Arizona's Tree Nut Industry and Its Contributions to the State Economy

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Executive Summary

What Is the Issue?

Arizona's tree nut industry has experienced rapid growth in recent years. Arizona ranks among the top four states in its production of pecans and is one of only three states with commercial production of pistachios. Pecan and pistachio production in Arizona, combined, ranks within the state's top ten agricultural commodities by cash receipts and state cash receipts for tree nuts are poised to increase in coming years. Tree nut production contributes to local communities, supporting economic activity and jobs in businesses both directly and indirectly linked to tree nut production. Meanwhile, challenges exist around sustainable withdrawal of water resources by a growing industry in groundwater-dependent areas, balancing the livelihoods of rural residents employed in agriculture and agriculture-linked industries with the availability and affordability of groundwater supplies relied upon by residents, agricultural users, and the environment. This report presents an analysis of the tree nut industry's contribution to Arizona's economy, including multiplier effects, as well as an overview of the industry, its trends, and water use for tree nut production in Arizona.

What Did the Study Find?

Arizona's tree nut industry directly generated an estimated $92.6 million in sales in 2017.

- Arizona's tree nut industry derives income though cash receipts from on-farm production (sales), farm-related activities, and shelling and hulling of tree nuts.
- Cash receipts for pecans totaled $70 million in 2017, and estimated cash receipts for pistachios totaled $8.4 million.
- Arizona tree nut growers generated estimated additional sales of $1.4 million through other farm-related activities such as agritourism and sales of agricultural byproducts.
- The industry generated an estimated $12.8 million in sales through tree nut processing, including shelling and hulling.

The economic contribution of the expanding tree nut industry in Arizona goes beyond the industry's cash receipts.

- Because growers are investing in new, non-bearing acreage, grower expenditures on orchard establishment and maintenance stimulate additional economic activity within the state not reflected in cash receipts for tree nut commodities sold.
- In 2017, 38% of the state's total tree nut acreage was non-bearing, 36% for pecans and 44% for pistachios. While this acreage does not generate revenues for producers, it does incur expenses, some of which are fulfilled through local businesses and labor force.

The tree nut industry's total economic contribution was an estimated $113 million in gross state product and $190 million in sales in 2017.

- Total industry production expenses in 2017 were an estimated $94.5 million, including costs for bearing and non-bearing acreage. Meanwhile, cash receipts for commodities sold totaled an estimated $78.4 million, reflecting the high level of new investment by producers in non-bearing acreage.

In total, the industry supported an estimated 1,436 jobs, including on-farm jobs, farm proprietors, and jobs in industries supported through indirect and induced linkages.

- Total labor income supported, including employee compensation and business owner income, was $73 million.

In 2017, 343 Arizona farms produced tree nuts, 267 of which produced pecans and 69 of which produced pistachios. Tree nut acreage totaled 35,261 acres in 2017, 21,724 acres of which were bearing and 13,537 acres were non-bearing. This includes non-commercially produced almonds and walnuts.

- Between 2013 and 2019, total pecan acreage has nearly doubled, from around 17,000 acres statewide to over 30,000 acres.
- Small-scale producers account for most Arizona pecan farms, but just a few producers account for a large majority of acreage and production. In Arizona in 2017, farms with 100 acres or more (the top 9% of pecan farms by acreage) held nearly 94% of pecan acreage in the state.

The total irrigation water use of the tree nut industry in Arizona was an estimated 118,145 acre-feet (AF) in 2017. This figure is expected to rise in coming years as non-bearing acreage matures and enters into production, requiring more inrrigation.

- Unlike annual field crops which can be fallowed in times of drought or limited irrigation water availability, orchards represent years of investment and cannot simply be fallowed from one year to the next.
- Much of the state's tree nut acreage is in groundwater-dependent areas of the state. As bearing acreage continues to expand, balancing the water needs of a growing industry with water supply sustainability for nearby communities and agricultural producers alike will continue to be an important issue in these areas.
- Compared with other crops in Arizona, average per-acre irrigation water application requirements for tree nuts rank just below the average of 4.4 AF applied per acre for irrigated cropland statewide (NASS, 2014).
- Gross revenues per acre-foot of water applied for pecans and pistachios are roughly equal to or higher than major field crops in the state, when considering both bearing and non-bearing acreage. Considering only bearing acreage, gross revenues per acre-foot of water applied exceed $1,000 per acre-foot for pecans and $800 per acre-foot for pistachios in 2017. Gross revenues per acre-foot applied for major field crops in the state ranged between $200 and $400, on average, in 2017.

How Was the Study Conducted?

This study relies on secondary data from the 2017 USDA Census of Agriculture, USDA National Agricultural Statistics Service (NASS), USDA Economic Research Service (ERS), Bureau of Labor Statistics, and Arizona Department of Agriculture. Economic multiplier effects were estimated using the 2017 IMPLAN 3.1 input-output model for Arizona.

Introduction

Arizona ranks among the top four states in its production of pecans and is one of only three states with commercial production of pistachios. Pecan and pistachio production in Arizona, combined, ranks within the state's top ten agricultural commodities by cash receipts (USDA ERS, 2019) and state cash receipts for tree nuts are poised to increase in coming years. Arizona's commercial tree nut industry has existed for many decades. However, the last decade has been characterized by rapid expansion of acreage, particularly in rural areas of the state. Both ongoing tree nut production by mature orchards and investment in new tree nut acreage contribute to local communities and the state economy. Meanwhile, challenges exist around sustainable withdrawal of water resources by a growing industry in groundwater-dependent areas, balancing the livelihoods of rural residents employed in agriculture and agriculture-linked industries with the availability and affordability of groundwater supplies relied upon by residents, agricultural users, and the environment.

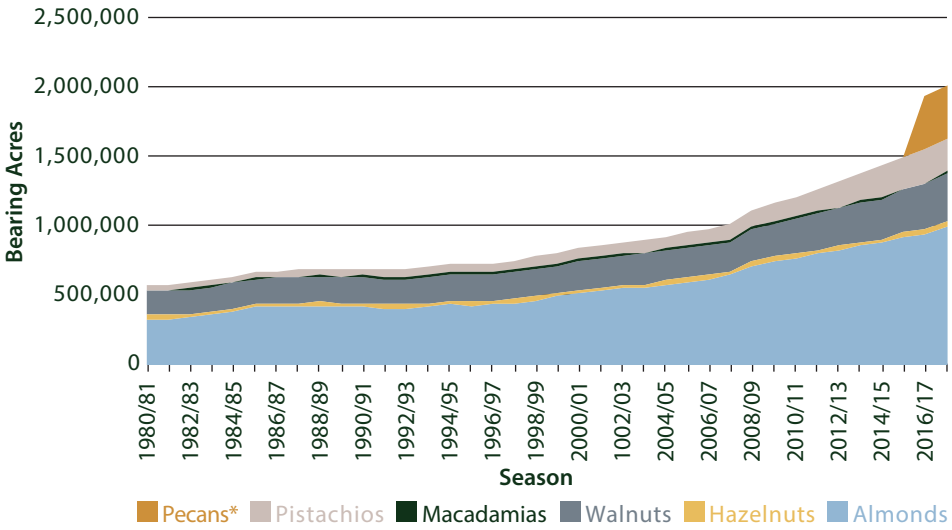
This report presents an analysis of the tree nut industry's economic contribution to Arizona's economy, focusing on those tree nut commodities that Arizona produces commercially in measurable quantities: pecans and pistachios. It provides a general overview of the tree nut industry at the national level, again with a focus on pecans and pistachios, followed by an overview of tree nut production in Arizona and an estimate of the industry's total contribution to the state economy in 2017, including multiplier effects. Last, we provide an estimate of statewide irrigation water use for tree nut production to contextualize discussions around implications of the industry's growth on water use sustainability.

Background and Industry Overview

Tree nuts are a category of nuts commercially grown and harvested from orchards, which includes almonds, Brazil nuts, cashews, macadamia, pecans, pine nuts, pistachios, and walnuts, among other less common types of nuts (FDA, 2016). The most commonly produced tree nuts in the U.S. are almonds, walnuts, pistachios, and pecans, both as measured by utilized in-shell production and value of production.

Tree nut orchard acreage in the United States has seen steady increases since the 1980s and particularly, since the late 2000s (Figure 1). In terms of acreage today, almonds are the largest tree nut crop nationally, followed by walnuts, pecans, and pistachios (USDA ERS, 2018). California represents roughly 100% of almond acreage nationally as of 2017 and 97% of pistachio acreage nationally. Walnut production is also highly concentrated in California, which represents roughly 99% of U.S. acreage. Pecan acreage is less concentrated and top producing states include New Mexico, Georgia, Arizona, Texas, and Oklahoma as of 2018 (USDA NASS, 2018).

Figure 1. U.S. Tree Nut Bearing Acreage by Crop and Season, 1980/1981–2017/2018

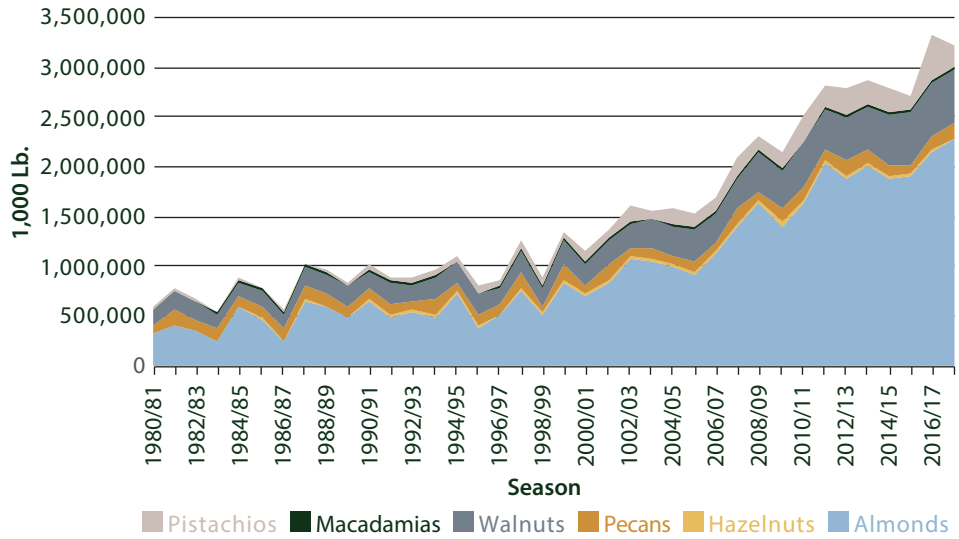


Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

** Pecan bearing acreage only available beginning in 2016/2017 growing season*

In line with increases in acreage, U.S. production of tree nuts has been increasing, both in weight and in terms of value. Increases in almond production have driven much of this growth. Alternate bearing contributes to some year-to-year volatility in tree nut production over time, though not all tree nuts or varieties thereof are alternate bearing. Overall, total U.S. tree nut production has seen significant growth, with total in-shell production by weight increasing more than five-fold between 1980 and 2018 from 593 million pounds to more than 3.2 billion pounds (Figure 2).

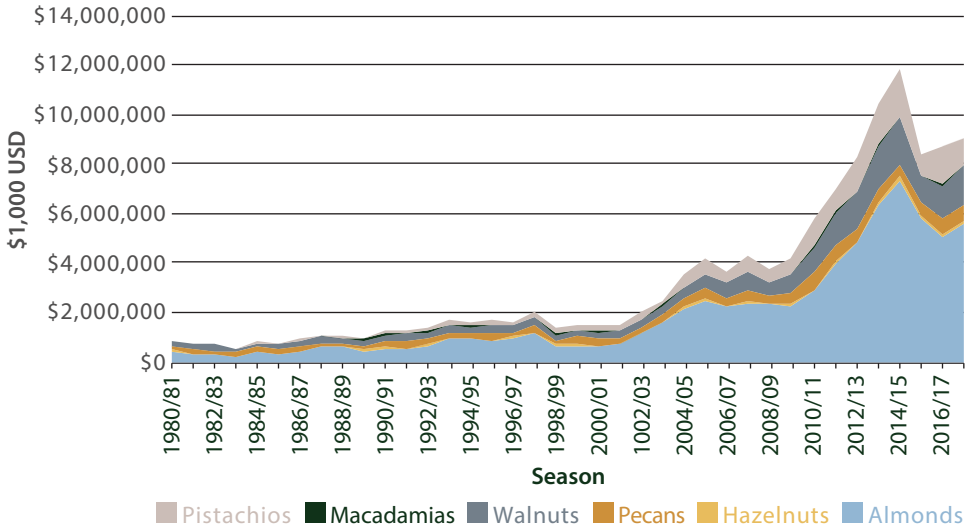
Figure 2. U.S. Tree Nut Utilized Production, Shelled Basis, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

National value of tree nut production mirrors production trends, with a notable spike in almond prices driving total value of production in the 2014/2015 growing season (Figure 3).

