

# **Agriculture in Graham and Greenlee Counties**

*An Economic Contribution Study*

**Ashley K. Bickel | Dari Duval | George Frisvold**



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## Executive Summary

### What's the issue?

Graham and Greenlee counties, located in eastern Arizona, are largely rural, with well-established agricultural industries. These notably include crop production along the Gila River and livestock grazing throughout the region's remote and rugged public lands.

- The significance of agriculture in the economies of these counties is not limited to on-farm production. By purchasing inputs such as seed, fertilizer, feed crops, and banking services, and by hiring labor, a “ripple” of economic activity is created in other industries that provide those goods and services. Additionally, households that derive their income from agriculture contribute to the local economy by purchasing everyday household goods and services. Economists call these *indirect* and *induced multiplier effects*.
- This study provides a summary of current agricultural production in Graham and Greenlee counties in 2017, the most recent year for which comprehensive data are available. The study also conducts separate economic contribution analyses for each county to characterize and quantify economic activity attributable to agriculture. These economic contributions include the direct contributions of agriculture, such as sales of crops and livestock products and employment in agricultural industries, as well as the contributions supported through indirect and induced multiplier effects.
- Finally, as the availability of irrigation water is critical for crop production in this region, this study considers the potential effects of hypothetical reductions in irrigation water supplies and estimates the reduction in acreage, on-farm sales, and the resulting effects on the Graham and Greenlee county economies.

### What did the study find?

*Graham County is primarily a crop-producing county while Greenlee County is primarily a livestock-producing county.*

- While beef cattle ranches are the most common type of farm in Graham County with 221 of the county's 448 total farms, 88% of the county's agricultural cash receipts in 2017 originated from crop sales and 12% from livestock sales. Crop production in the county is dominated by cultivation of cotton, alfalfa, and greenhouse commodities.
- In 2017, 75% of Greenlee County agricultural cash receipts originated from the sale of livestock and 25% from crop sales. Livestock production is dominated by cattle ranching, and beef cattle ranches are the most common type of farm, with 68 of the county's 123 total farms.

*Agricultural activities in the region reflect differences in geography and land ownership.*

- Of Graham County's 4,641 square mile land area, federal lands account for 37%, state lands account for 17%, and tribal lands within the San Carlos Apache Reservation account for 36% of the county's total land area. Of the county's total land area, approximately 43% is in farms.
- Of Greenlee County's 1,848 square mile land area, federal lands account for 77%, with a large proportion of county land falling within the Apache-Sitgreaves National Forest. State lands account for 15% of the county's total land area. Greenlee County is one of only three counties in Arizona (along with Cochise and Santa Cruz counties) without land in an Indian Reservation. Characterized by its rugged, mountainous terrain, Greenlee County has a relatively small proportion of land in farms (6%).



## Executive Summary

- Crop production in the region is primarily concentrated along the Gila River, in the Duncan Valley of Greenlee County and the Gila Valley of Graham County, near the city of Safford. Additionally, irrigated crop production also occurs in the southern part of Graham County in the Sulphur Springs Valley.
- Livestock production occurs throughout both counties, with many operations depending on federal lands for forage, particularly lands managed by the Forest Service and, to a lesser extent, the Bureau of Land Management.

### ***Nearly all crop acreage in the region is irrigated and agricultural irrigation is by far the largest water user in both counties.***

- Of the 43,056 acres of harvested cropland in Graham County in 2017, 98% is irrigated. There is an additional 1,183,759 acres of pastureland (land used for grazing livestock), although less than 1% is irrigated.
- Of the 3,279 acres of harvested cropland in Greenlee County in 2017, 100% is irrigated. There is an additional 59,714 acres of pastureland with 3% irrigated.
- Agricultural irrigation accounts for 96% and 60% of water use in Graham and Greenlee counties, respectively. Mining is a significant user of water, particularly in Greenlee County where it accounted for 29% of county withdrawals in 2015.

### ***Most farms in Graham and Greenlee counties are family- or individually-owned and are considered small scale, both in terms of acreage and sales.***

- Of 448 total farms in Graham County, more than three-quarters are family- or individually-held and most farms are considered small scale (farms with less than 10 acres or \$1,000 in sales). There are a small number of large farms in the county, accounting for the majority of county farm acreage and sales. In 2017, the top 6% of farms in Graham County accounted for 95% of county farm acreage and 82% of county agricultural sales.
- Of 123 farms in Greenlee County, a large majority (72%) are family- or individually-held and most are considered small scale (farms with less than 10 acres or \$1,000 in sales), though Greenlee County has a smaller proportion of farms with less than 10 acres (13% in Greenlee County compared to 46% in Graham County). Similar to Graham County, there are a small number of large farms that account for the majority of county farm acreage and sales. In 2017, the top 5% of farms in Greenlee County accounted for 67% of county acreage and the 4 farms with more than \$500,000 in sales accounted for 71% of total county sales.

### ***On-farm agriculture contributes to the Graham and Greenlee county economies directly through crop and livestock production as well as indirectly through multiplier effects.***

- In Graham County, on-farm agriculture directly contributed \$66.2 million in sales, \$15.0 million to the county's gross regional product, and supported 1,067 full- and part-time jobs corresponding to \$16.4 million in labor income in 2017.
- Including multiplier effects, the total contribution of on-farm agriculture to Graham County's economy in 2017 was \$84.3 million in sales, \$23.7 million in gross regional product, and \$20.6 million in labor income. Including multiplier effects, nearly 1,200 full- and part-time jobs were supported by agriculture in the county.

- In Greenlee County, on-farm agriculture directly contributed \$10.9 million to sales, \$5.5 million to gross regional product, and supported 225 full- and part-time jobs corresponding to \$3.8 million in labor income in 2017.
- Including multiplier effects, the total contribution of on-farm agriculture to Greenlee County's economy in 2017 was \$11.8 million in sales, \$6.2 million in gross regional product, and \$4 million in labor income. Including multiplier effects, 230 full- and part-time jobs were supported by agriculture in the county.

***Hypothetical reductions in water supply for agriculture and corresponding reductions in crop acreage have economic implications for the larger regional economy.***

- Considering a hypothetical water supply reduction of 27,436 acre-feet (AF), or 20% of current agricultural irrigation water use, Graham County producers would be estimated to fallow nearly 6,000 acres of cotton or 23% of 2017 cotton acreage, resulting in approximately 15,000 fewer bales of cotton and \$5.3 million in reduced cotton sales. Including indirect and induced multiplier effects, total sales reductions in Graham County would total \$6.6 million and correspond to approximately \$1.0 million less labor income, a decrease in Graham County's gross regional product of \$1.1 million, and 23 fewer jobs.
- Considering a hypothetical water supply reduction of 2,550 AF, or 20% of current agricultural irrigation water use, Greenlee County producers would fallow an estimated 440 acres of alfalfa or 18% of the county's 2017 hay acreage, resulting in approximately 1,900 fewer tons of alfalfa and approximately \$323,000 in reduced hay sales. Including indirect and induced multiplier effects, total sales reductions in Greenlee County would total nearly \$350,000 and correspond to \$98,500 less labor income, a decrease in Greenlee County's gross regional product by \$175,000, and 1 fewer job.

**How was the study done?**

- This study presents separate economic contribution analyses for Graham and Greenlee counties that characterize and quantify economic activity attributable to agriculture.
- Economic contributions were estimated using the IMPLAN 3.1 input-output data and software. The models were modified using data from the 2017 Census of Agriculture to more accurately reflect production practices and economic conditions in Graham and Greenlee counties in 2017. Data and research methods used for estimating the economic contribution of agriculture are presented in Appendix A.
- Contributions are reported by value of sales, value added (also known as gross regional product (GRP)), labor income, and the number of full- and part-time jobs supported.
- Using the same model, the study then examines potential regional economic effects of reduced crop production in Graham and Greenlee counties due to hypothetical reductions in irrigation water supplies. Hypothetical reductions reflect a 20% reduction in current irrigation water supplies for each county, with Graham County facing a hypothetical cutback of 27,436 AF and Greenlee County facing a hypothetical cutback of 2,550 AF. Crop budgets, water application rates, yields, and price data were used to identify crops for fallowing and estimate reductions in acreage and crop sales. Reductions in crop sales were then modeled in IMPLAN to estimate resulting decreases in regional economic activity.



## Introduction

This study examines the contribution of agriculture to the economies of Graham and Greenlee counties. Located in southeastern Arizona, these two counties once comprised a single county until the early 20th century. Despite being administratively independent today, they are still closely linked to one another. The counties maintain strong economic relationships through trade in goods and services, and through a labor force that travels between them for employment and access to goods and services. The economies of Graham and Greenlee counties have distinct characteristics, such as differences in their agricultural production. Graham County is crop-focused, with agricultural production dominated by cultivation of cotton, alfalfa, and greenhouse commodities. In contrast, Greenlee County's agricultural production is livestock focused, primarily in cattle ranching.

