield would be 9,595,215 bushels, an increase of 456,915 bushels. At an average price received of $8.36 per bushel for the 2014 marketing year (NASS, 2014), that would equate to $3,819,809 in additional production. That additional production would support 30 direct jobs earning $850,000 in labor income. Including the indirect and induced effects of the increase in yield, the total economic impact of a 5% increase in wheat yield would be roughly $7.6 million in sales, nearly $2 million in labor income, roughly 55 jobs, and more than $3 million in value added (Table 8).

Arizona's average barley yield was 125.0 bushels per acre in 2014. An increase of 5% in yield would produce a yield of 131.25 bushels per acre. Assuming constant acreage harvested of 32,000 acres (2014), total yield would be 4,200,000 bushels, an increase of 200,000 bushels. At an average price received of $4.44 per bushel for the 2014 marketing year (NASS, 2014), that would equate to $888,000 in additional production. The total economic impact of that additional production would be approximately $1.8 million in sales, 13 jobs, nearly $500,000 in labor income, and $733,000 in value added (Table 9).

Estimated Gains to Arizona Economy from a 10% Increase in Price

In the case of a price increase, there is no indirect effect because the price increase was assumed to occur without increasing inputs to production, and indirect effects are created through business-to-business spending on inputs. In this case, the economic impact occurs as a result of an increase in farm operator income, which only produces induced effects. Given an average price received of $8.36 per bushel of wheat for the 2014 marketing year, a 10% increase in price would equate to an increases of 83.6 cents per bushel. With $75,600,000 in value of production of wheat for 2014, that amount would increase by $7,560,000 given a 10% increase in price. A $7.6 million increase in farm operator income would produce an additional $7.1 million in sales through induced effects, for a total impact of $14.7 million in sales (Table 10).

Given an average price received of $4.44 per bushel of barley for the 2014 marketing year, a 10% increase in price would equate to 44.4 cent per bushel increase in price. With $17,760,000 in value of production of barley for 2014, that amount would increase by $1,776,000 given a 10% increase in price. That $1.8 million increase in farm operator income supports and additional $1.7 million in sales through induced effects, for a total economic impact of $3.4 million in sales (Table 11).

Table 8. Economic Impact of 5% Increase in Wheat Yield

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	30	$850,200	$1,091,200	$3,819,800
Indirect Effect	14	$654,700	$1,249,500	$2,376,800
Induced Effect	11	$469,700	$811,600	$1,428,900
Total Effect	55	$1,974,700	$3,152,300	$7,625,500

Table 9. Economic Impact of 5% Increase in Barley Yield

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	7	$197,700	$253,700	$888,000
Indirect Effect	3	$152,200	$290,500	$552,500
Induced Effect	3	$109,200	$188,700	$332,200
Total Effect	13	$459,100	$732,800	$1,772,700

Table 10. Economic Impact of 10% Increase in Wheat Price

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	0	$7,560,000	$7,560,000	$7,560,000
Indirect Effect	0	$0	$0	$0
Induced Effect	54	$2,341,000	$4,043,700	$7,116,200
Total Effect	54	$9,901,000	$11,603,700	$14,676,200

Table 11. Economic Impact of 10% Increase in Barley Price

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	0	$1,776,000	$1,776,000	$1,776,000
Indirect Effect	0	$0	$0	$0
Induced Effect	13	$549,900	$949,900	$1,671,700
Total Effect	13	$2,325,900	$2,725,900	$3,447,700

Conclusions and Discussion

Arizona's small grains industry contributes to the state economy not only through sales of agricultural products, but also through economic activity supported by its supply chains and employees. Wheat, particularly durum wheat, is grown for a wide variety of domestic and foreign customers. Small grains, especially barley, have long served as a source of feed for the state's large cattle feedlot and dairy industries, as well as its hog, sheep, and poultry industries. Additionally, Arizona businesses use small grains to produce local foods sold directly to consumers. The industry is characterized by high yields, growers with diverse crop specializations, and niche customers both domestically and abroad. **Arizona's small grains industry had a total estimated economic contribution to the state economy of $206 million in sales in 2014, including direct, indirect, and induced effects. In total, 1,485 jobs were supported, with labor income of $54 million, and a contribution of $85 million to value added.**