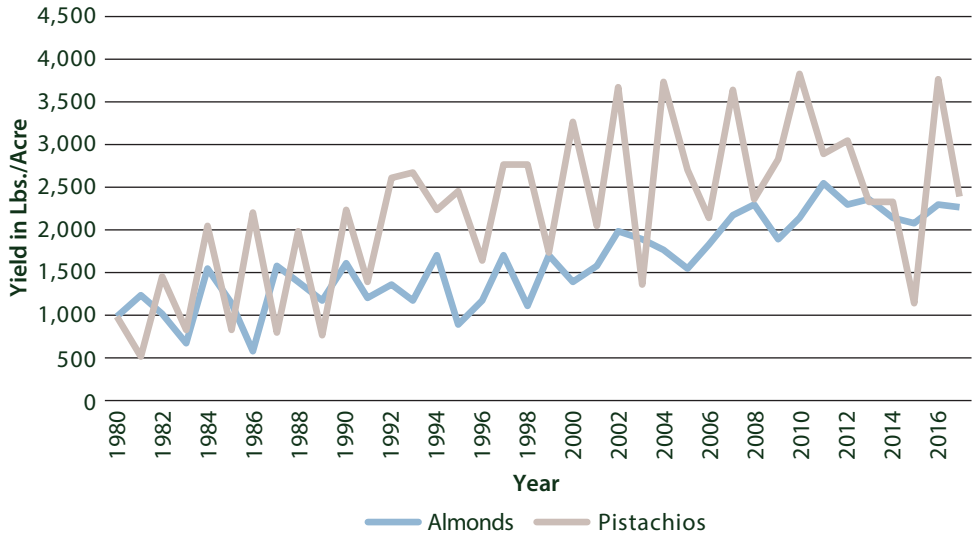
Figure 3. U.S. Tree Nut Value of Production (Nominal), 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

As mentioned earlier, alternate bearing is a behavior of some tree nut varieties characterized by alternating years of high yield and low yield (Jacobs, 2013). Almond and pistachio yield provides a strong example of this behavior (figure 4). Pecans also alternate bear, though native pecans do so to a greater degree than do improved varieties, those generally produced in the Soutwest United States.

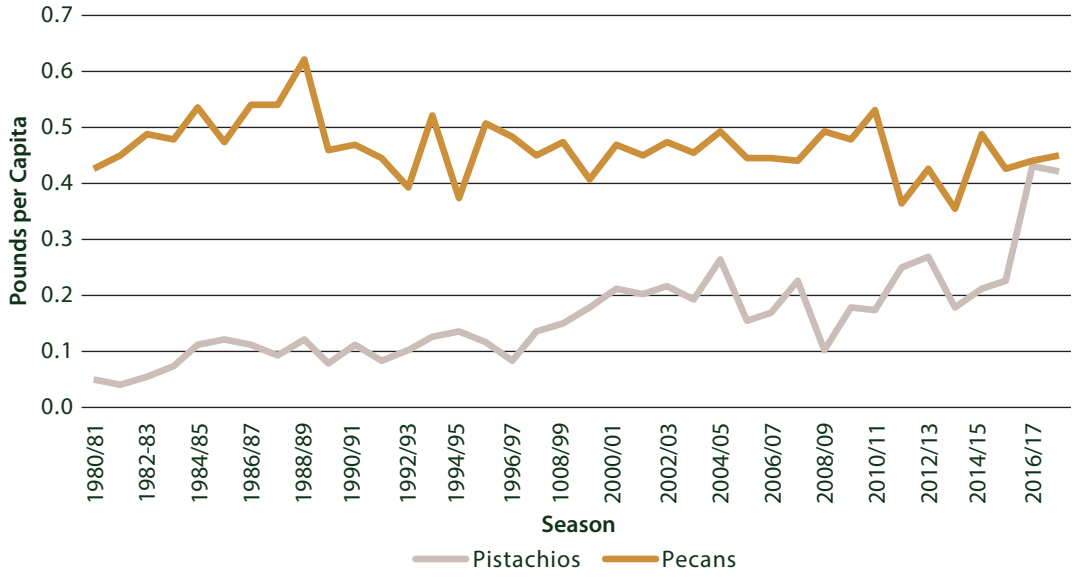
Figure 4. U.S. Average Yield per Acre, Almonds and Pistachios, 1980–2017



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

On a per capita basis, availability of pecans in the U.S. has held relatively stable over the past 30 years (Figure 5). That said, a recent federal marketing order passed in 2016 supports investment in marketing and promotion efforts to help boost demand for pecans and pecan products (APC, 2019). Per capita utilization of pistachios in the United States has grown significantly from the early 1980s, increasing from roughly 1/20th of a pound per capita to nearly half a pound per capita for the 2017/2018 marketing year (Figure 5). The sharp increase in per capita consumption coincides with marketing efforts funded through the federal marketing order for pistachios, which went into effect in 2004 (USDA AMS, N.D.).

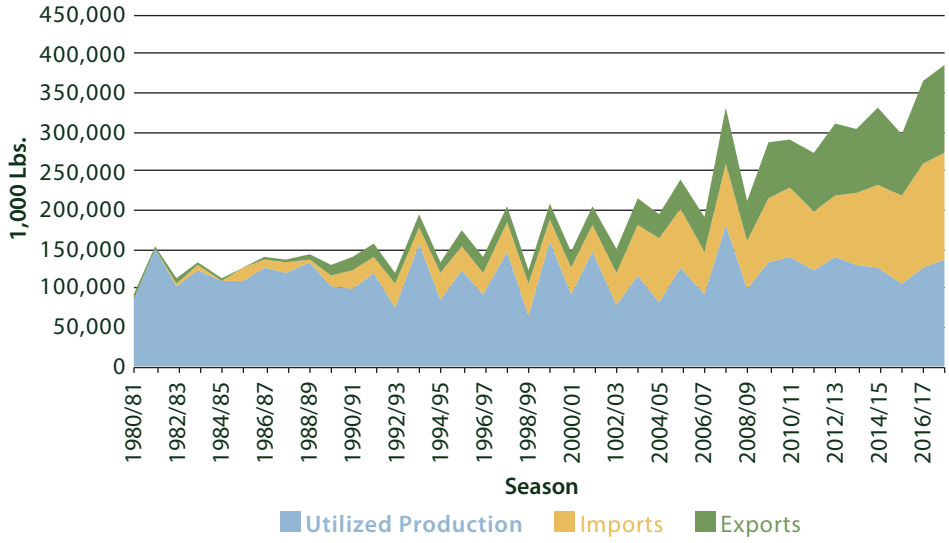
Figure 5. U.S. Per Capita Utilization of Pecans and Pistachios, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Total U.S. demand for pecans has been increasing. Domestic utilization of U.S. pecan production has remained relatively stable since the early 1980s, with year-to-year fluctuations due to alternate bearing. Meanwhile, imports and exports have both increased over time (Figure 6).

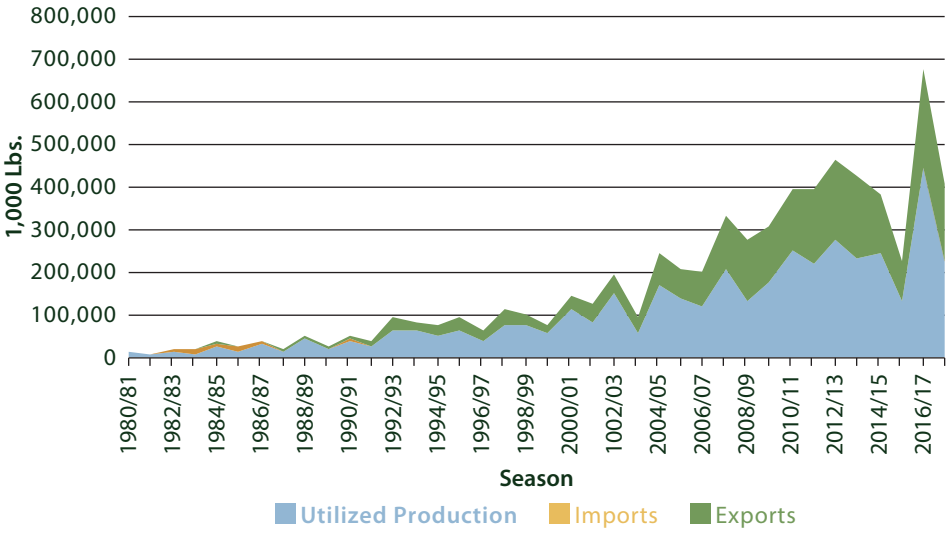
Figure 6. U.S. Pecan Production, Imports, and Exports, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

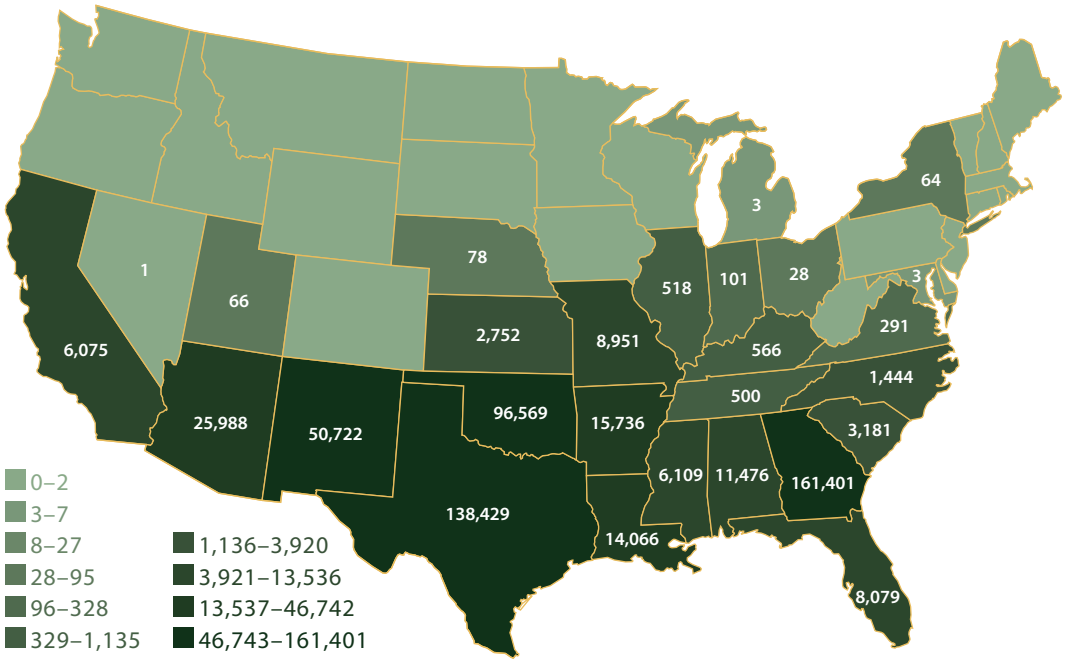
Domestic consumption and exports account for nearly all of U.S. pistachio supply as the country imports little to no pistachios (Figure 7). Similar to pecans, total U.S. demand for pistachios has increased over the past 40 years.

Figure 7. U.S. Pistachio Production, Imports, and Exports, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Figure 8. Total Pecan Acreage (Bearing and Non-Bearing) by State, 2017

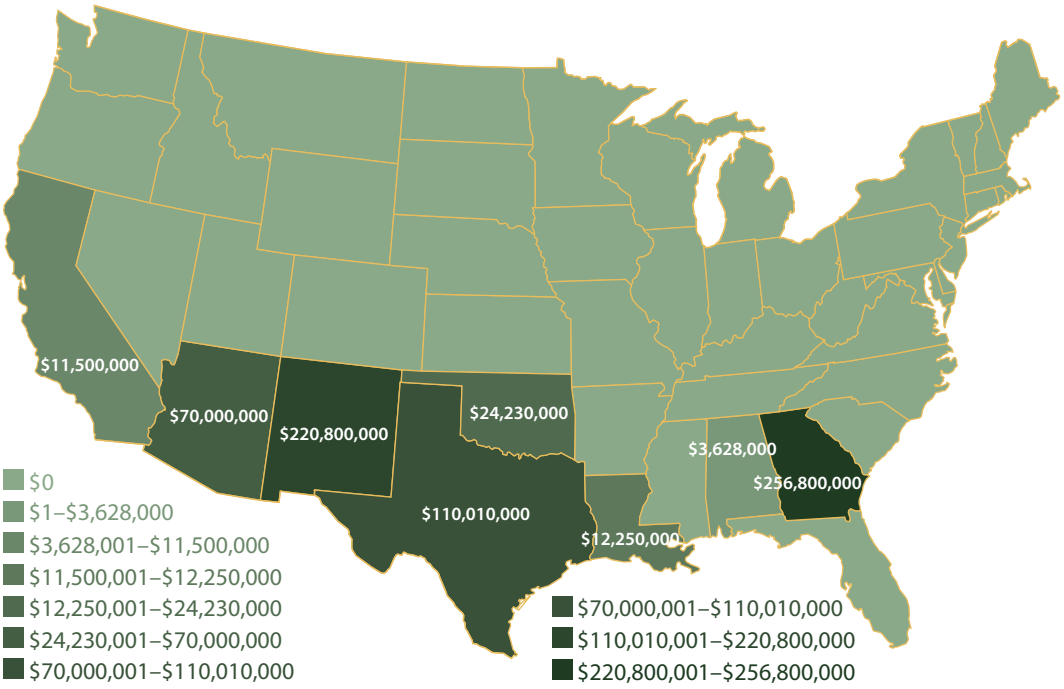


Source: USDA NASS, 2018

Pecans

Pecan trees are native to North America and the U.S. is currently one of the world's top producers of pecans. In 2017, Mexico was the largest producer of pecans globally, followed closely by the U.S. (Ott, 2019). In recent years, the U.S. and Mexico have alternated between first and second largest producers of pecans globally. Two types of pecans are cultivated in the U.S.: native pecans and improved varieties (Blayney and Gutierrez, 2017). Improved varieties are trees that have been bred and grafted to improve productivity. Most native pecans are cultivated in Oklahoma, Texas, and surrounding states. Production in the southwest (Arizona and New Mexico) is exclusively of improved varieties. In order for pecan nuts to mature, trees must have between 205 and 233 frost-free days during the year (Blayney and Gutierrez, 2017). Therefore, U.S. production is concentrated in southerly states (Figure 8).