The study characterizes agricultural production in both counties, including the direct value of crop and livestock sales by commodity. It also considers economic activity supported indirectly in businesses connected with agriculture through input supply relationships, as well as spending at local businesses by people employed in agriculture. These “ripples” of economic activity that are stimulated in other local industries are referred to as *multiplier effects*. By estimating the multiplier effects of agriculture in Graham and Greenlee counties, we can characterize and quantify economic activity attributable to agriculture that occurs in other, non-agricultural industries.

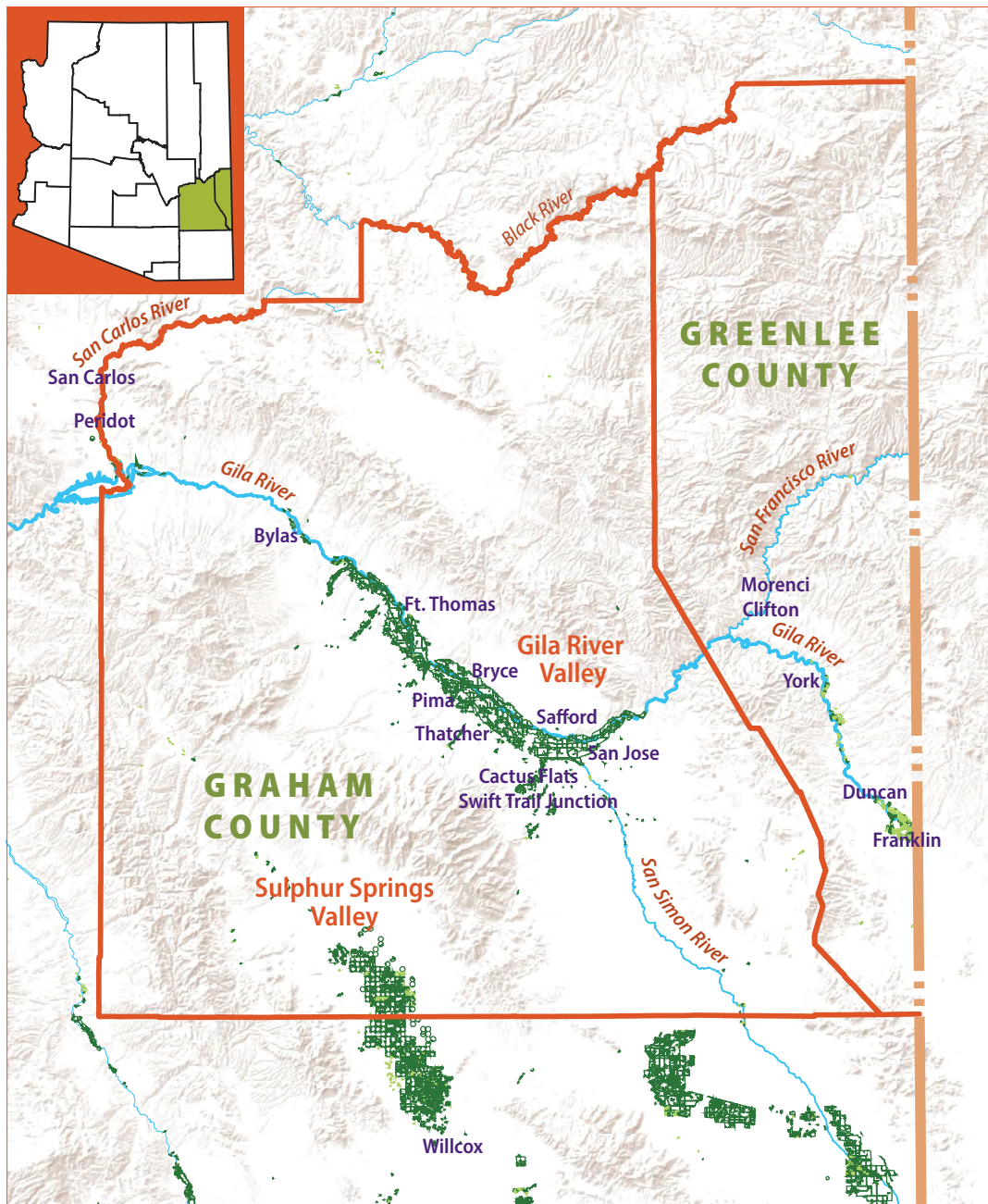
This report begins with a broad overview of the characteristics of Graham and Greenlee counties and the history of agriculture in the region. It then provides a comprehensive summary of current agricultural production, relying primarily on data from the 2017 Census of Agriculture, the most recent data available on agricultural production at the county level. Results from separate economic contribution analyses are then presented, one for each county. Contributions are reported by value of sales, value added (also known as gross regional product (GRP)), labor income, and the number of full- and part-time jobs supported. Finally, as the availability of irrigation water is critical for crop production in this region, the study considers the potential effects of hypothetical reductions in irrigation water supplies and estimates the corresponding reductions in acreage, on-farm sales, and the resulting effects on the Graham and Greenlee county economies.

## Background

### Regional Overview

Graham and Greenlee counties are located in southeastern Arizona, in a geographic and geologic region known as the Mexican Highland section of the Basin and Range province. This region has highly variable terrain and ecosystems, from high-elevation mountain ranges to broad flat basins and desert valleys, such as the Gila River Valley and the Sulphur Springs Valley (Banister et al., 2014; NPS, 2020).

Figure 1. Map of Graham and Greenlee Counties



Note: Green denotes areas of cropland.

## Background

About 46% of residents of the two counties live in rural areas (U.S. Census Bureau, 2010). In 2018, Graham County had a population of about 38,000 while Greenlee County's population was roughly 9,450 (U.S. Census Bureau, 2020). Population is generally concentrated along the Gila and San Francisco rivers. Population centers in Greenlee County include Clifton, Duncan, and Morenci. In Graham County, population is concentrated in the eastern part of the county, in Safford, Pima, and Thatcher.

Federal lands account for 77% of Greenlee County's 1,848 square mile area, the second highest share of federal lands<sup>1</sup> among Arizona counties (ESRI, 2019). The two primary federal agencies managing land in Greenlee County (as well as Graham County), are the Forest Service (FS) and the Bureau of Land Management (BLM). Most of Greenlee County falls within the Apache-Sitgreaves National Forest, located in the northern part of the county, where ranching is prevalent. In addition to federal land, 15% of Greenlee County is state land (Greenlee County AZ, 2020). Along with Cochise and Santa Cruz counties, Greenlee County is one of three counties in Arizona without land in an Indian Reservation (Arizona Commerce Authority, 2018). Graham County is significantly larger than Greenlee County with a land area of approximately 4,641 square miles. Federal lands account for a smaller share of Graham County, at 37% of the county's total land area (ESRI, 2019). Of this, Bureau of Land Management (BLM) lands account for approximately 24% and U.S. Forest Service (USFS) lands account for about 13%. State lands account for 17% of county land and, unlike Greenlee County, Graham County is home to portions of the San Carlos Apache Reservation, with tribal lands accounting for 36% of county land area (Figure 9) (Arizona Commerce Authority, 2018).

Once constituting a single county (Graham County), the counties separated in 1909, establishing Greenlee County (Greenlee County, AZ, 2020). Though separated by a political boundary, Graham and Greenlee counties are closely linked and act as a single functional economic market. Greenlee County's economy is heavily dependent on copper mining and mining-related industries, and is home to the largest copper producing mine in North America, the Morenci mine (Mining Technology, 2020). In comparison, major industries in Graham County include government, agriculture (specifically cotton production), and retail and service industries. In 2018, Greenlee County had estimated annual employment of 4,800 out of a population of 7,180 people between the ages of 25 and 64 years old (67%) (U.S. Bureau of Labor Statistics, 2020; U.S. Census Bureau, 2020). Meanwhile, Graham County had an estimated annual employment of 9,150 out of a population of 18,500 people between the ages of 25 and 64 years old (49%) (U.S. Bureau of Labor Statistics, 2020; U.S. Census Bureau, 2020). The higher employment-to-working-age population in Greenlee County suggests that it imports labor from Graham County. This is also supported by data on commuter patterns. An estimated 20% of workers in Greenlee County are commuters from Graham County (U.S. Census Bureau, 2015). While many individuals living in Graham County commute to Greenlee County for work, Greenlee County residents rely on Graham County for access to retail and service providers. Retail businesses are more prevalent in Graham County with 81 retail trade establishments operating in the county in 2018, while in Greenlee County there were only 13 (U.S. Bureau of Labor Statistics, 2020).