Because agricultural production and prices are highly variable, estimates of direct effects and total agribusiness economic contributions can fluctuate significantly from year to year. In 2015, both total small grains production and prices increased to above 2014 levels. Direct sales rose from $103 million in 2014 to more than $150 million in 2015. The model used in this study (calibrated to represent Arizona's economy as of 2014) was also used to estimate the multiplier effects of the 2015 small grains crop. Accounting for multiplier effects (based on 2014 relationships), the **estimated total contribution of small grains production to Arizona's economy in 2015 was approximately $300 million in sales, roughly 1,990 jobs, $98 million in labor income, and a contribution of $142 million to value added.**

References

BLS (2014). Quarterly Census of Employment and Wages. Bureau of Labor Statistics. Accessed at http://data.bls.gov/cew/apps/data_views/data_views.htm#tab=Tables

BLS (2016). CPI Inflation Calculator. Bureau of Labor Statistics. Accessed at http://www.bls.gov/data/inflation_calculator.htm

California Wheat Commission & Arizona Grain Research and Promotion Council. (2014). 2014 Desert Durum Crop Quality Report. Arizona Grain Research & Promotion Council and California Wheat Commission. Accessed at http://www.uswheat.org/cropQuality/doc/B909A739533CF48D85257D93006CD089/$File/desertDurum2014.pdf?OpenElement

Costantino, Christopher (2015). Durum Wheat: Arizona's Gem of the Southwest. Edible Phoenix, Winter 2015.

ERS (2014). Farm Income and Wealth Statistics. Cash receipts by commodity 2010–2016. United States Department of Agriculture. Accessed at http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics/data-files-us-and-state-level-farm-income-and-wealth-statistics.aspx

Machelor, Patty (2015). Organic white Sonora wheat makes comeback in area. Arizona Daily Star, March 21, 2015.

Martinez, Steve, et al (2010). Local Food Systems: Concepts, Impacts, and Issues. United States Department of Agriculture, Economic Research Service, Report Number 97, May 2010. Accessed at http://www.ers.usda.gov/media/122868/err97_1_.pdf

Murphree. J. (2015). Meet Arizona Agriculture's Harold Payne and Fort McDowell Farms. The Voice. Arizona Farm Bureau. http://info.azfb.org/blog/meet-arizona-agricultures-harold-payne-and-fort-mcdowell-farms

NASS (2014). National Agricultural Statistics Service. Quick Stats. Accessed at https://quickstats.nass.usda.gov/

Native Seeds/SEARCH (2016). White Sonora Wheat. Accessed at http://nativeseeds.org/learn/seed-diaries/363-white-sonora-wheat

OSHA (2016). Grain Handling. Occupational Safety and Health Administration. Accessed at https://www.osha.gov/SLTC/grainhandling/

Ottman, Mike (2001). Historical Cropping Patterns in Arizona. University of Arizona Cooperative Extension. Accessed at https://cals.arizona.edu/crop/counties/yuma/farmnotes/fn0502crophistory.html

Santos, Fernanda (2013). Arizona Is Fertile Ground for New York Matzo. The New York Times, June 28, 2013.

United States Department of Agriculture (USDA) (2014) Farm and Ranch Irrigation Survey. http://agcensus.usda.gov/Publications/2012/Online_Resources/Farm_and_Ranch_Irrigation_Survey/ Various years.

USDA (2015). Small Grains 2015 Summary, September 2015. Accessed at http://usda.mannlib.cornell.edu/usda/current/SmalGraiSu/SmalGraiSu-09-30-2015.pdf

United States Department of Agriculture (USDA) (2012) Census of Agriculture. State Level Data. http://agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/ Various years.