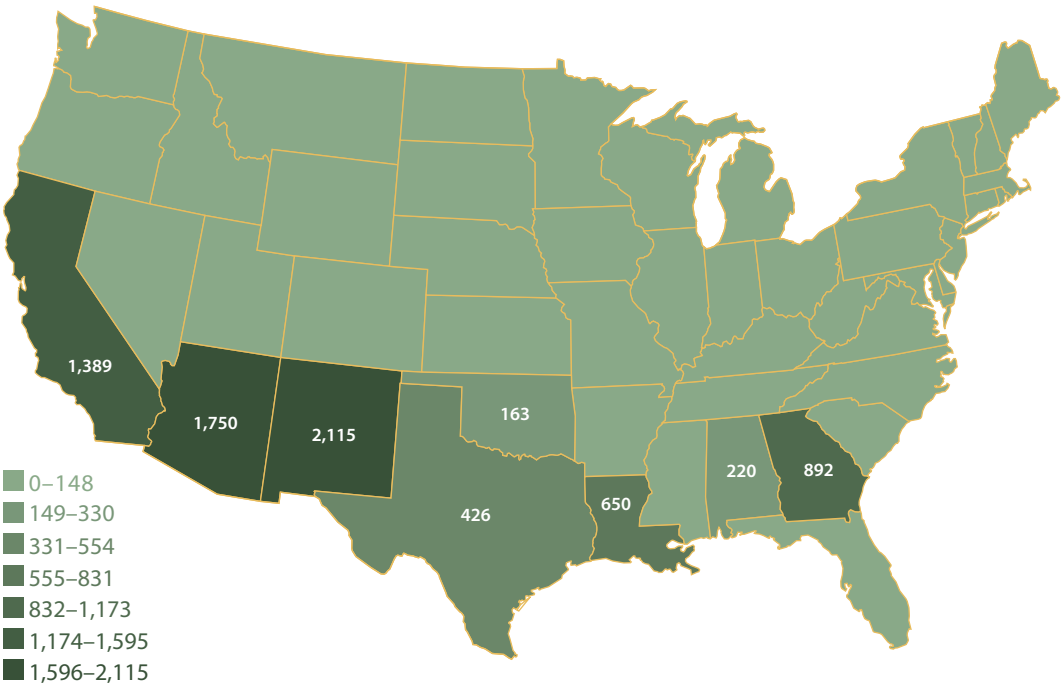
Figure 9. Value of Pecan Production by State, 2017



Source: USDA NASS, 2018

While acreage is widely distributed throughout the country, the value of production is concentrated in just a few states (Figure 9) where yields are highest (Figure 10), as tends to be the case with improved varieties.

Figure 10. Pecan Yield in Pounds per Bearing Acre, 2017



Source: USDA NASS, 2018

Table 1. Utilized In-Shell Production of Pecans by State, by Weight and Value, 2017 and 2018

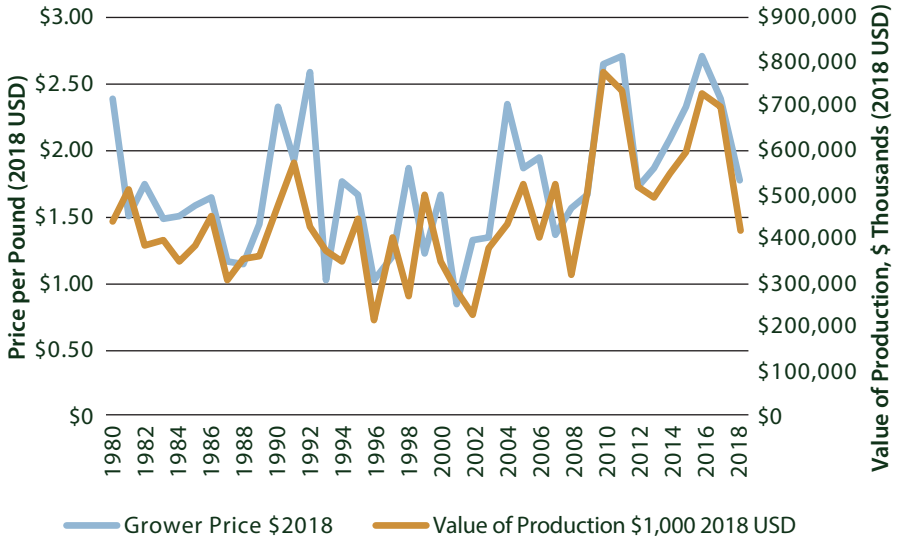
State	2017 Production (lb)	2018 Production (lb)	2017 Production ($)	2018 Production ($)
New Mexico	92,000,000	91,100,000	$220,800,000	$173,090,000
Georgia	107,000,000	70,000,000	$256,800,000	$113,400,000
Texas	49,000,000	33,600,000	$110,010,000	$56,064,000
Arizona	28,000,000	27,900,000	$70,000,000	$52,173,000
Oklahoma	14,000,000	9,000,000	$24,230,000	$14,884,000
California	5,000,000	3,700,000	$11,500,000	$7,400,000
Louisiana	8,000,000	6,030,000	$12,250,000	$5,954,000
Alabama	1,850,000	1,600,000	$3,628,000	$2,366,000

Source: USDA NASS Quick Stats, 2019

As of 2018, New Mexico was the largest producer of pecans, followed by Georgia, Texas, and Arizona (Table 1). Value of production saw major shifts between 2017 and 2018 after a significant decline in production in Georgia due to Hurricane Michael. Further exacerbating declines in the value of production for all states was a reduction in price following imposition of Chinese tariffs on agricultural imports from the U.S.

The year 2018 was challenging for the pecan industry. A hurricane significantly affected growers in Georgia, one of the top producing states, and tariffs by China went into place in December 2018 and April and July of 2019, leading to decreases in demand for U.S. exports. Top export markets for U.S. pecans include China (via Hong Kong), Mexico, and Canada (USDA FAS, 2018). Decreased demand in Asia resulted in lower prices. Figure 11 illustrates average price over time and total value of production.

Figure 11. U.S. Pecan Value of Production and Price per Pound, 1980–2018



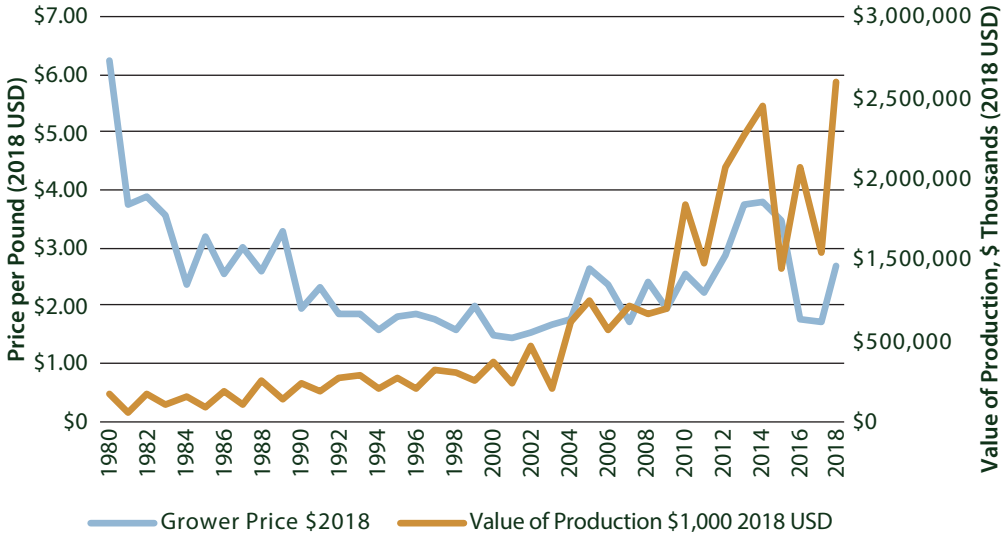
Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Pistachios

Pistachios are a tree nut crop native to Asia (UC Davis, 2005). The U.S. is the top producer of pistachios in the world, followed by Iran, Turkey, and Syria (USDA FAS, 2018). The top export markets for U.S.-grown pistachios are China, the European Union, and Hong Kong (USDA FAS, 2018). Pistachios are produced almost exclusively in California, and in small part, in Arizona and New Mexico (ACP, 2018).

Because California dominates U.S. pistachio production, annual price and production data are most readily available for California. Value of production has increased significantly since the early 2000s, and grower price received has generally fallen as production has increased (Figure 12).

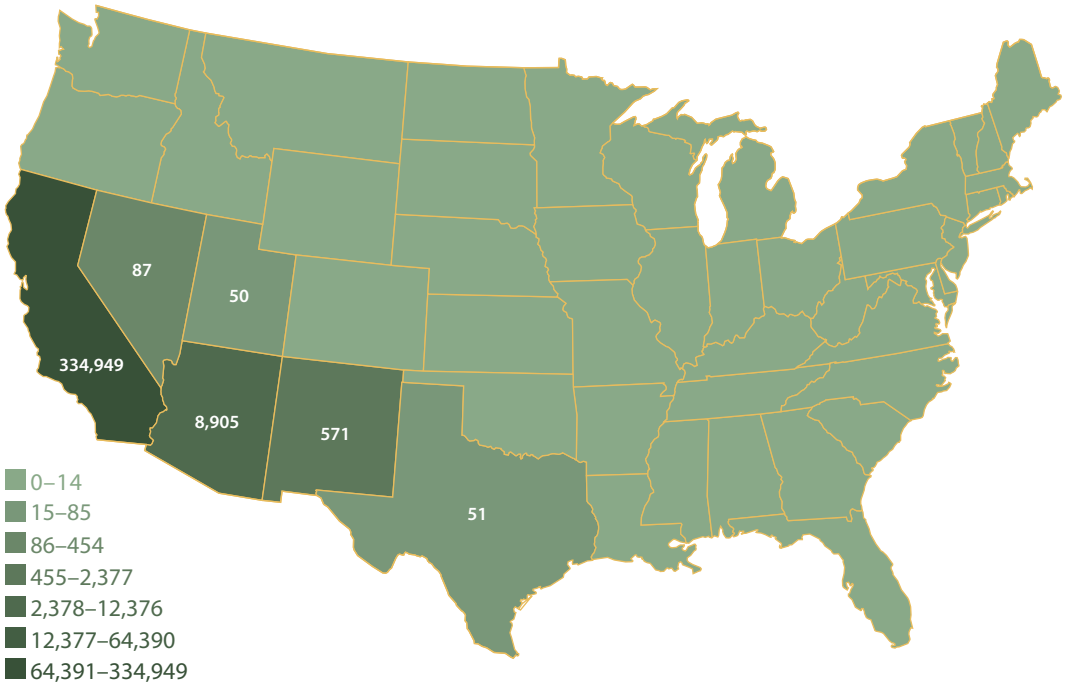
Figure 12. California Pistachio Value of Production and Price per Pound, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Pistachio production is heavily concentrated in California, which accounts for over 97% of total bearing and non-bearing acreage nationally. Arizona ranks second with 2.6% of acreage, and New Mexico third with less than 1% of acreage (Figure 13). In terms of bearing acreage only, Arizona represented 2.0% of national acreage in 2017.

Figure 13. Pistachio Acreage (Bearing and Non-Bearing) by State, 2017



Source: USDA NASS, 2018

Figure 14. Tree Nut Industry Value Chain

Tree Nut Industry Value Chain

The following section examines the different stages of investment, production, harvest, and post-harvest activities involved in the tree nut industry. Depending on the type of tree, the life cycle of an orchard can be well upwards of 40 years (J. Walworth, personal communication, July 2019).