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<sup>1</sup> Federal lands include lands owned by the Forest Service, Department of Defense, Bureau of Land Management, Fish and Wildlife Service, National Park Service, Bureau of Indian Affairs, Bureau of Reclamation, and other federal agencies. These figures do not include state lands or tribal lands.

Similarly, areas of southwest Graham County known as the Sulphur Springs Valley are economically linked with Cochise County, the county to the south (Figure 1). This is due to proximity to the town of Willcox in Cochise County and the geographic isolation from other areas of Graham County due to large mountain ranges. In particular, farms in the Sulphur Springs Valley depend on a labor force residing primarily in Cochise County. The economic implications of this regional connectivity are presented later in the report.

With both counties located primarily within the Upper Gila Watershed, the Gila River and its tributaries play an important role in the region and its history. This is especially true for agricultural production. Originating in the Mogollon Mountains of southwestern New Mexico, the Gila River flows west, entering Arizona near the town of Duncan in Greenlee County. Flowing intermittently through the Safford Valley, it joins with the San Carlos River and is then impounded at Coolidge Dam creating the San Carlos Reservoir, located on the San Carlos Apache Indian Reservation. Described later in this section, Coolidge Dam and management of the Gila River play critical roles in sustaining agricultural activity in Graham and Greenlee counties.

In Greenlee County, irrigated crop production is concentrated in the Duncan Valley. In Graham County, irrigated crop production is concentrated in the Gila Valley near the city of Safford, as well as in the southern part of the county, in the Sulphur Springs Valley (Figure 1) (Banister et al., 2014).

Ranching occurs throughout both counties, with many operations depending heavily on federal lands for forage, particularly lands managed by the Forest Service and the Bureau of Land Management. Ranching on public lands presents a series of unique considerations for producers. Wildland fire is one issue that affects livestock producers, particularly those operating in forested areas. Greenlee County has been significantly impacted by wildland fire in recent years. In the summer of 2011, the Wallow Fire burned a large portion of the Apache-Sitgreaves National Forest in Greenlee and Apache counties. As one of the largest fires in the state's history, grazing activity was disrupted for livestock producers who were forced to flee and move livestock to safety. Additionally, grazing on public or state lands requires coordinating with one or many land managers, complying with federal or state regulation, obtaining permits, and paying fees (Teegerstrom & Tronstad, 2016).

### **History of Agriculture in the Region**

Agriculture has a long history in the region, with archaeological evidence of agricultural fields and irrigation canal systems in the Safford area dating back to before the 1400s and as early as AD 800 (Neely, 2001). These prehistoric canals were constructed along the Gila River to divert the river's perennial flows, as well as carved into the foothills of the Pinaleño mountains to deliver water from natural springs and mountain precipitation run-off (Neely, 2001; Banister, et al., 2014). When Anglo settlers began to arrive in the 1860s, the region had been inhabited for several hundred years by different bands of Apaches who cultivated crops along the Gila River and its tributaries and migrated seasonally throughout the area harvesting native plants and animals (Banister, et al., 2014). Further downstream on the Gila River, in Central Arizona, the Pima and Maricopa tribes had a more sedentary, agrarian lifestyle and had developed an extensive system of irrigation canals, producing significant amounts of wheat, squash, melons, and other vegetables (Introcaso, 1986).

The introduction of Anglo settlers to the region triggered numerous conflicts with native inhabitants, not least of which was the allocation of Gila River water for agriculture. When Anglo settlers arrived, they began diverting Gila River water for crop irrigation, utilizing and building upon several of the existing



## Background

prehistoric canals (Neely, 2001; Banister, et al., 2014). As early as 1873, settlers in the Upper Gila River Valley (Graham County) began to divert Gila River flows for irrigation and by 1890 had approximately 16,000 acres of irrigated cropland (Introcaso, 1986). In the 1870s and 1880s, commercial ranching also began to take hold in the region, relying on native vegetation for livestock grazing (Banister et al., 2014).

Coupled with greater diversions of Gila River water and a multi-year drought in the late 1880s and early 1890s, agricultural water demand had reached an unsustainable level. Diversions in the Upper Gila River Valley often resulted in insufficient water for irrigation lands downstream, particularly native lands cultivated by the Pima and Maricopa tribes, but also lands irrigated by non-Indian senior water rights holders in Central Arizona. Meanwhile, exacerbated by drought conditions at the time, large-scale ranching operations contributed to overgrazing, resulting in a significant contraction of livestock inventory in the region (Banister, et al., 2014; U.S. Fish and Wildlife Service, 2014). Overgrazed lands in the U.S. southwest were often later obtained by the federal government to become part of the National Forest system (U.S. Fish and Wildlife Service, 2014).

In an attempt to satisfy all demands on the Gila River, Congress authorized the construction of Coolidge Dam in 1924 and the dam was completed in 1928 (Kipple, 1971; Introcaso, 1986). The dam, located on the San Carlos Apache Reservation and managed and operated by the Bureau of Indian Affairs (BIA), would store floodwaters that could subsequently be released to downstream users and reduce the need to limit diversions upstream (Feller, 2007).

In anticipation of the completion of Coolidge Dam, the United States brought about litigation in 1925 on behalf of downstream users to determine rights on the Gila River and provide protocols for the operation of the dam (Feller, 2007). A decade later, in 1935, the parties reached a settlement known as the Globe Equity Decree (Decree) (*U.S. v. Gila Valley Irrigation District*, 1935). Broadly, the Decree determined water rights on the Gila River from its headwaters to its confluence with the Salt River west of Phoenix, dividing water between users upstream of the dam (in Hidalgo County, New Mexico and Greenlee and Graham counties, Arizona) and users downstream of the dam (in Gila and Pinal counties, Arizona). The Decree explicitly determined priority dates for each water right, allowed for the storage of water in the San Carlos Reservoir behind Coolidge Dam, established the authority of the Gila River Water Commissioner to regulate diversions on the river, and stipulated that the total allowable diversion in a given irrigation season could not exceed 6 acre-feet (AF) per acre (*U.S. v. Gila Valley Irrigation District*, 1935; Feller, 2007). It is through this decree that the Gila River Indian Community, downstream in Pinal County, was awarded 210,000 acre-feet of water with an immemorial priority date and the San Carlos Apache Reservation, in northwestern Graham County, was awarded 6,000 acre-feet with a priority date of 1846.

An important provision of the Decree stipulated that upstream users would be permitted to make diversions from the natural flow of the Gila River equivalent to the amount of water stored in the reservoir, disregarding priority dates (*U.S. v. Gila Valley Irrigation District*, 1935; Feller, 2007). These apportioned rights to Gila River water are determined by the Gila Water Commissioner at the beginning of the calendar year or soon thereafter, with additional apportionments being made as availability of stored water permits. If not for this stipulation, many of the upstream water users in Graham and Greenlee counties could face limited ability to irrigate in dry years because their water rights would be considered junior to the Gila River Indian Community's immemorial water rights, the San Carlos Apache Reservation's 1846 rights, as well as the non-Indian lands downstream with priority dates of 1916.

While the Globe Equity Decree is the most significant regulation addressing water rights in this stretch of the Gila River, many other court cases and agreements affect the water management in the Upper Gila Watershed. These include the San Carlos Apache Tribe Water Rights Settlement Act of 1992, the Arizona Water Rights Settlement Act of 2004, the Upper Valley Forbearance Agreement in 2007, and the Gila River General Stream Adjudication—a court case that began in 1974 and still continues today, marking it the largest and longest judicial proceeding in the history of Arizona (Banister, et al., 2014; Feller, 2007; U.S. v. GRIC, 2017).

While agricultural irrigation is by the far the largest water user in both counties (96% in Graham County and 60% in Greenlee County), mining is a significant user of water, particularly in Greenlee County, where it accounted for 29% of county withdrawals in 2015 (Dieter, et al., 2018). Agreements between mining and agricultural users in the region exist to free up water supplies when not required for mining activities. In this regard, agricultural production in the region is partially dependent on the mining industry.

Adjudication of water rights has and will continue to play a critical role in the region's agricultural production. In addition to these legal proceedings, other factors such as population growth and climate variability introduce uncertainty about future water supplies in the region. This study presents an economic contribution analysis to establish a baseline understanding of the region's agricultural economy, and provide a "snapshot" of current economic activity attributable to agricultural production. Additionally, the study estimates the potential regional economic effects of reduced crop production in Graham and Greenlee counties due to hypothetical reductions in irrigation water supplies.