Vergati, Jessica & Daniel Sumner (2012). Contributions of Agriculture to Employment and the Economy in Southern California. University of California Agricultural Issues Center. Accessed at http://aic.ucdavis.edu/publications/socal.pdf.

Appendix

Data Sources and Research Methods

The economic contribution of the small grains industry was estimated using the 2014 IMPLAN Version 3.1 input-output model. The IMPLAN model captures the linkages between economic sectors in a particular region and is used to understand how specific industries or economic events affect the regional economy overall. While IMPLAN has data built into the model, modifications were made to the IMPLAN data to more accurately capture the economic contribution of the small grains industry.

First, modifications were made to the baseline IMPLAN data for Arizona's agricultural sectors in an effort to more accurately represent the economic conditions and agricultural practices in Arizona. Modifications included changes to state-level output and value added, which includes employee compensation of hired farm labor,[6] farm proprietor income,[7] and taxes on agricultural production and imports.[8] 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 the grain farming industry and all other agricultural industries. These modifications are necessary because the default IMPLAN industry production functions are based on a national average spending patterns, which may not represent grain farming spending patterns in Arizona. For example, Arizona differs from the national average in that nearly all grain farming in Arizona is irrigated. Farm expense data were obtained from the 2012 Census of Agriculture and the oilseed and grain farming industry spending pattern was modified to reflect the reported shares of input expenditures.

When conducting the economic contribution analysis, the model was customized to ensure that state-level economic output was not overstated and that there was no double counting. We utilize IMPLAN's industry contribution analysis procedure applied to a new sector we created in IMPLAN (using an industry that does not exist in the study area) that refers only to small grains production.

Employment

Estimating the number of jobs supported directly by the small grains industry is challenging because employment data are aggregated by industry at a level slightly less detailed than needed to segment small grains from other grains employment. Furthermore, employment data only reflect employment at establishments specializing in grains production. According to the Bureau of Labor Statistics, 95 individuals were employed in wheat farming (NAICS 11114) at 13 establishments in Arizona, earning annual wages of $3,127,256 in 2014. Seventy-three (73) individuals were employed in all other grain farming (NAICS 11119), which includes barley, earning wages of $2,833,000 annually (QCEW, 2014). In total there were 207 jobs in oilseeds and grain farming in Arizona in 2014 (QCEW, 2014). Using those data and shares of grains production by commodity, an estimated 139 direct jobs could be attributed to small grains production at establishments specializing in grain

6 Data from Department of Commerce, Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment: Farm Income and Expenses.
7 Bureau of Economic Analysis (BEA), Annual State Personal Income and Employment: Farm Income and Expenses.
8 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.

production. This estimate, however, does not account for production of small grains by other types of farms. As mentioned previously, most of the state's small grains production occurs on farms that specialize in other crops such as vegetables, melons and alfalfa hay. Using data on value of production of small grains and a regional estimate of output per job for grains and oilseeds farming (Vergati & Sumner, 2012), an estimate of 814 direct jobs was obtained for the industry and is used for this economic contribution analysis. The jobs estimate provided in Vergati and Sumner's analysis is generated using IMPLAN's 2010 dataset for the eight southern California counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, Santa Barbara and Ventura. IMPLAN's jobs estimates account for both hired workers as well as proprietors.

Addendum: Annual Changes in Price and Production

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

Table 12. 2014 & 2015 Small Grains Price and Production Levels by Commodity

	Wheat		Barley	
	2014	*2015*	*2014*	*2015*
Acres Harvested	83,000	142,000	32,000	16,000
Acres Planted	85,000	150,000	36,000	17,000
Production, in $	$75,600,000	$131,928,000	$17,760,000	$8,064,000
Production, Bu	9,136,000	14,346,000	4,000,000	1,920,000
Yield, Bu/Acre	110.1	101	125	120
Price Received, $/Bu*	$8.36	$9.14	$4.44	$4.15