Orchard Preparation and Establishment

The pre-production phase of tree nut orchards involves selection of appropriate land for an orchard, land preparation, orchard design, installation of irrigation infrastructure, purchasing equipment, planting trees, and employing cultural practices for establishing the orchard.

Orchard site evaluation involves assessing soil type, quality, and drainage, elevation, availability of irrigation water supplies, and climate. Between 205 and 233 frost-free days are required for successful pecan production depending on the tree variety (Blayney and Gutierrez, 2017). For this reason, most commercial pecan production is restricted to southerly states. Deep, uniform, alluvial soils are ideal for cultivation of tree nuts (Fulton, Sanden, and Estrom, 2005). Within Arizona, most pecan and pistachio production occurs in Cochise County, as well as Pima County, in higher elevation basins. Site evaluation and land preparation include collecting soil samples and assessing any layering or soil stratification, which may require soil modification, and installation of irrigation systems. While historically orchards in Arizona used flood or furrow irrigation, new orchards currently rely almost exclusively on closed irrigation systems such as drip or micro-sprinkler irrigation to enhance water use efficiency. While the costs associated with site evaluation and soil modification may be significant, poor orchard design or failure to adequately address soil types and drainage can make trees more susceptible to disease or constrain their growth years down the road, leading to poor yields (Fulton, Sanden, and Edstrom, 2005; Kallsen, Sibbett, and Fanucchi, 2005). Water supply is of utmost importance for site selection. Unlike annual field crops that can be fallowed in times of drought or limited irrigation water availability, ceasing irrigation to orchards can lead to damage or death of trees, which represent years of investment lost. Since payback of investment costs occurs over many years, once producers plant an orchard, they do not have flexibility to fallow land or shift to another crop.

After land preparation is complete, trees of improved varieties are planted and irrigated. Trees are sourced from nurseries where vegetative propagation techniques are used to bud scion wood varieties to rootstock (Kong, N.D., J. Walworth, personal communication, July 2019). Improved varieties of pecans are developed either through selection or breeding, exemplified, respectively, in the top two varieties planted in Arizona, Western Schley and Wichita (M. Kilby, personal communication). Once established, young trees are trained, pruned, and managed for disease, pests, and weeds. Depending on the type of tree nut, orchards can take several years before they begin bearing a crop and as long as ten years before they achieve their full yield potential (Teegerstrom, 2014; Freeman, et al., 2015; Brar, et al., 2015). For pecans, it takes around 4 years to reach bearing age (Freeman, et al., 2015) and for pistachios about 5 to 6 years (Brar, et al., 2015).

This phase of an orchard's life cycle is characterized by years of major upfront investments with little or no revenue generation from production to offset those investment costs. Producers can expect negative cash flows for a number of years in the initial phases of orchard establishment, and negative net returns for even longer as upfront costs are recovered gradually as trees enter full productive potential after roughly 10 years. Generally speaking, a small orchard requires the same cultivation and harvest equipment as a large orchard. Large orchards therefore tend to be more profitable compared with smaller orchards due to investment costs being spread over more producing acres, and thereby lower investment costs on a per acre basis. Small orchards are not as economically efficient as larger orchards.

Production

Once trees begin bearing an economic yield, they can stay in production for many decades. The commercial production phase of an orchard's life cycle involves ongoing cultural activities to maintain the health and productivity of trees, pest and weed management, fertilization, irrigation, and harvest on an annual basis. As pecan orchards mature, they are mechanically pruned every 2 to 4 years (J. Walworth, personal communication, July 2019). This helps regulate growth in such a way that trees within the orchard are not competing for sunlight. This also helps reduce alternate bearing tendencies.

Harvest and Processing

Both pecans and pistachios are harvested mechanically using shakers that clamp to the base of mature trees, shaking the tree nuts loose. Pecans are shaken to the ground where they are collected, and pistachios are harvested directly from trees into a receptacle (J. Walworth, personal communication, July 2019). Pecans are typically harvested between November to January or February. Pistachios are harvested earlier, from late August to early October. After harvest, nuts must be cleaned, transported, and processed for marketing or storage. For both pecans and pistachios, it is common that growers contract with processors, though some large producers own and operate their own processing facilities.

Most U.S. pecan production for domestic consumption is shelled, though a small portion of production is marketed in shell. Pecans are shelled, whereby the meat is separated from the shell, and then dried to a specified level of temperature and humidity, at which point the pecans can be marketed or put into cold storage for marketing later. A more significant share of exports is marketed in-shell, particularly to China, Hong Kong, and Mexico.

Pistachios are most commonly marketed in shell. Pistachio nuts must be hulled, dried, and then separated according to whether or not the shell has

split. The most desirable pistachios for market are those whose shells have split open and are free from any staining. They are roasted and salted for marketing. Any non-split nuts are shelled, salted, and then packaged either for marketing, processing for products such as ice cream, or for storage (Ferguson, Kader, and Thompson, 2005).

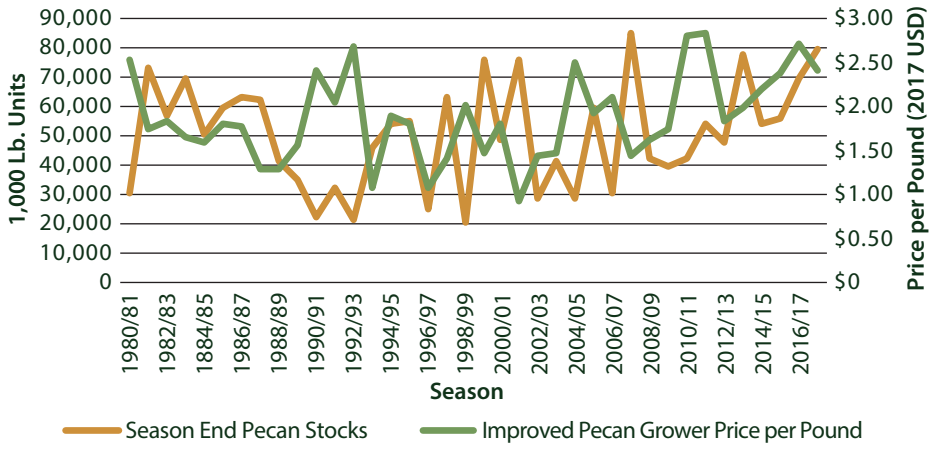
Marketing and Storage

Typically, shelled pecans are marketed by processors, and processors will contract with growers for their production to ensure sufficient product for customers (Clevenger and Blake, 1991). In-shell pecans may be sold directly by producers. During processing, tree nuts are separated according to their grade for marketing. Both pecans and pistachios are covered by federal marketing orders that stipulate grades and standards for marketing. Shelled pecans are sized as halves, halves and pieces, and pieces, depending on how intact the nut halves are after shelling, and graded as U.S. No. 1 or Commercial, depending upon the uniformity of color (USDA AMS, 2018). Pistachios are graded according to the means by which the shell has split, size, and any shell discoloration or other defects (USDA AMS, 2004).

To support industry research and marketing efforts, the industry established the pecan federal marketing order in 2016, enabling them to collect an assessment on pecan production (U.S. Federal Register, 2016). The order covers pecan production in 15 U.S. states, including Arizona, and established the American Pecan Council as the governing body overseeing administration of funds collected through the order through an assessment of $0.03 per pound for improved pecan varieties and $0.02 per pound for native pecans. Pistachios produced in California, Arizona, and New Mexico are also governed by a federal marketing order, in effect since 2004, that establishes uniform standards, requirements around testing for aflatoxin, and shipping and processing procedures for the pistachio industry (U.S. Government Publishing Office, 2017). A $0.0001 per pound assessment is applied to production in order to fund the Administrative Committee for Pistachios, which oversees activities under the federal marketing order and manages industry promotion and marketing efforts (USDA AMS, 2019).

Unlike perishable produce commodities that must be sold within a few days or weeks of harvest, cold storage can increase the marketing window for pecans and pistachios for as long as a year. Pecans can be stored for up to a year at between 32° and 34° F (Kong, N.D.). Beyond a year, pecans may be frozen for storage. Pistachios also can be stored for up to a year at 68° F and between 65% to 70% relative humidity (Ferguson, Kader, and Thompson, 2005). Each year, stored pecans and pistachios may be marketed to supplement production, or in the case of unfavorable market conditions, new production can be stored for marketing at a future date. Figure 15 shows end stocks of pecans nationally. In many instances, stocks noticeably move opposite to market prices, suggesting that producers and handlers sell when prices are high and hold stock when prices are low.

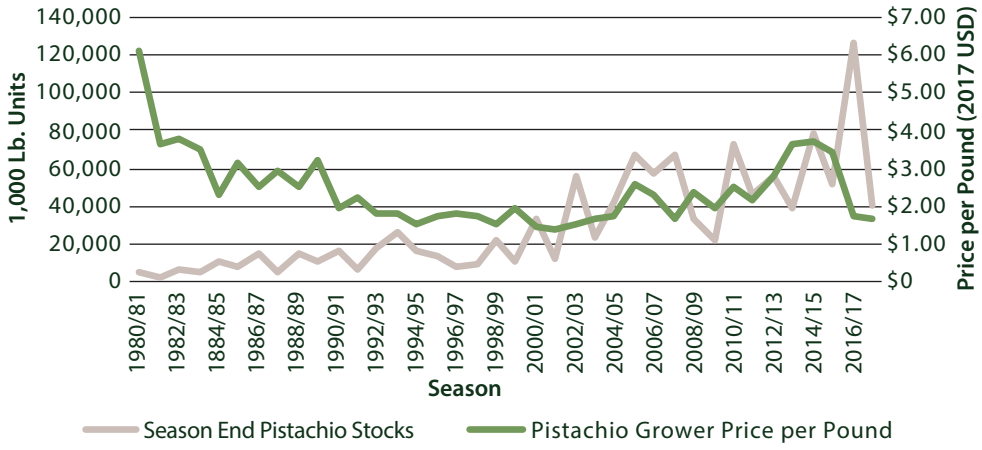
Figure 15. U.S. Season-End Pecan Stocks and Improved Pecan Grower Price per Pound, 1980/1981–2017/2018



Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Figure 16 shows the stock and producer price of pistachios. Similar to pecans, stocks and prices exhibit noticeably divergent behavior in many years.

Figure 16. U.S. Season-End Pistachio Stocks and Grower Price per Pound, 1980/1981–2017/2018



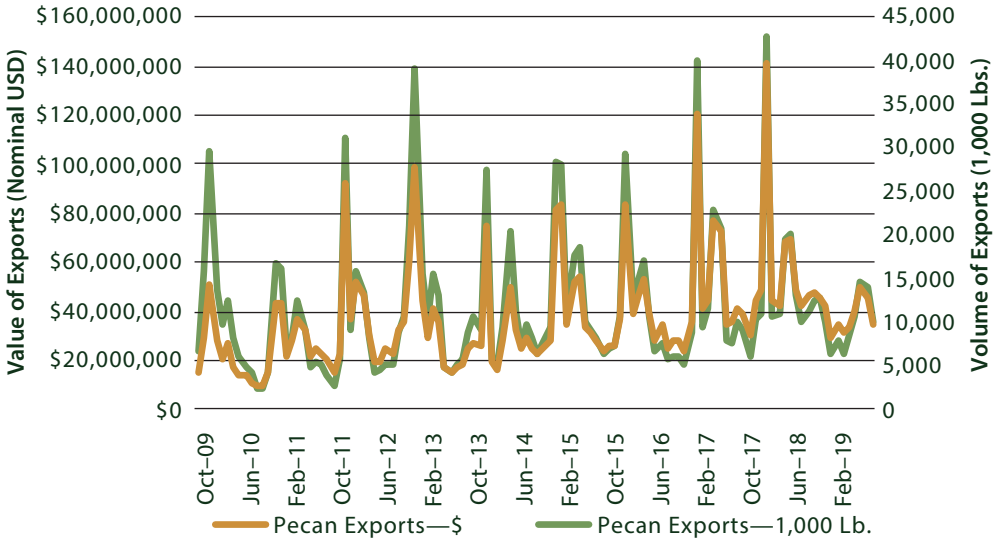
Source: USDA ERS Fruit and Tree Nut Yearbook, 2018

Trade

The U.S. exports billions of dollars' worth of tree nuts on an annual basis in recent years. Top export markets for U.S. pecans include China (via Hong Kong), Mexico, and Canada (USDA FAS, 2018). Demand in Europe, combined, is similar in magnitude to demand in China (APC, 2018). The top export markets for U.S. grown pistachios are China, the European Union, and Hong Kong (USDA FAS, 2018).