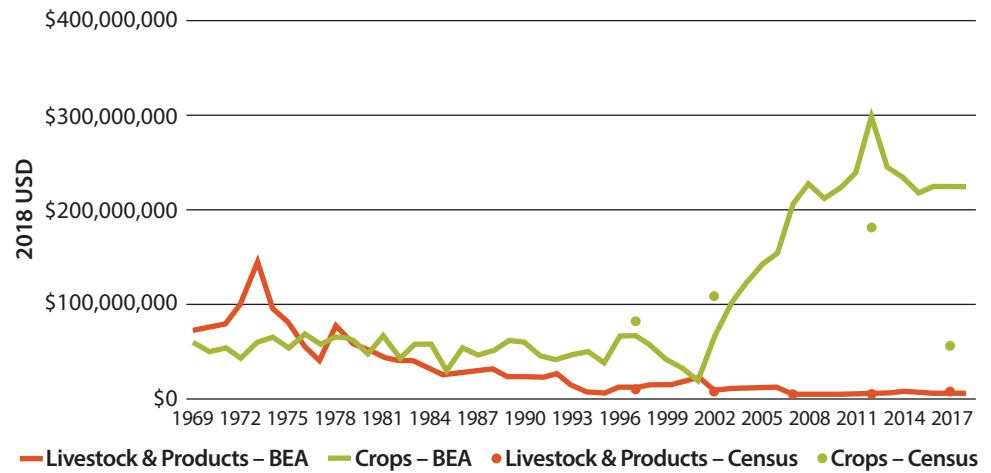
To begin, the following two sections provide a comprehensive summary of current agricultural production in Graham and Greenlee counties, relying primarily on data from the 2017 Census of Agriculture, the most recent data available on agricultural production at the county level.

## Graham County Agriculture

### Overview

Graham County is a crop-dominant county, with 88% of county agricultural cash receipts in 2017 originating from crop sales and 12% from livestock sales (U.S. Department of Agriculture, 2019a). While cash receipts were once more evenly split between livestock and crops, Graham County has been crop-dominant since the 1980s (Figure 2).

Figure 2. Graham County Agricultural Cash Receipts from Crops and Livestock, 1969–2018

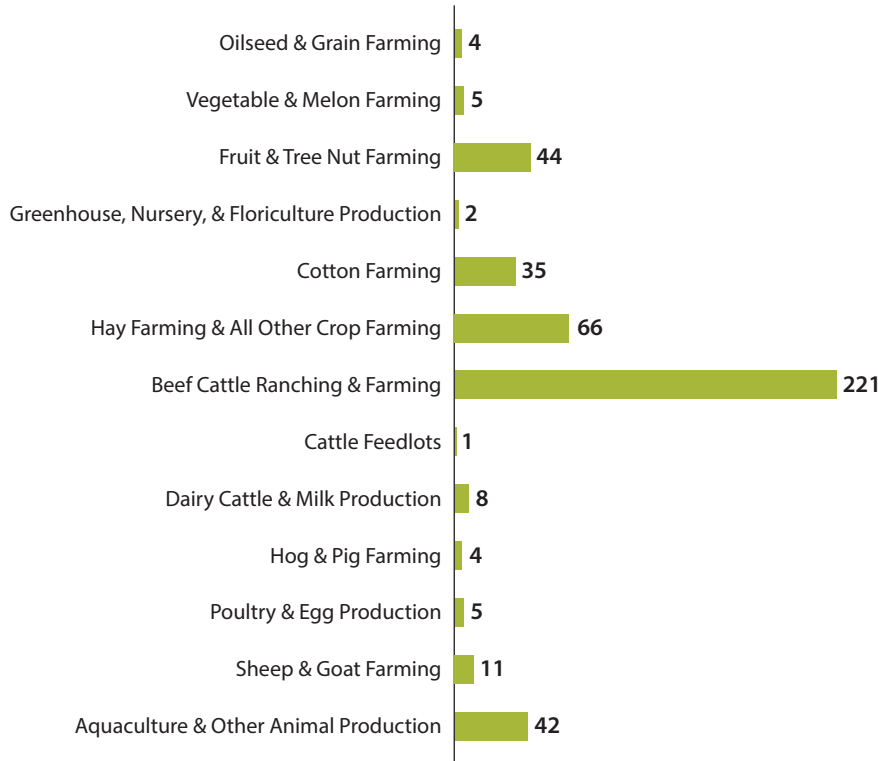


Source: USDA (2019a); BEA (2019b)

In 2017, there were 448 farms in Graham County, covering 43,056 acres of harvested cropland (98% irrigated) and 1,183,759 acres of pastureland (less than 1% irrigated) (U.S. Department of Agriculture, 2019a). With more than 2,000 square miles of the county’s 4,641 square mile land area in farms (either crops or grazing), approximately 43% of Graham County land is in farms.

Farms are classified by the type of agricultural products they produce using the North American Industry Classification System (NAICS) codes. When a farm or ranch produces more than one agricultural product, they are classified by the product that constitutes more than 50% of their sales. The most common type of farm in Graham County is beef cattle ranches, with 221 farms. This is followed by hay and all other crop farming (66 farms), fruit and tree nut farming (44 farms), and aquaculture and other animal production (42 farms). This last category includes operations where animal products account for a majority of farm sales, but no single, specific animal product accounts for most sales (Figure 3).

Figure 3. Graham County Farms by Industry NAICS Code



Source: USDA (2019a)



In 2017, Graham County had \$62.1 million in agricultural sales. Major agricultural commodities by sales included cotton and cottonseed (\$28.5 million), grains, oilseeds, dry beans, and dry peas (\$14.2 million), cattle and calves (\$6.8 million), nursery, greenhouse, floriculture, and sod, as well as fruits, tree nuts, and berries (sales data not disclosed to prevent identifying individual operations) (Table 1).

**Table 1. Graham County Sales and Farms by Commodity, 2017**

Commodity	Sales (\$1,000s)	Farms
<b>Total</b>	<b>62,074</b>	<b>448</b>
<b>Crops</b>	<b>54,751</b>	<b>145</b>
Grains, oilseeds, dry beans, and dry peas	14,220	21
Corn	9,590	6
Wheat	995	10
Barley	1,104	4
Other grains, oilseeds, dry beans, and dry peas	2,436	4
Cotton and cottonseed	28,479	39
Vegetables, melons, potatoes, and sweet potatoes	11	5
Fruits, tree nuts, and berries	(D)	44
Nursery, greenhouse, floriculture, and sod	(D)	4
Other crops and hay	2,458	70
<b>Livestock, poultry, and their products</b>	<b>7,323</b>	<b>200</b>
Poultry and eggs	(D)	29
Cattle and calves	6,759	153
Milk from cows	—	—
Hogs and pigs	59	14
Sheep, goats, wool, mohair, and milk	(D)	4
Horses, ponies, mules, burros, and donkeys	215	31
Aquaculture	(D)	1
Other animals and other animal products	37	10

Source: USDA (2019a); (D) – Not Disclosed

The following sections examine the commodities produced in Graham County in more detail.

### Crops

Graham County’s top crop by acreage and sales value is cotton. In 2017, there were 39 farms growing cotton on more than 26,000 acres (Table 2). The majority of producers in Graham County were growing upland cotton, harvesting nearly 17,000 acres of upland cotton on 27 farms. There were also 9,200 acres of Pima cotton harvested on 21 farms (Table 2). Graham County is the largest producer of Pima cotton in the state, producing 20,200 bales, accounting for approximately two-thirds of Arizona’s production.

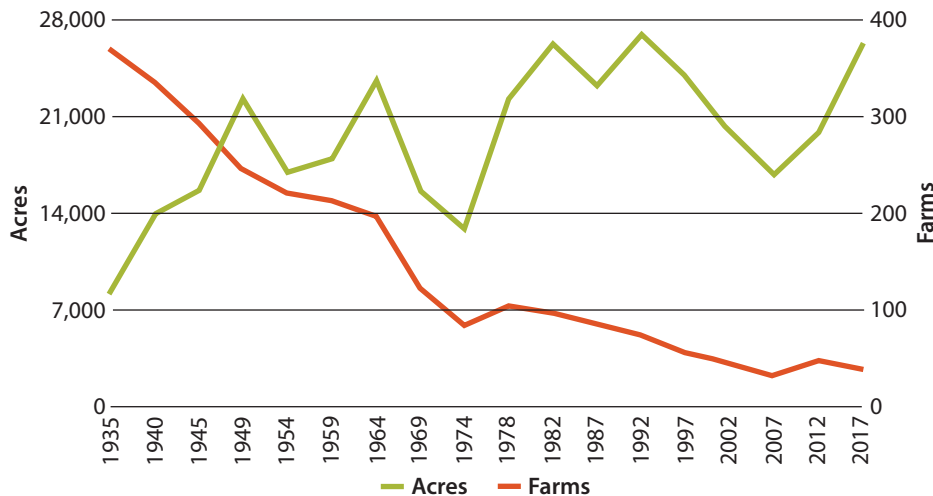
Cotton has played a prominent role in Graham County agriculture for many years. Over time, cotton production has consolidated from nearly 370 farms in 1935 to fewer than 50 farms in 2017 (Figure 4). Acreage, however, has increased over that same period, from approximately 8,300 acres to more than 25,000 acres in 2017. From 1992 to 2007 cotton acreage declined, but has since rebounded to near-historic highs, over 26,000 acres (Figure 4).