* *Prices measured by marketing year, not calendar year.*

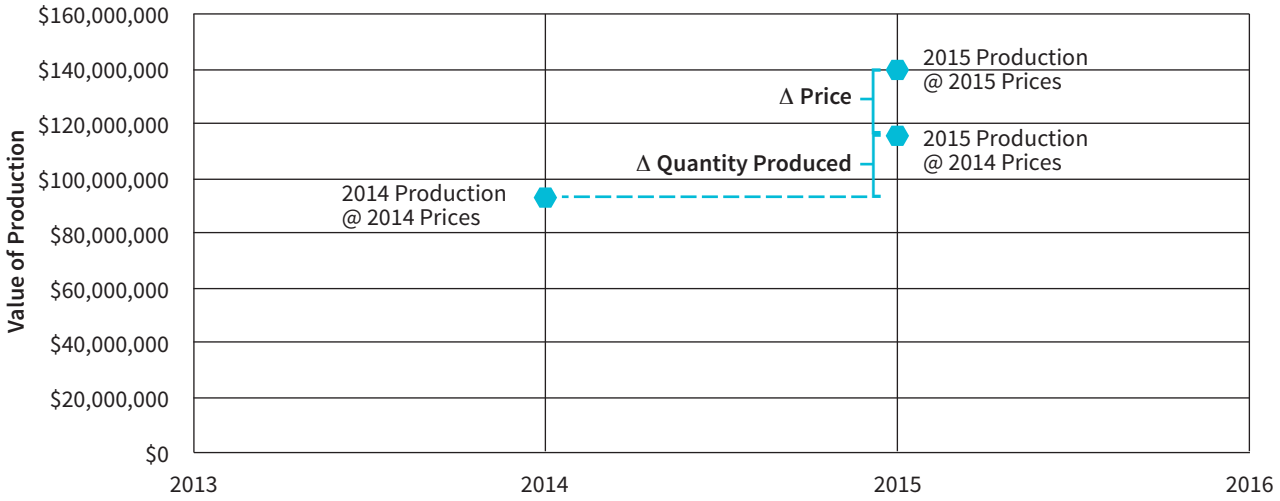
Table 12 provides a comparison of acres harvested, planted, production, yield, and price received for wheat and barley between 2014 and 2015.

Combining bushels of production for wheat and barley and calculating an annual (calendar year) weighted average price based upon bushels of production, aggregated small grains value of production figures were calculated for 2014 and 2015. The change in value of production between 2014 and 2015 can be broken down by the change attributable to increased production versus increased price received (Table 13).

Table 13. Contribution of Production and Price Changes to Change in Small Grains Value of Production from 2014 to 2015

Component of Change	Magnitude of Change
Change in Quantity of Production	$22,245,493
Change in Price Received	$24,386,507

Figure 20. Components of Change in Value of Production of Arizona Small Grains from 2014 to 2015



These changes can be visualized on a graph by plotting 2015 production at 2014 prices and 2015 production at 2015 prices (Figure 20). These two vertical distances represent the magnitude of change in value of production attributable to either price or production changes.

Using this information on direct effects we can estimate the impact of these changes in sales by jointly modeling an industry production change (increase in quantity produced) and a farm proprietor income change (change in price received), adjusted to include a small margin for other farm-related income, in addition to the 2014 economic contribution. In total, including a margin to account for other farm-related income, there was an estimated $47 million in additional direct sales in 2015 compared to 2014.

Examining 2015 production of small grains as a whole, total cash receipts for small grains and other farm related income generated a total of $151 million in direct sales. If that level of sales were to occur in the 2014 Arizona economy, the total economic contribution would be $300 million in sales, 1,991 total jobs supported, $98 million in labor income, and $142 million in value added for the state economy (Table 14).

Table 14. Economic Contribution of 2015 Small Grains Production Based on 2014 Baseline Model Simulations

Impact Type	Employment	Labor Income	Value Added	Sales
Direct Effect	994	$53,193,600	$60,462,000	$150,665,600
Indirect Effect	465	$21,645,000	$41,305,900	$78,575,000
Induced Effect	532	$23,296,200	$40,247,300	$70,850,200
Total Effect	1,991	$98,134,700	$142,015,200	$300,091,000