In April and July of 2018, China increased its tariffs on a variety of U.S. agricultural products in response to increases in U.S. tariffs on a variety of Chinese goods. The tariff for importing U.S. pecans increased from 7% to 47% (Pecan Report, 2018) and the tariff on pistachios increased from 10% to 45% (Farm Bureau, 2018). Monthly pecan exports experienced a noticeable decline in later months of 2018 compared with previous years (Figure 17).

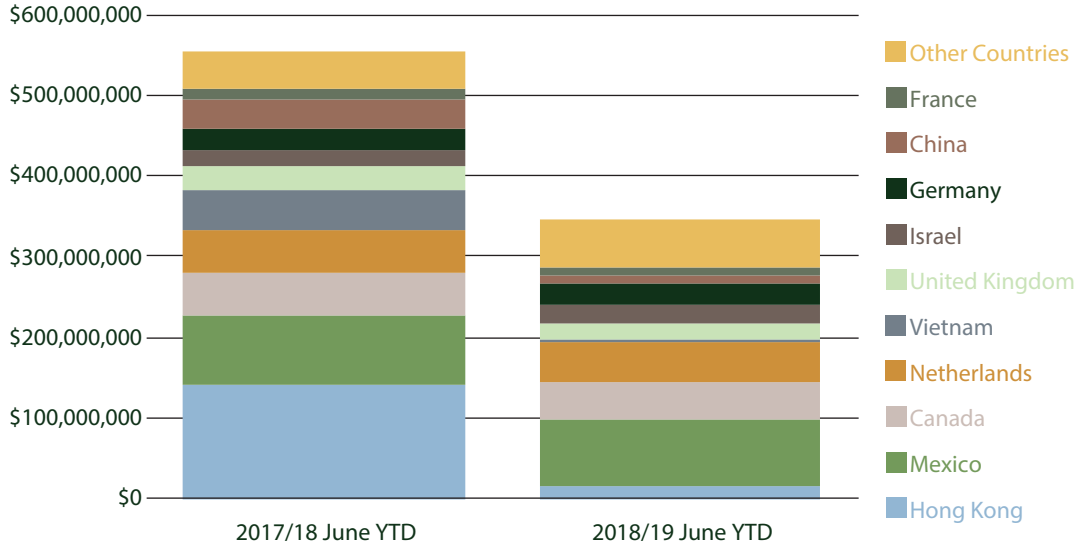
Figure 17. U.S. Monthly Pecan Exports, 2009–2019



Source: USDA ERS, 2019b

Most of the decline in exports was due to lower exports to Hong Kong and China (Figure 18). Hong Kong commonly serves as a conduit for trade with China.

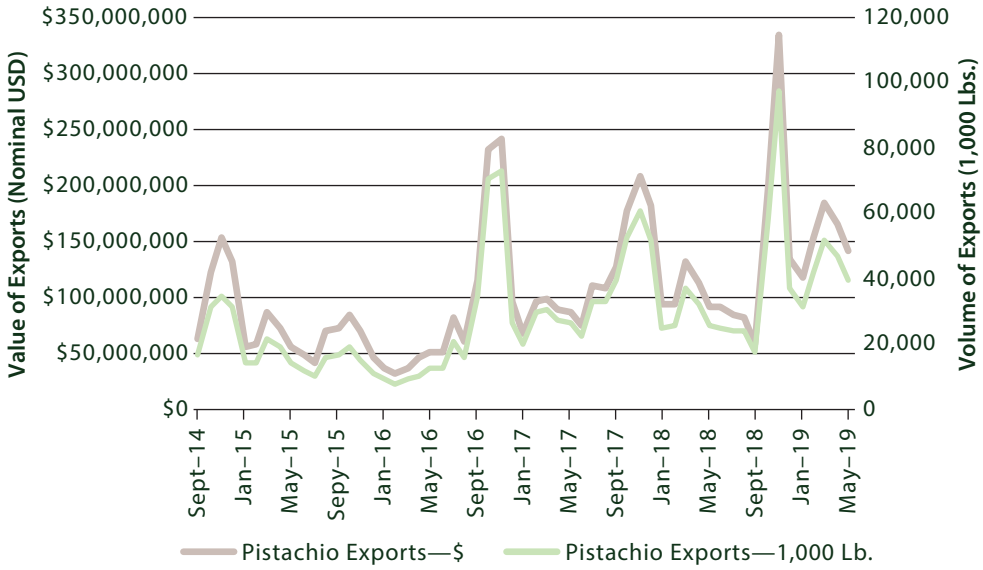
Figure 18. U.S. Pecan Exports by Destination Country, June Year-to-Date for 2017/2018 and 2018/2019 Seasons



Source: USDA ERS, 2019b

Pistachios did not experience the same decline in exports that pecans did (Figure 19). Pistachios are popular in China, particularly during the Chinese New Year, with a spike in exports in the months preceding the holiday.

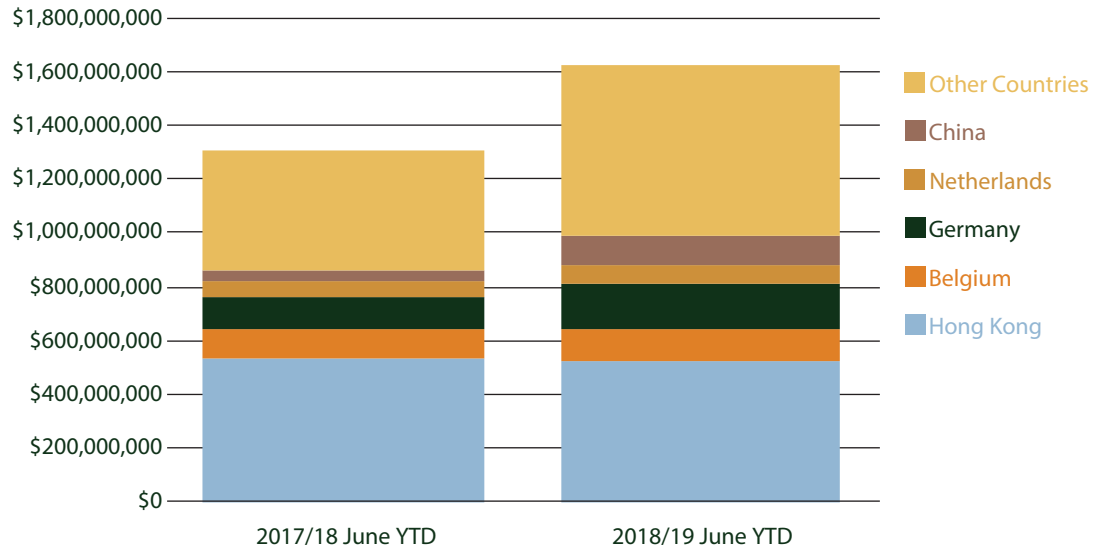
Figure 19. U.S. Monthly Pistachio Exports, 2014–2019



Source: USDA ERS, 2019b

Pistachio exports between September and May grew in value between the 2017/18 and 2018/19 seasons, with a small decline in exports to Hong Kong and a small increase in exports to China (Figure 20).

Figure 20. U.S. Pistachio Exports by Destination Country, June Year-to-Date for 2017/2018 and 2018/2019 Seasons



Source: USDA ERS, 2019b

Services, Value Added Products, and Agritourism

Beyond revenues generated from the sale of their harvests, tree nut producers may earn revenues through other activities directly linked with their tree nut operations. Orchards generate considerable amounts of organic byproducts. As trees are pruned and nuts are hulled and shelled, commercially valuable materials such as pecan wood, shells for landscaping mulch, and biomass are produced and marketed both directly to consumers as well as indirectly through wholesale or industrial market channels. In addition to byproducts, an additional source of revenue for some tree nut orchards is agritourism. This includes such activities as farmstand stores, farm tours, and seasonal events and festivals. Finally, considering that timely processing and storage of tree nuts is imperative to maintaining their quality and marketability, some pecan and pistachio producers own and operate processing facilities to process their own production, as well as to offer processing services to other nearby producers.

Tree Nut Production in Arizona

Background

Pecans were first planted in Arizona by settlers in the 19th century (Payne, 2018). However, commercial-scale pecan production took root in the 1960s with the planting of large orchards in Southern Arizona along the Santa Cruz River. Since that time, tree nut production has expanded into areas of Central and Southeastern Arizona. Pistachios were not cultivated in large quantities in Arizona until the 1990s. Currently, new pistachio plantings have resulted in a high proportion of non-bearing acreage that will be entering into production in the next few years. Major increases in production can be expected in upcoming years as a result. In Arizona, pecan harvest occurs in late fall, beginning in November. Marketing of pecans occurs over that same window to as late as the end of March, or later for stored pecans. Pistachio harvest occurs from September through October, and marketing is done from September through January (USDA NASS, 2006).

The following section provides the most up-to-date data on the tree nut industry in Arizona from multiple data sources. We rely on the 2017 Census of Agriculture, released every 5 years, and most recently in 2019. It is the most comprehensive source of agricultural statistics at the state and local level. Additionally, we use pecan acreage data from the Arizona Department of Agriculture. Finally, we draw from USDA NASS annual survey estimates of production, yield, price received, and value of production.

Acreage and Operations

While the number of Arizona farms cultivating tree nuts has not increased over the past 20 years (Table 2), tree nut acreage has expanded rapidly (Table 3).

Table 2. Arizona Tree Nut Farms by Crop, 1997–2017

	1997	2002	2007	2012	2017
Pecans	302	466	196	222	267
Pistachios	78	109	50	77	69

Source: USDA, 1999; USDA, 2004; USDA, 2009; USDA, 2014a; USDA, 2019

Table 3. Arizona Tree Nut Acreage by Crop, 1997–2017

	1997	2002	2007	2012	2017
Pecans	14,959	18,811	12,365	17,061	25,988
Pistachios	N.A.	3,509	1,523	3,645	8,905

Source: USDA, 1999; USDA, 2004; USDA, 2009; USDA, 2014a; USDA, 2019

In 2017, pecans represented the largest share of tree nut acreage in Arizona, in terms of bearing, non-bearing, and total acreage. Both pecans and pistachios have a significant share of non-bearing acreage, reflecting the recent surge in new plantings across the state. A small amount of acreage in almonds and walnuts was reported in the Census, but the breakdown of bearing versus non-bearing acreage was not disclosed and no production data were recorded (Table 4).

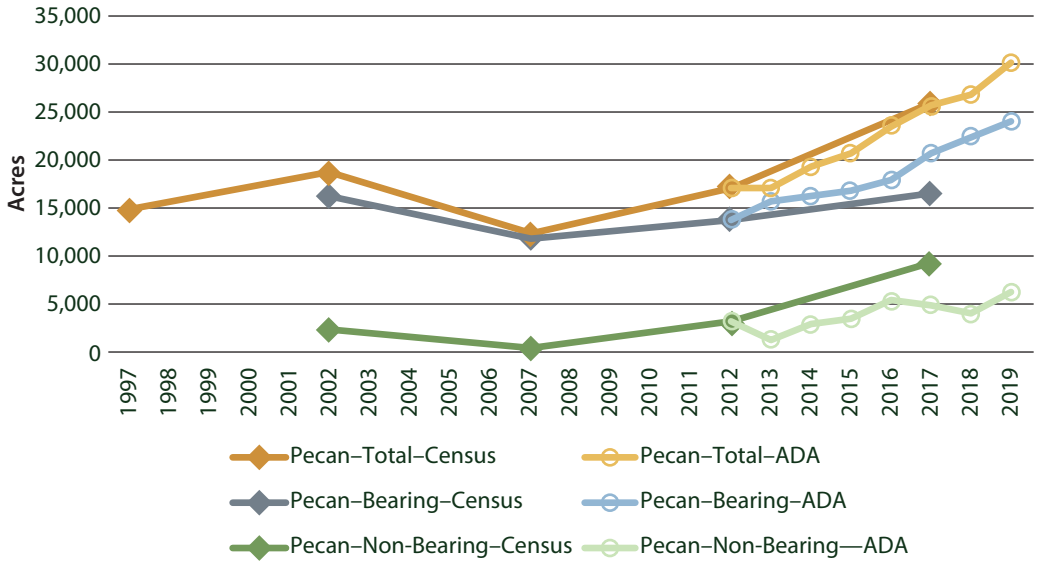
Table 4. Arizona Operations Producing Tree Nuts with Bearing and Non-Bearing Acreage, 2017

	Almonds	Pecans	Pistachios	Walnuts	Tree Nuts Total
Total Operations	22	267	69	8	343*
Acres Bearing	N/A	16,629	4,972	N/A	21,724
Acres Non-Bearing	N/A	9,358	3,933	N/A	13,537
Total Acres	163	25,988	8,905	203	35,261

** Row does not sum to total as some operations produce more than one type of tree nut.*
Source: USDA, 2019

Figure 21 presents Arizona pecan acreage data from past and current USDA Censuses of Agriculture (released every 5 years) and annual estimates from the Arizona Department of Agriculture. The Arizona Department of Agriculture began collecting pecan acreage data in 2012. Arizona pecan acreage fluctuated between 1997 and 2012, growing 14% over that period (USDA, 2019), but since has increased steadily each year. Between 2013 and 2019, total pecan acreage has nearly doubled, from around 17,000 acres statewide to over 30,000 acres. Of those total 30,000 acres, roughly 24,000 of those acres are bearing. Differences in bearing versus non-bearing estimates for 2017 are likely due to differences in definitions of bearing trees (tree age versus trees having entered into commercial production).