**Table 2. Farms and Acres Harvested for Selected Crops in Graham County, 2017**

Commodity	Farms	Acres	Production
Hay (including alfalfa)	108	3,974	19,006 dry tons
Barley for grain	4	1,459	233,628 bushels
Corn for grain	6	5,156	1,215,244 bushels
Cotton (all)	39	26,179	63,457 bales
Upland cotton	27	16,943	43,248 bales
Pima cotton	21	9,236	20,209 bales
Dry edible beans	4	2,083	55,871 cwt
Sorghum for grain	6	228	(D)
Wheat for grain	10	1,492	155,292 bushels
Grapes	11	107	Data not available
Peaches	14	40	Data not available
Pecans	21	98	Data not available
Pistachios	12	801	Data not available

Source: USDA (2019a)

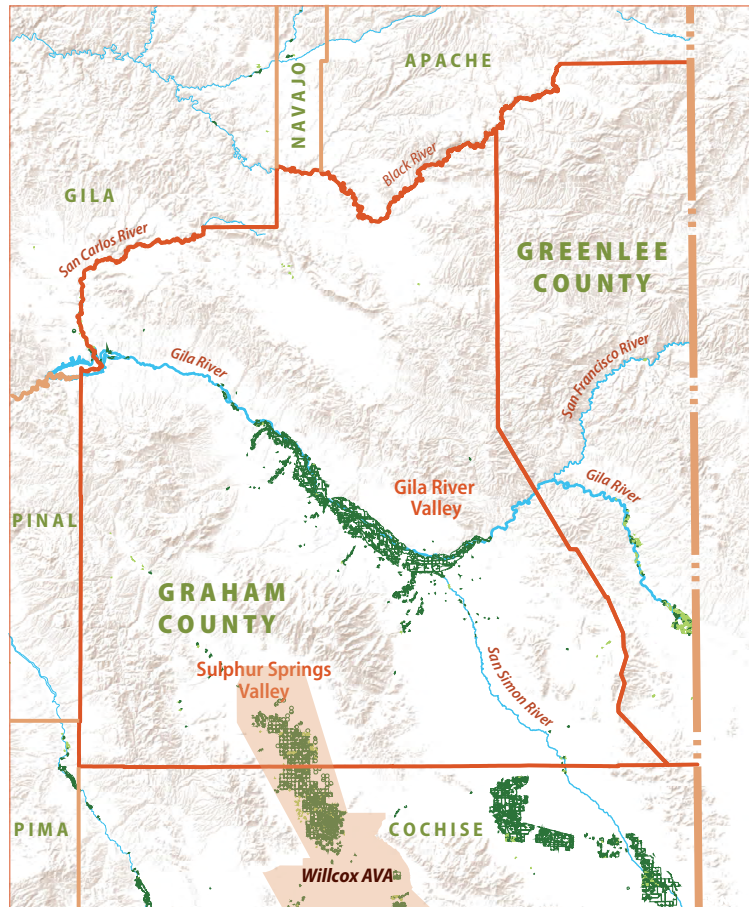
**Figure 4. Cotton Farms versus Cotton Acreage in Graham County, 1935–2017**



Source: USDA Census of Agriculture, various years

With sales of \$28.5 million in 2017, cotton accounted for more than 50% of Graham County’s crop sales (Table 1). Sales originated from 39 farms, and 35 farms were classified as specializing in cotton production (Table 1 and Figure 3). By value of cotton sales, Graham County ranks second in the state, behind Pinal County, and 56th (top 10%) in the nation among all counties producing cotton. Graham County has two cotton gins supporting the region’s cotton producers (U.S. Bureau of Labor Statistics, 2020), and the Gila Valley has a grower-owned cooperative in existence since the 1940s that provides cotton ginning for its members.

Figure 5. Graham County and Willcox American Viticultural Area (AVA)



Sales of grains, oilseeds, dry beans, and dry peas accounted for another 25% of Graham County’s crop sales in 2017, most of which was corn production (Table 1). There were 6 farms with nearly 5,200 acres that produced more than 1.2 million bushels of corn for grain (Table 2). Sales of corn in 2017 were \$9.6 million (Table 1). Other field crops produced in this category include barley, wheat, dry peas, and other grains such as sorghum. There were nearly 1,500 acres in barley and wheat, yielding 234,000 and 155,000 bushels, respectively, and accounting for about \$2.0 million in sales (Tables 1 and 2). With 4 farms producing roughly 56,000 hundredweight of dry beans<sup>2</sup> on 2,100 acres, Graham County accounts for about 42% of Arizona’s production of dry edible beans (Table 2). Much of this crop production occurs outside of the Gila Valley, primarily in the northern extent of the Sulphur Springs Valley.

Other top crops produced in Graham County include nursery, greenhouse, floriculture, and sod, as well as fruits, tree nuts, and berries, though sales data for these commodity groups are not disclosed in 2017 (Table 1). Similar to the field crops described above, much of this crop production occurs outside of the Gila Valley, in the Sulphur Spring Valley.

Like its southern neighbor Cochise County, Graham County has a growing wine and tree nut industry. The southern part of Graham County is considered part of the Willcox American Viticultural Area (AVA), an area that has been designated and recognized as a wine grape growing region (Figure 5). Between 2012 and 2017, there were 10 new farms producing grapes in the county and, as of 2017, Graham County had 107 acres of grape production (U.S. Department of Agriculture, 2019a).

In 2017, Graham County also had 33 farms with 899 acres of tree nut production, most of which were producing pistachios (U.S. Department of Agriculture, 2019a). In fact, of the 899 acres in tree nuts in Graham County, 801 acres (89%) were pistachio acreage. While most of Arizona’s pistachio acreage occurs in neighboring Cochise County, in 2017 Graham County accounted for 22% of Arizona’s pistachio acreage (Duval, et al., 2019; U.S. Department of Agriculture, 2019a). The county’s total tree nut acreage data is not disclosed in the 2012 or 2007 Censuses, but the growth of the industry is highlighted by reported bearing acreage in 2007 and 2017. In one decade, bearing acreage increased from 233 acres to 723 acres, an increase of more than 200% (U.S. Department of Agriculture, multiple years).

<sup>2</sup> Dry edible beans exclude chickpeas, dry edible peas, lima beans, or southern (black eyed/ cowpeas).

One last key component of crop production in Graham County is greenhouse production. There were a reported 4 farms in the county engaged in nursery, greenhouse, floriculture, and sod production in 2017. Because of data privacy issues, production estimates within this category are not disclosed due to the influence of one large producer in the county. While data suggest the scale of production at this facility has decreased in recent years, its production of greenhouse vegetables has had a major impact on the county's aggregate crop production over time. That said, the facility falls within a region of the county that is geographically isolated from population centers in Graham County and is primarily linked economically to communities in Cochise County. Details of estimating greenhouse production and employment in the county are presented in Appendix C.

### Livestock

Graham County's top livestock product by inventory and value of sales is cattle and calves. In 2017, there were 260 farms raising cattle with more than 13,700 head (Table 3). Only 153 of the 260 farms had sales in 2017, which were valued at nearly \$6.8 million (Table 1). Farms with cattle sales are also the most common type of operation in the county, accounting for 221 of the county's total 448 operations (Figure 3). Sales of cattle and calves accounted for 92% of total livestock sales in Graham County. Other livestock products include horses, ponies, mules, burros, and donkeys (\$215,000 in sales), hogs and pigs (\$59,000), other animals and animal products (\$37,000), poultry and eggs (sales data not disclosed), and sheep, goats, wool, mohair, milk (sales data not disclosed) (Table 1).

**Table 3. Farms and Inventory for Selected Livestock Products in Graham County, 2017**

Commodity	Farms	Inventory
Cattle and calves	260	13,759
Hogs and pigs	12	650
Sheep and lambs	7	255
Goats	21	296
Horses and ponies	134	1,229
Layers (poultry)	60	1,454

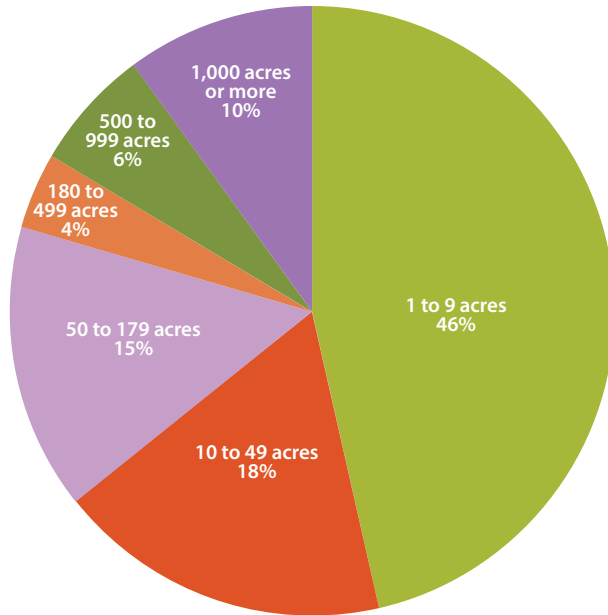
Source: USDA (2019a)



### Farm Characteristics

By acreage, most farms in Graham County would be considered small. Approximately 46% of farms had less than 10 acres and 18% had between 10 and 49 acres (Figure 6). That said, the average farm size in Graham County in 2017 was 2,880 acres, significantly larger than the national average of 441 acres. This is because there are a small number of very large farms in the county. In fact, about 10% of farms had 1,000 acres or more and the top 6% of farms by size accounted for 95% of county acreage (U.S. Department of Agriculture, 2019a).

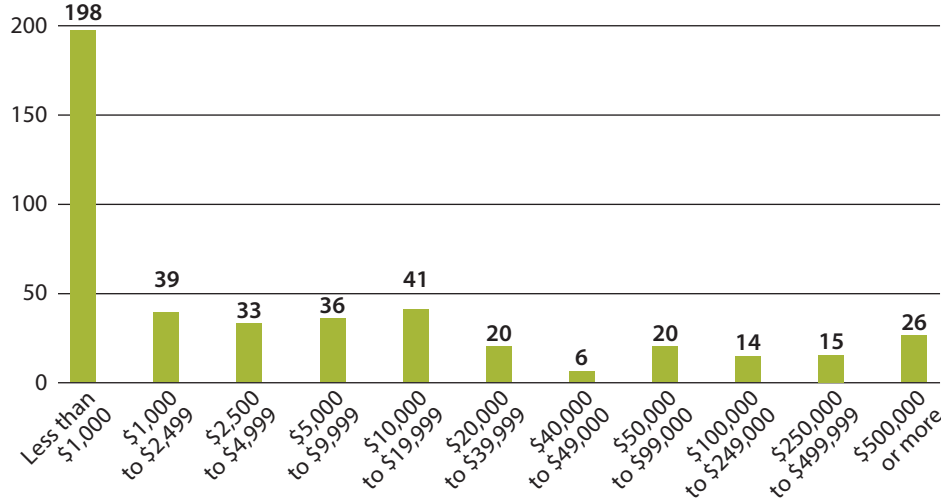
Figure 6. Graham County Farms by Size



Source: USDA (2019a)

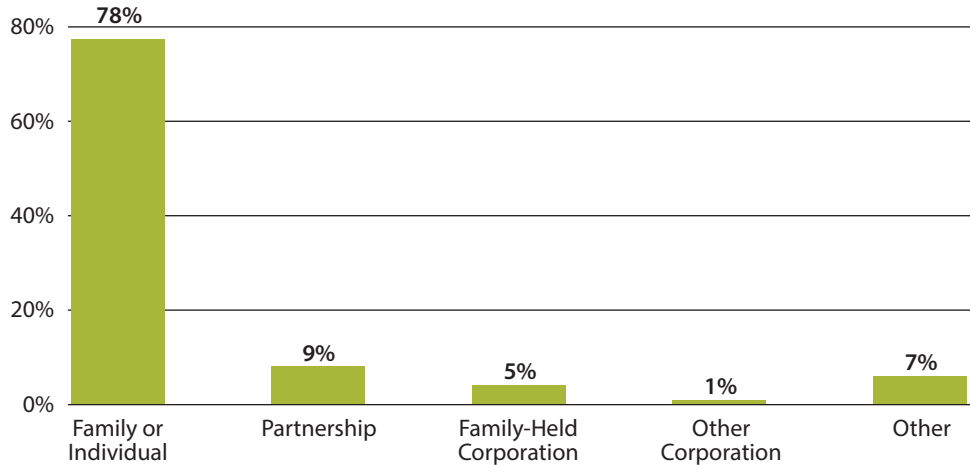
Of 448 total farms, most farms (198) had less than \$1,000 in sales. There were 26 farms that had more than \$500,000 in sales and accounted for approximately 82% of county sales (Figure 7). By legal structure and organization, more than three-quarters of Graham County farms were family- or individually-held, 9% were partnerships, 5% were family-held corporations, and 1% were non-family-held corporations (Figure 8). Another 7% were classified as other, which may include estates or trusts, prison farms, grazing associations, or American Indian reservations (Figure 8).

**Figure 7. Graham County Farms by Market Value of Agricultural Products Sold and Government Payments**



Source: USDA (2019a)

**Figure 8. Graham County Farms by Legal Organization**



Source: USDA (2019a)

## Graham County Agriculture

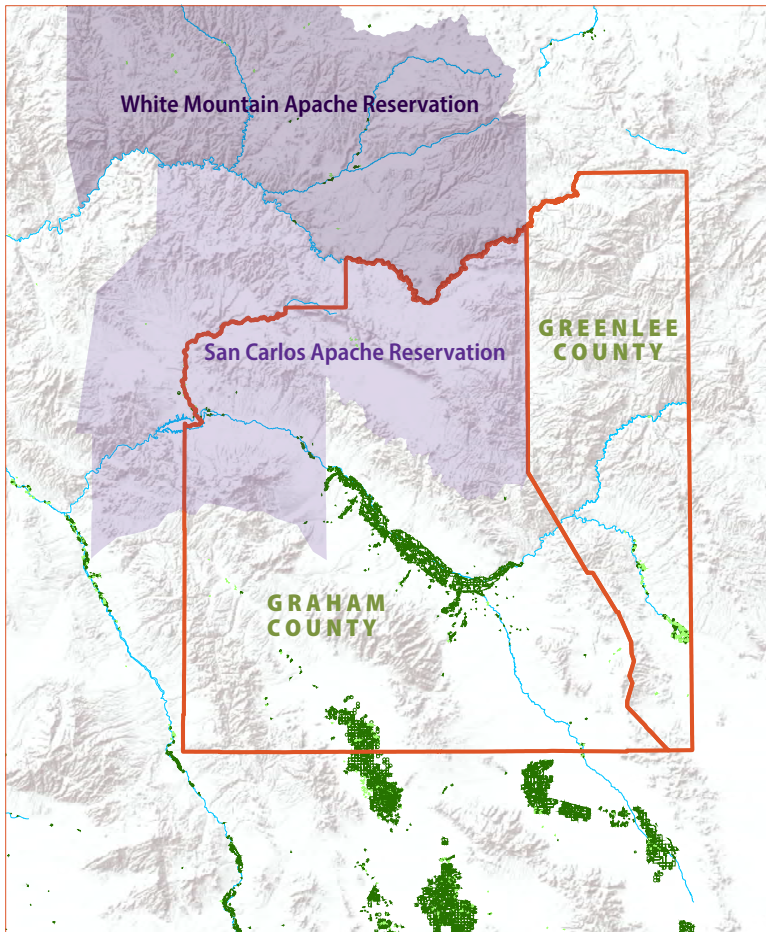
The majority (55%) of Graham County's 448 farms were operated by a single producer. That said, the total number of producers in Graham County in 2017 was 742<sup>3</sup> (U.S. Department of Agriculture, 2019a). Approximately 64% of producers are male and 36% are female. As of 2017, the average producer age in Graham County was 59.9 years old and 80% of producers reported their race as white, followed by 18% as American Indian or Alaska Native.<sup>4</sup>

### Tribal Agriculture

As mentioned previously, Graham County encompasses a portion of the San Carlos Apache Reservation, which spans into portions of southeastern Gila County and eastern Pinal County (Figure 9). Statistics reported below represent production within the entire tribal area; therefore production occurring within Graham County is only a portion of the San Carlos Apache Reservation totals reported below.

A total of 198 farms operated on the San Carlos Apache Reservation in 2017. Of these 198 farms, 187 were between 1 and 9 acres in size and 169 farms sold less than \$1,000 in agricultural products. Nearly all operations (193 farms) had inventory of cattle and calves, while only 66 farms sold cattle. Most cattle production within the San Carlos Apache Reservation is of beef cattle (U.S. Department of Agriculture, 2019b).