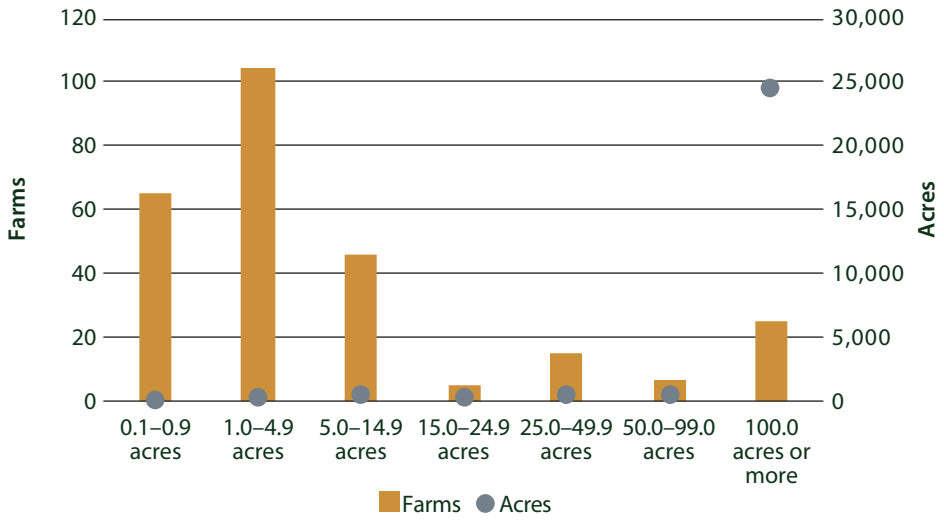
Figure 21. Arizona Pecan Acreage, Bearing and Non-Bearing, 1997–2019



Source: USDA 2017 Census of Agriculture, 2019; Arizona Department of Agriculture, 2018

Similar to other types of farms in Arizona, pecan farms are dominated in number by small-scale producers, while just a few producers account for a large majority of acreage and production. In Arizona in 2017, farms with 100 acres or more held nearly 94% of pecan acreage in the state (Figure 22).

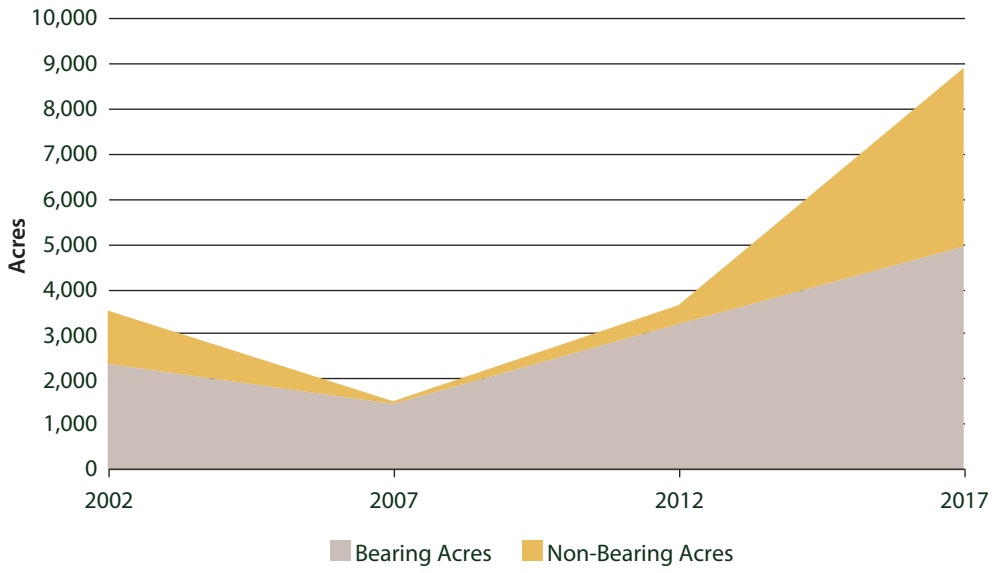
Figure 22. Arizona Pecan Farms and Acreage by Size of Farms, 2017



Source: USDA 2017 Census of Agriculture, 2019

Year-to-year estimates of pistachio acreage are not available as they are for pecans. However, state acreage is reported every 5 years in the Census of Agriculture starting in 2002. Between 2002 and 2017, pistachio acreage nearly tripled from 3,000 acres to 9,000 acres (Figure 23). Similarly, data on the size of pistachio producing farms in Arizona were not available.

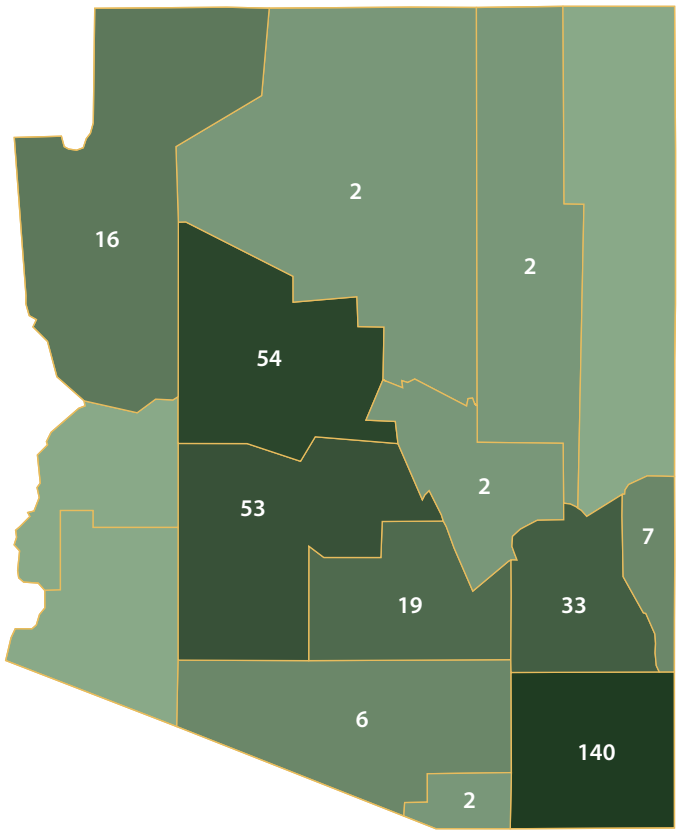
Figure 23. Arizona Pistachio Acreage, Bearing and Non-Bearing, 2002–2017



Source: USDA, 2004; USDA, 2009; USDA, 2014; USDA, 2019

By number of operations, tree nut production in Arizona is concentrated in Southeastern Arizona (Figure 24). Considering that production is concentrated in a small number of large farms, however, the number of operations by county is not necessarily representative of the distribution of acreage or production by county. Acreage and production by county are generally unavailable for pecan and pistachio production, though Arizona pistachio production occurs almost entirely in Cochise County (APC, 2018) with some acreage recently established in neighboring Graham County.

Figure 24. Number of Tree Nut Producing Farms by Arizona County, 2017

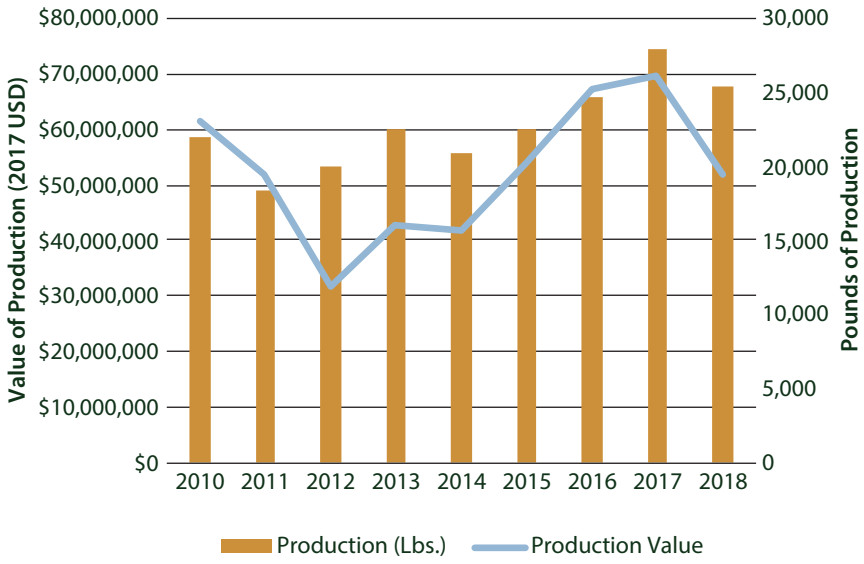


Source: USDA, 2019

Value of Production

The value of Arizona pecan production in 2017 was $70 million, up from $67 million in 2016. Production increased from 23.5 million pounds to 28 million pounds, in shell (Figure 25). Production dropped to 25.5 million pounds in 2018, and value of production dropped even more, to $51 million, due to low prices.

Figure 25. Arizona Pecan Production by Value and Weight, 2010–2018

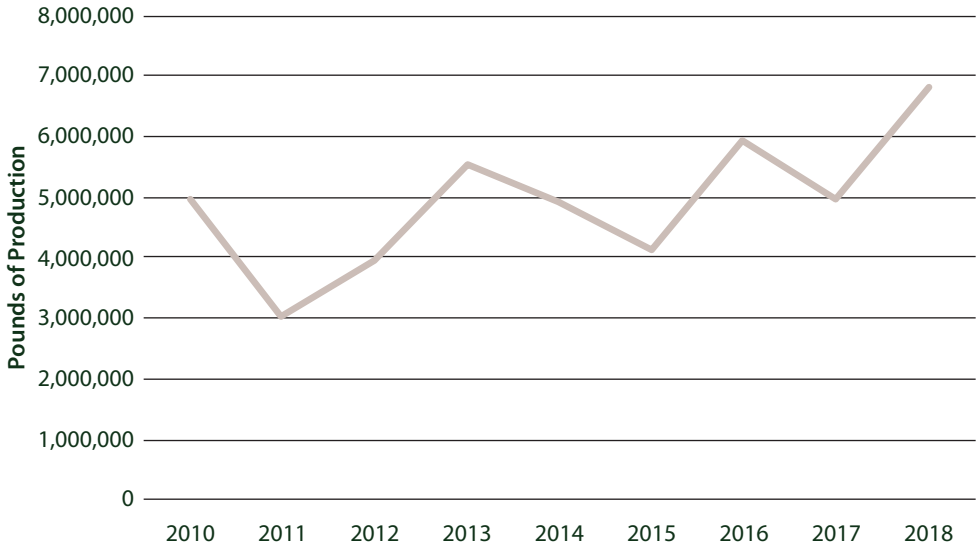


Source: USDA NASS, 2019

Due to a relatively small number of producers with most production concentrated amongst a handful of farmers, data on the value of pistachio production in Arizona is not available through the USDA. Therefore, for this analysis, we derive an estimate of pistachio production value using data on volume produced, market prices, yield, and bearing acreage.

The Administrative Committee on Pistachios reports production data for the combined Arizona and New Mexico region and each state's relative share of combined bearing acreage. Using this data and assuming yields in Arizona and New Mexico are equal, we estimate Arizona produced 5 million pounds in 2017, with a value of roughly $8.4 million. The year 2017 was an off year for pistachio production in the region, with higher production weight achieved in 2016 and 2018 (Figure 26).

Figure 26. Estimated Arizona Pistachio Production by Weight, 2010–2018



Source: Administrative Committee on Pistachios, 2019; USDA, 2009; USDA, 2014; USDA, 2019; Author calculations

Though included in previously reported figures of cash receipts from commodities, direct to consumer and farmstand sales are a part of some producers' strategies to market their production. One hundred and fifty-nine (159) Arizona fruit and tree nut farms reported selling directly to consumers, with total direct to consumer sales of $18.7 million in 2017. In 2017, 57 Arizona fruit and tree nut farms reported selling a combined $38.9 million to retail markets, institutions, and food hubs for local or regionally branded products. As a subset of fruit and tree nut farms, pecan and pistachio orchards represent a share of these two sales figures. These, however, do not represent additional farm-related income, but rather represent a share of cash receipts for commodities sold.

Processing, Services, Value Added Products, and Agritourism

Arizona tree nut producers earn revenues beyond those generated from the sale of their harvests, including from such activities as agritourism, sale of byproducts from production, providing custom agricultural support services to other producers, and tree nut processing. The Census of Agriculture does not report specifically on the tree nut industry's sales generating other farm-related income, however, it reports on Fruit and Tree Nut farming (NAICS 1113) combined.