Figure 9. Map of San Carlos Apache Reservation and Graham County



<sup>3</sup> A producer is anyone that is involved in decisions for the operation (such as planting, harvesting, livestock management, or marketing) and can include the owner, a member of the owner's household, a hired manager, a tenant, a renter, or a sharecropper. More detail on agricultural producers is presented in Appendix B.

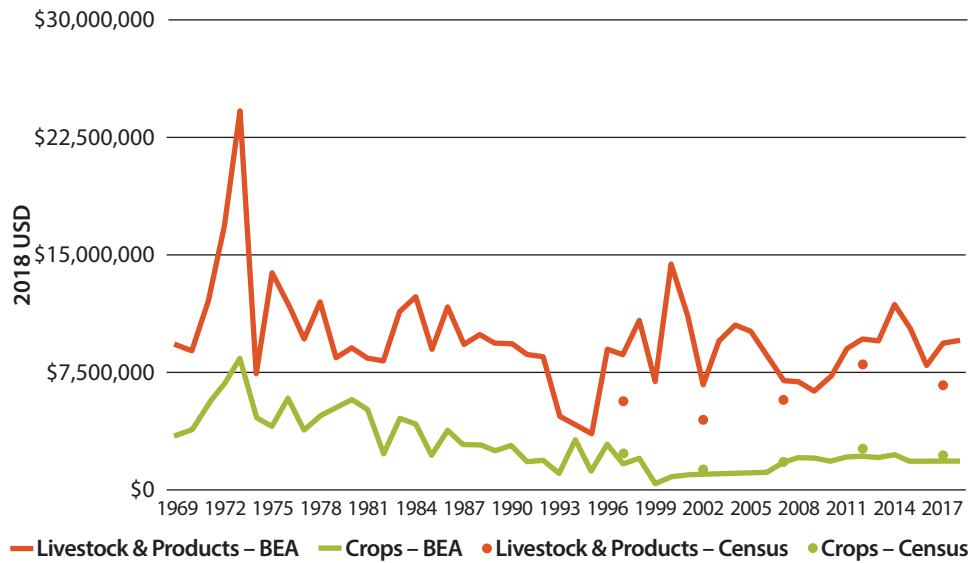
<sup>4</sup> These statistics reflect the gender and race background for up to 4 producers per farm.

## Greenlee County Agriculture

### Overview

Unlike Graham County, Greenlee County has continually been a livestock-dominant county by value of sales, with 75% of county agricultural cash receipts originating from the sale of livestock and 25% from crops in 2017 (U.S. Department of Agriculture, 2019a) (Figure 10).

Figure 10. Greenlee County Agricultural Cash Receipts from Crops Livestock, 1969–2018



Source: USDA (2019a); BEA (2019b)

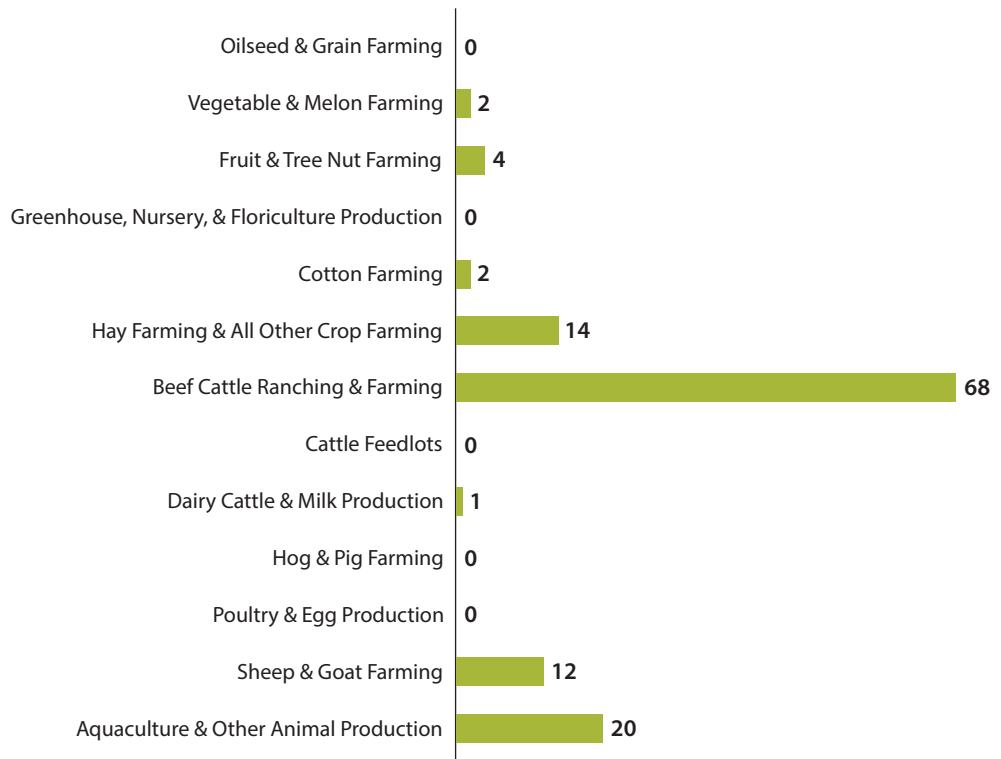


## Greenlee County Agriculture

There were 123 farms in Greenlee County in 2017, covering 3,279 acres of cropland (100% irrigated) and 59,714 acres of pastureland (3% irrigated) (U.S. Department of Agriculture, 2019a). Characterized by its rugged, mountainous terrain, Greenlee County has a relatively small proportion of land in farms (6%).

The most common type of farm in Greenlee County is beef cattle ranching and farming operations, with 68 farms (Figure 11). This is followed by aquaculture and other animal production (20 farms), which includes farms where no single type of livestock accounts for more than 50% of farm sales, and hay and all other crop farming (14 farms).

**Figure 11. Greenlee County Farms by Industry NAICS Code**



Source: USDA (2019a)

Greenlee County had approximately \$8.7 million in agricultural sales in 2017 (Table 4). Major commodities by sales include cattle and calves (sales data not disclosed to prevent identifying individual operations) and other crops and hay (\$1.9 million) (Table 4).

**Table 4. Greenlee County Sales and Farms by Commodity, 2017**

Commodity	Sales (\$1,000s)	Farms
<b>Total</b>	<b>8,689</b>	<b>123</b>
<b>Crops</b>	<b>2,164</b>	<b>20</b>
Grains, oilseeds, dry beans, and dry peas	(D)	2
Corn	(D)	2
Cotton and cottonseed	(D)	3
Vegetables, melons, potatoes, and sweet potatoes	(D)	2
Fruits, tree nuts, and berries	11	5
Nursery, greenhouse, floriculture, and sod	(D)	2
Other crops and hay	1,857	16
<b>Livestock, poultry, and their products</b>	<b>6,526</b>	<b>79</b>
Poultry and eggs	4	15
Cattle and calves	(D)	61
Milk from cows	(D)	1
Hogs and pigs	(D)	2
Sheep, goats, wool, mohair, and milk	79	10
Horses, ponies, mules, burros, and donkeys	55	10
Aquaculture	—	—
Other animals and other animal products	20	3

Source: USDA (2019a); (D) – Not Disclosed

The following sections provide a more detailed examination of agricultural commodities produced in Greenlee County.

### Crops

Greenlee County's top crop by acreage and sales value is hay and haylage, or forage crops. In 2017, there were 25 farms growing hay (including alfalfa) on nearly 2,400 acres (Table 5). With sales of about \$1.9 million, sales of hay and other crops accounted for approximately 86% of Greenlee County's crop sales (Table 4). These sales originated from 16 farms, 14 of which were classified as specializing in hay farming (Table 4 and Figure 11).

Other crops produced in Greenlee County include corn and cotton, though sales data for these commodities are not disclosed. In 2017 there were 2 farms growing corn for grain and 1 farm growing corn for silage or greenchop, though acreage data are not disclosed (Table 5). There were 3 farms growing cotton on 176 acres (Table 5).

**Table 5. Farms and Acres Harvested for Selected Crops in Greenlee County, 2017**

Commodity	Farms	Acres
Hay (including alfalfa)	25	2,396
Corn for grain	2	(D)
Corn for silage or greenchop	1	(D)
Cotton (all)	3	176
Upland cotton	1	(D)
Pima cotton	2	(D)

Source: USDA (2019a)

**Livestock**

Although sales data for cattle and calves are not available for Greenlee County, beef cattle ranching is the most prevalent agricultural activity in the county. In 2017, there were 77 farms with an inventory of nearly 9,500 head of cattle and calves (Table 6). There were 61 farms that reported sales of 4,324 head, though value of sales is not disclosed. A small number of farms account for a large share of the county’s cattle and calf inventory. The 8 largest farms (each with 200 head or more) account for approximately 73% of county cattle inventory (U.S. Department of Agriculture, 2019a). Greenlee County accounts for about 3% of Arizona’s total inventory of beef cows. There are also 4 farms with inventories of milk cows and 1 farm with reported sales of milk, but data on the number of head and value of sales are not disclosed to protect the privacy of individual operations.