According to the 2017 Census of Agriculture, 22 Arizona fruit and tree nut farms reported combined income of $39,000 from sales of 'forest products (excluding Christmas trees), short rotation woody crops, and maple products.' Though small relative to commercial tree nut production, byproducts repre-

sent an additional source of revenue and generate additional economic value. Eight fruit and tree nut farms in Arizona reported income from agritourism and recreational services, though the revenue figure was not disclosed in the Census. We apply statewide average agritourism sales per farm to estimate agritourism revenues of Arizona tree nut farms. Finally, 71 fruit and tree nut farms in Arizona reported combined income of $837,000 for custom work and other agricultural services, which includes services such as pruning. As a subset of fruit and tree nut farms, pecan and pistachio custom services represents a share of this sales figure.

Combining estimates of sales of byproducts, agritourism, and custom work, income from farm-related sources totaled $5.7 million in 2017 for fruit and tree nut farms (NAICS[1] code 1113) in Arizona. Of 760 fruit and tree nut farms in Arizona in 2017, 217 were reported as tree nut farms in terms of their primary NAICS code. Assuming that the same proportion of farms applies to sales, and excluding custom work which is already captured as a production expense, that would translate to $1.4 million in other farm-related income for tree nut producers in Arizona.

A number of Arizona tree nut producers are also involved in processing tree nuts, including both pecan shelling and pistachio hulling. Using cost estimates from Ott (2019) and Evans and Madley (2018), average shell-out rates from Call, Gibson, and Kilby (2006) and Ott (2019), state production by weight, and industry estimates of the share of Arizona tree nut production shelled or hulled in state, we derive an estimate of $12.8 million in sales in 2017 for tree nut shelling and hulling.

Summary

Arizona's tree nut industry generates sales through a variety of channels, including production of agricultural commodities, sales of agricultural byproducts, and sales from agritourism activities. Combined, these activities generated an estimated $79.8 million in 2017. Additionally, tree nut processing, including shelling and hulling, generated an estimated $12.8 million in 2017. In total, Arizona's tree nut industry had an estimated $92.6 million in sales in 2017 (Table 5).

Table 5. Estimated Arizona Tree Nut Industry Sales, 2017

Sales Component	Estimate
Cash Receipts	$78.4 million
Pecans	$70.0 million
Pistachios	$8.4 million
Other Farm-Related Income	$1.4 million
Shelling & Hulling	$12.8 million
Total Industry Sales	**$92.6 million**

** Totals may not add due to rounding*

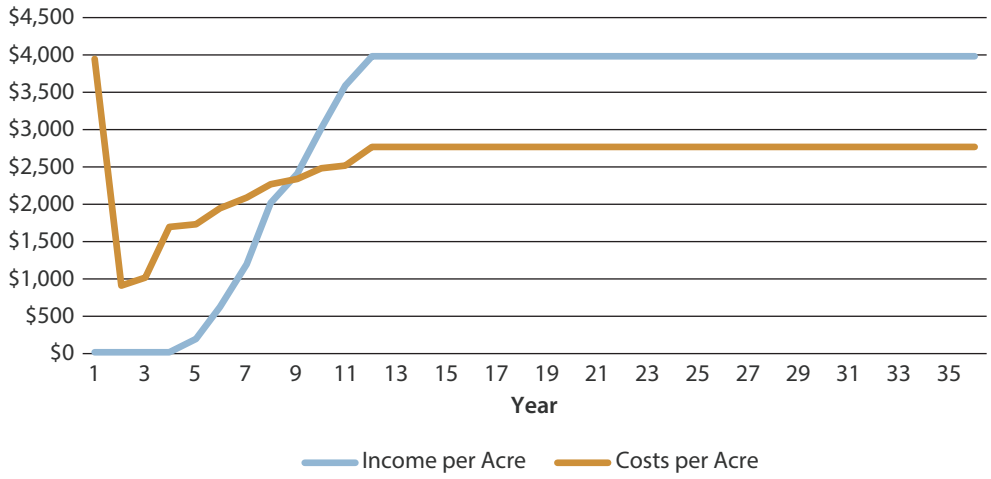
1 North American Industry Classification System (NAICS) codes are used to classify business entities by their primary economic activity for statistical purposes.

Economic Contribution Analysis

Arizona's tree nut industry contributes to the state economy in different ways, and to understand how, it is helpful to revisit the different phases of an orchard's life cycle.

Initially, producers make large, one-time investments in land preparation, irrigation infrastructure, and trees. Following this initial investment, a number of non-bearing years follow in which trees are not yet producing a crop to generate sales, but meanwhile they are incurring expenses for orchard maintenance as they grow. Finally, trees enter into production and, over time, the revenues generated by crop cash receipts offset production expenses and gradually pay back the initial orchard investments. Just because an orchard is not yet yielding a crop and generating revenues, however, does not mean that it is not generating a contribution to the state's economy. In that sense, a tree nut industry that is expanding in new acreage may be contributing more to the economy than annual cash receipts from sales of commodities might suggest. Figure 27 illustrates the high upfront orchard investment costs and gradual entrance into full production (revenue generation).

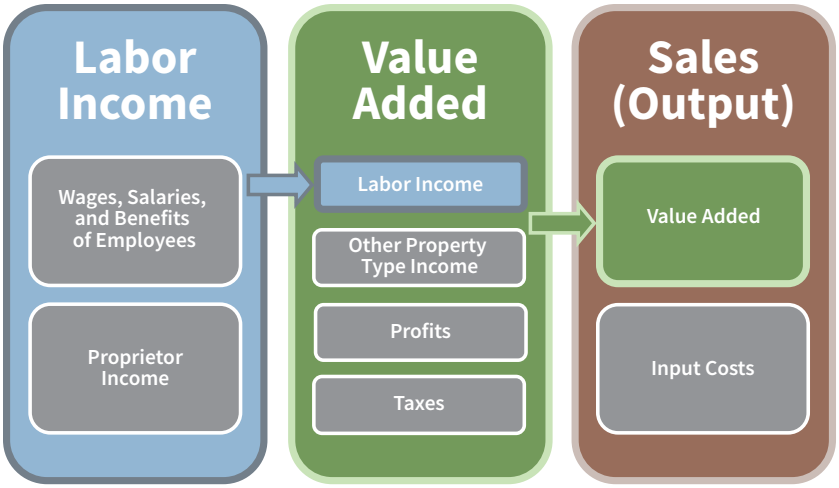
Figure 27. Tree Nut Orchard Costs and Income from Production over Time



Source: Teegerstrom, 2014

The expenses incurred for orchard establishment, maintenance, and production are fulfilled in part by a wide variety of local businesses, and the individuals employed by the orchard and in indirectly supporting businesses earn wages that are also spent in the local economy. This activity generates a ripple of economic activity beyond the direct contribution of the industry. These are referred to as economic multiplier effects. Indirect multiplier effects include economic activity generated by Arizona tree nut farms purchasing inputs to production from other local business such as fertilizer suppliers, machinery manufacturers, and contracting the services of crop consultants. Those businesses in turn must use inputs and services to produce their goods, generating yet another round of multiplier effects. This effect eventually dissipates because of leakages, when money is spent on goods or services from outside the regional economy. Once the money leaves the regional economy, it no longer circulates locally. Induced multiplier effects occur when individuals employed in the tree nut industry spend their earnings on household goods and services, such as rent or mortgage, groceries, or medical care. Similar to indirect effects, induced effects generate additional rounds of activity that eventually dissipate due to leakages.

Figure 28. Component Measures of Economic Contributions



This analysis considers the total contribution of Arizona's tree nut industry to the state economy in 2017, including direct, indirect, and induced multiplier effects. Economic contributions are quantified using a number of metrics. Economic output is perhaps the most intuitive. It measures the total value of sales generated in the economy and represents the flow of money through an economy. Output (sales), however, double counts the cost of inputs to production as goods and services change hands across the value chain. Value added is an alternative measure that does not double count and is synonymous with gross domestic product (GDP) or gross state product (GSP). It is a measure that more accurately reflects the value of production of goods and services within an economy as it captures the value of a good or service beyond the cost of inputs used in production. It includes wages, salaries, and benefits of employees; proprietor income; profits; and taxes. Labor income, a subset of value added, includes wages, salaries, and benefits of employees, and proprietor income. The relationship between output (sales), value added, and labor income is illustrated in Figure 28.

To model the industry's contribution to the state economy, we use the 2017 Arizona IMPLAN 3.1 model (IMPLAN Group LLC, 2019). Expenses of bearing and non-bearing acreage are modeled separately, net of taxes, as well as labor income and proprietor income of the industry. Additionally, we model income from other farm-related activities such as agritourism and tree nut processing. To account for leakages from the state economy due to purchase of non-local inputs, local purchase percentages were set to SAM (Social Accounting Matrix) values in the model. More detailed research methods are presented in the Appendix.

Tree nut grower expenditures vary over the course of the orchard life cycle. Initial investment in orchard establishment includes spending on irrigation infrastructure, land leveling and preparation, and trees. Once trees have started bearing a crop, growers incur annual harvest costs in addition to orchard maintenance costs. For this study, grower spending on inputs to production is estimated using bearing and non-bearing acreage figures and typical grower expenditure patterns from Cooperative Extension crop budgets. Some of the largest expenses for growers on an average, per-acre basis are custom and contract work, irrigation, fertilizers and chemicals, labor, and overhead.

Results of the analysis show that the tree nut industry's total economic contribution, including multiplier effects, was an estimated $113 million in gross state product and $190 million in sales in 2017 (Table 6). Note that the multiplier effects, combined, are greater than the direct effect, reflecting that fact that direct sales are not fully representative of the industry's economic contribution due to continued investment in new, non-bearing acreage. In total, the industry supported roughly 1,400 jobs, including on-farm jobs as well as jobs in industries supported through indirect and induced linkages. Total labor income supported, including employee compensation and business owner income, was $72.7 million.

Table 6. Arizona Tree Nut Economic Contribution Summary, 2017

Impact Type	Employment	Labor Income	GSP (Value Added)	Sales (Output)
Direct Effect	678	$35,297,000	$55,362,000	$92,560,000
Indirect Effect	378	$19,962,000	$26,285,000	$43,167,000
Induced Effect	380	$17,483,000	$31,591,000	$54,738,000
Total Effect	1,436	$72,742,000	$113,238,000	$190,466,000

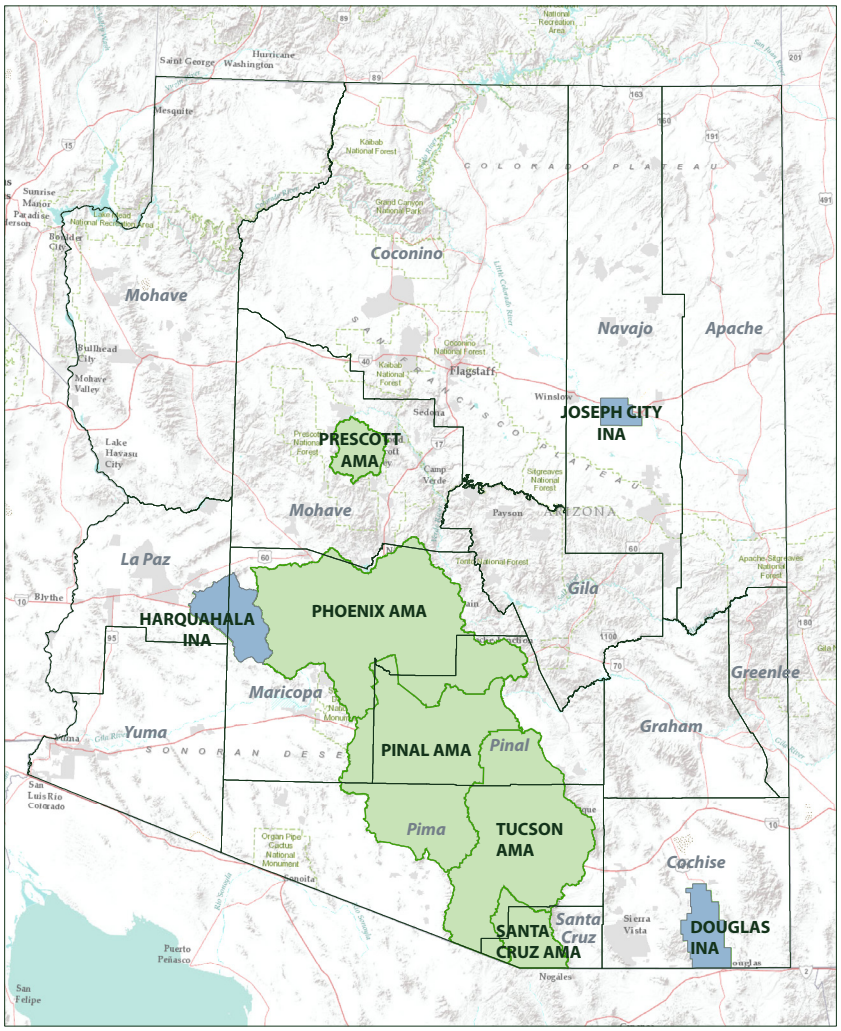
** Totals may not add due to rounding*

An estimated $6.6 million in state and local tax revenues were supported by the industry. Top industries supported, including direct, indirect, and induced effects, include support activities for agriculture and forestry, water sewage and other systems, and non-depository credit intermediation and related services.

Water and Environmental Context

This section of the report presents information on irrigation water use for tree nut production in Arizona. Much of Arizona's tree nut acreage resides in areas of the state that are not governed by Active Management Areas (AMAs) or Irrigation Non-Expansion Areas (INAs) under Arizona's 1980 Groundwater Management Act (Figure 29). Many of these also happen to be rural areas whose economies depend heavily on agriculture. Pecan and pistachio production in Arizona, combined, ranks within the state's top ten agricultural commodities by cash receipts. This gives rise to challenges around sustainable withdrawals of irrigation groundwater amongst competing users, meanwhile balancing the livelihoods of rural residents employed in agriculture and agriculture-linked industries, as detailed in the previous section. This section presents an estimate of statewide irrigation water use for tree nut production to contextualize discussions around trade-offs and implications of the industry's growth on water use sustainability. That considered, because of a lack of county-level acreage data, the report does not present county water use estimates and the results do not necessarily reflect conditions within individual basins.

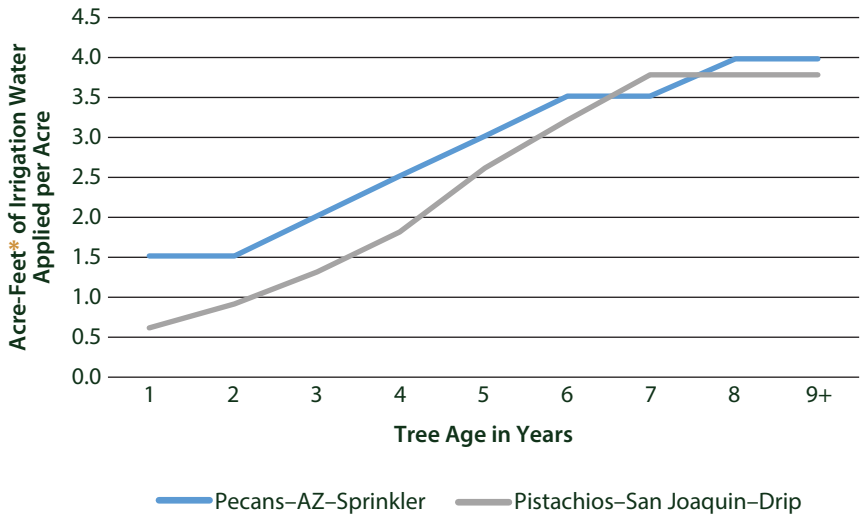
Figure 29. Arizona Groundwater Active Management Areas (AMAs) and Irrigation Non-Expansion Areas (INAs)



Unlike annual field crops which can be fallowed in times of drought or limited irrigation water availability, orchards represent years of investment and cannot simply be fallowed from one year to the next. Some water use flexibility can be achieved through a practice known as deficit irrigation. Research has shown that deficit irrigation can be used in pistachios in response to drought. If practiced during strategic times of the year, it may not significantly affect key stages, such as nut filling, bloom, and shell expansion (Goldhamer, 2005). Pecans, on the other hand, are more sensitive to water stress, with percent reductions in yield exceeding proportional decreases in plant water availability (Skaggs, et al., 2008). Some efficiencies may be achieved by soil moisture monitoring and optimizing irrigation scheduling to match pecan water needs during different stages of growth (Miyamoto, Henggeler and Storey, 1995; Kallestad, et al., 2006).

Irrigation technology used in Arizona tree nut orchards has shifted over time in consideration of these challenges. Early orchards in Arizona relied on flood irrigation. Today, newly planted orchards are almost exclusively installing drip and micro sprinkler irrigation to increase water use efficiency. Irrigation water needs of tree nut orchards gradually ramp up over time as trees establish and grow. Figure 30 shows two estimates of irrigation water required per acre by tree age, including pecans and pistachios under sprinkler and drip irrigation.

Figure 30. Tree Nut Irrigation Application Rates by Type and Tree Age



Source: Teegerstrom, 2014; Brar, et al., 2015
** An acre-foot is the amount of water required to cover one acre one foot deep in water.*

These water application rates are in line with estimates from Brown (2019) and data from the 2013 Farm and Ranch Irrigation Survey, which reports that for land in orchards in Arizona, average water application per acre is 3.6 AF/acre. By irrigation technology, water application rates are 3.5 AF/acre for sprinkler systems, 3.6 AF/acre for gravity, and 3.7 AF/acre for drip or micro sprinklers (USDA, 2014b).

Relying on these water use estimates and bearing and non-bearing acreage figures for 2017, we derive an estimate of statewide on-farm water use by the tree nut industry in Arizona (Table 7).

Table 7. Estimated Arizona Statewide Irrigation Application for Pecans and Pistachios, 2017

	Pecan		Pistachio		TOTAL[3]
	Bearing	*Non-Bearing*	*Bearing*	*Non-Bearing*	
Acreage[1]	16,629	9,358	4,972	3,933	34,892
Water Applied in Ft/Ac[2]	4.0	2.5	3.8	2.4	3.4
Est. Total Water Applied (AF)	66,516	23,395	18,894	9,341	**118,145**

1 *Source: USDA, 2019*

2 *Pecan water application rates from Teegerstrom, 2014. Rate for bearing acres for year 8 onward (4 AF/Ac). Non-bearing rate average of application rates for years 1 to 7 (2.5 AF/Ac). Pistachio water application rates from Brar, et al., 2015. Bearing application rate for years 7 onward (45 inches per acre per year). Non-bearing application rate proportional to pecan non-bearing versus bearing application rates (2.375 AF/Ac).*

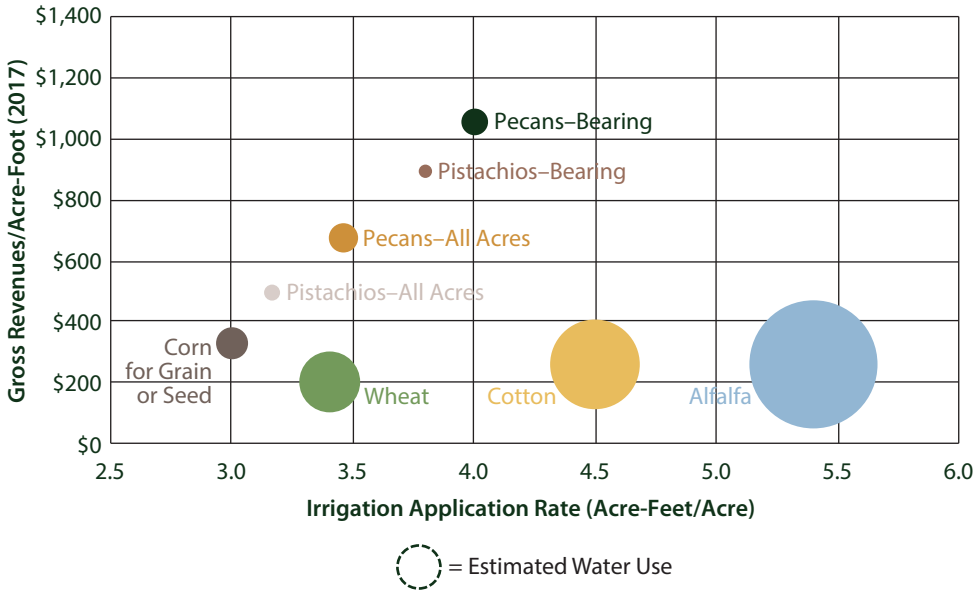
3 *Does not include orchard floor cover crops requiring irrigation.*

The total irrigation water use of the tree nut industry in Arizona was an estimated 118,145 acre-feet in 2017. This figure, however, does not tell us about the distributional impacts of water use throughout the state. A significant amount of the state's tree nut production occurs in groundwater dependent areas; much of the state's non-bearing acreage is also in these regions. As non-bearing acreage enters into production, tree water requirements increase. Therefore, with the large proportion of non-bearing acreage currently in Arizona, total water use for tree nut production can be expected to increase in the coming years, placing additional demands on groundwater resources. Increases in groundwater withdrawals can be expected to result in drops in depth to groundwater and increases in pumping costs. This has implications for orchards and other agricultural producers in tree nut producing areas, as well as nearby communities.

Compared with other crops in Arizona, average per-acre irrigation water application requirements for tree nuts rank just below the average of 4.4 AF applied per acre for irrigated cropland statewide (USDA, 2014b). An estimated total of 910,883 acres were irrigated in Arizona in 2017 (USDA, 2019). Figure 31 shows a comparison of different crops in Arizona plotted by their average irrigation application rate (X-axis), gross revenues per acre-foot of water applied in 2017[2] (Y-axis), and total estimated water applied in 2017 (area of circles). Pecans and pistachios are both plotted twice, with gross revenues per acre-foot and total water use calculated for all acreage (bearing and non-bearing), and for bearing acreage only.

Gross revenues per acre-foot of water applied for pecans and pistachios are roughly equal to or higher than major field crops in the state, when considering both bearing and non-bearing acreage. Considering only bearing acreage, gross revenues per acre-foot of water applied exceed $1,000 per acre-foot for pecans and $800 per acre-foot for pistachios. Gross revenues per acre-foot applied for major field crops in the state range between $200 and $400 per acre, on average.

Figure 31. Comparison of Gross Revenues per Acre-Foot of Applied Irrigation Water, by Crop and Acreage Harvested, 2017



Source: USDA, 2014b; USDA, 2019

2 Because when aggregated at the state level, pistachio production in Arizona exhibits a strong alternate bearing pattern, this calculation uses an average yield between on- and off-bearing years of 2,000 pounds per acre.

Discussion and Conclusions

Tree nuts rank as an important commodity within Arizona's agricultural economy. Arizona is the fourth largest producer of pecans and the second largest producer of pistachios in the U.S., as of 2017 and 2018. Cash receipts for these commodities are poised to grow in upcoming years as significant shares of new plantings enter into production. Both production and investment in new acreage contribute to the state's economy. This contribution was estimated at $113 million in gross state product and $190 million in sales in 2017. This economic activity supported an estimated 1,436 jobs in Arizona, including on-farm jobs as well as jobs in industries supported through indirect and induced linkages. Total labor income supported, including employee compensation and business owner income, was $72 million. Many of these jobs are supported in rural areas of the state.

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Appendix

Economic Contribution Analysis Methods

To model the economic contribution of Arizona's tree nut industry, state pecan and pistachio acreage were broken out into bearing and non-bearing acreage, and crop budget expenditures by bearing and non-bearing trees were applied to these acreage estimates accordingly. Crop budgets (Teegerstrom, 2014, and Brar, et al., 2015) were used to develop separate average crop budgets for bearing and non-bearing pecan and pistachio orchards. For non-bearing acreage, an average expenditure pattern was developed over non-bearing years, from planting up to bearing. While a more detailed estimate could be calculated using acreage by tree age, this data is not available. Therefore, an average per acre expenditure pattern was applied to all non-bearing acreage. All estimated expenditures were adjusted for inflation to 2017 dollars.

Proprietor income and profits were calculated using estimated cash receipts less producer expenditures on labor and intermediate inputs for bearing acreage, and the split between proprietor income and corporate profits was assumed to be 50% based on a rough share of in-state versus out-of-state farm ownership. Producer spending on taxes was excluded from the spending pattern as modeled but used to calculate proprietor income, corporate profits, and total state and local tax impact. Direct effects were modeled as cash receipts from crop sales and other farm-related income, less any income from custom work to avoid double counting since custom work is captured as a production expense.

For non-bearing acreage, economic contributions were modeled through the analysis-by-parts method using an industry spending pattern as the first indirect wave of spending via grower expenditures on intermediate inputs and labor (employee compensation). For bearing acreage, we employed the analysis-by-parts method to model intermediate expenditures with an industry spending pattern, and employee compensation and proprietor income using labor income changes.

Direct jobs were estimated using Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) annual average employment data for tree nut farming (NAICS 111335) for 2017 (BLS, 2018) and number of tree nut farming establishments (NAICS 111335) as a proxy for number of tree nut farm proprietors from the 2017 Census of Agriculture (USDA, 2019).

Indirect and induced multiplier effects were modeled using the 2017 IMPLAN 3.1 model (IMPLAN Group, LLC, 2019) for Arizona. As mentioned above, industry spending patterns were modified using crop budgets to reflect tree nut production practices in the southwest. In the case of modeling purchases of intermediate inputs, local purchase percentages were set to SAM (Social Accounting Matrix) model values.

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