Other livestock raised in Greenlee County include sheep and lambs (12 farms with an inventory of 830 animals) and goats (12 farms with an inventory of 250 animals) (Table 6). Sales of sheep, goats, wool, mohair, and milk accounted for 1% of county livestock sales in 2017. Finally, there were 67 farms with inventory of horses and ponies, but only 10 farms had sales in 2017 (Tables 4 and 6). Sales of horses, ponies, mules, burros, and donkeys were \$55,000 in 2017 (Table 4).

**Table 6. Farms and Inventory for Selected Livestock Products in Greenlee County, 2017**

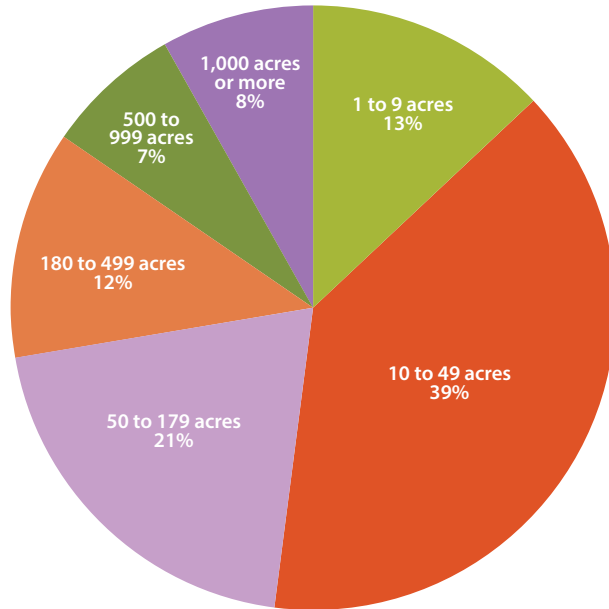
Commodity	Farms	Inventory
Cattle and calves	77	9,495
Hogs and pigs	5	10
Sheep and lambs	12	832
Goats	12	250
Horses and ponies	67	563
Layers (poultry)	30	460

Source: USDA (2019a)

**Farm Characteristics**

The average farm size in Greenlee County in 2017 was 536 acres, larger than the national average of 441 acres but significantly lower than average farm size in neighboring Graham County. That said, Greenlee County has a smaller proportion of farms with less than 10 acres (13% in Greenlee County versus 46% in Graham County) (Figures 6 and 12). The largest share of farms (39%) had 10 to 49 acres, followed by 21% with 50 to 179 acres (Figure 12). The top 5% of farms in Greenlee County accounted for 67% of county agricultural acreage.

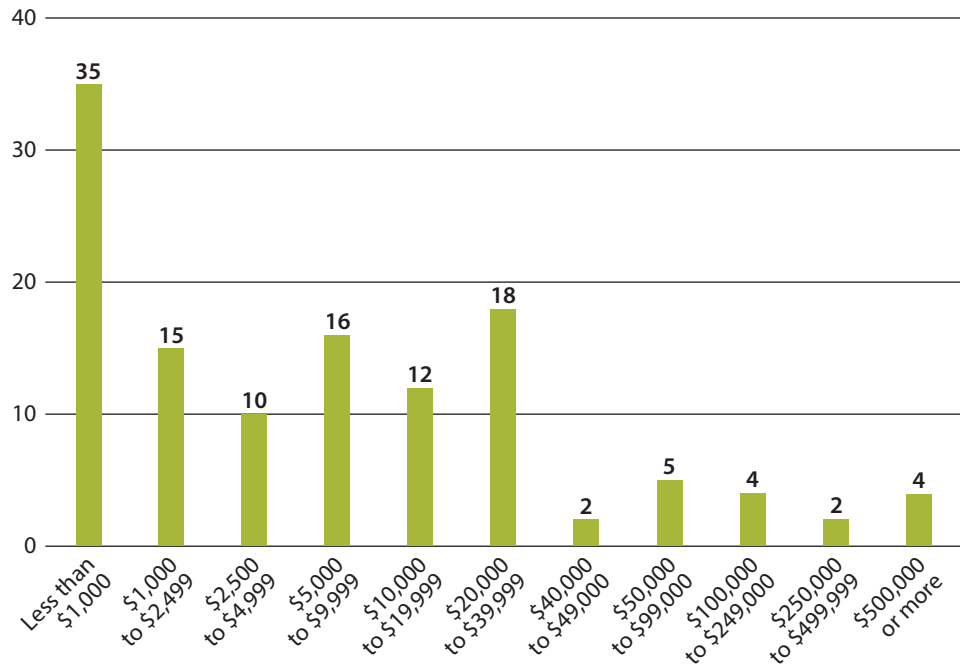
**Figure 12. Greenlee County Farms by Size**



Source: USDA (2019a)

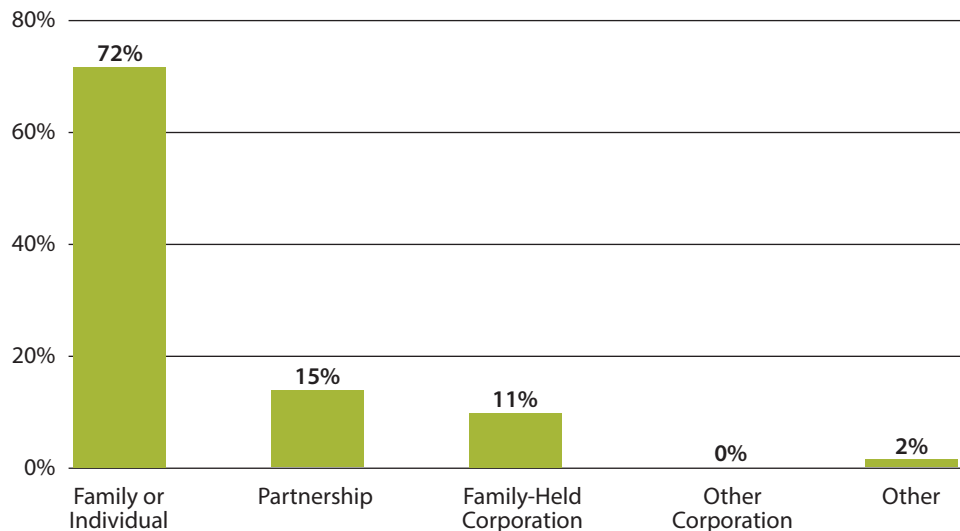
Of 123 total farms in the county, 35 farms had less than \$1,000 in sales. This is followed by 18 farms with \$20,000 to \$39,999 in sales. Only 4 farms had more than \$500,000 in sales, accounting for 71% of total county sales (Figure 13). By legal structure and organization, a majority (72%) of Greenlee County operations were family- or individually-held (Figure 14). Other common types of farms were partnerships (15%) and family-held corporations (11%). There were no non-family held corporate farms in the county.

**Figure 13. Greenlee County Farms by Market Value of Agricultural Products Sold and Government Payments**



Source: USDA (2019a)

**Figure 14. Greenlee County Farms by Legal Organization**



Source: USDA (2019a)



There were a total of 242 producers<sup>5</sup> in Greenlee County (U.S. Department of Agriculture, 2019a). The most common arrangements were farms with two producers (58 farms), followed by farms with only one producer (43 farms). Only 2 farms in the county had more than 5 producers. Approximately 61% of producers were male and 39% were female. As of 2017, the average age of producers in Greenlee County was 62.5 years old and 97% reported their race as white.<sup>6</sup>

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<sup>5</sup> A producer is anyone that is involved in decisions for the operation (such as planting, harvesting, livestock management, or marketing) and can include the owner, a member of the owner's household, a hired manager, a tenant, a renter, or a sharecropper. More detail on agricultural producers is presented in Appendix B.

<sup>6</sup> These statistics reflect the gender and race background for up to 4 producers per farm.

## Economic Contribution of Agriculture in Graham and Greenlee Counties

On-farm production is only one way that agriculture contributes to the Graham and Greenlee county economies. By purchasing inputs such as seed, fertilizer, feed crops, and banking services, and hiring labor to work on-farm, a “ripple” of economic activity is stimulated in other industries providing those goods and services. Additionally, households that derive their income from agriculture contribute to the local economy by purchasing everyday household goods and services. Economists call these *indirect* and *induced multiplier effects*.

*Indirect multiplier effects* measure local economic activity generated by farmers and ranchers purchasing inputs or supplies necessary for the production of agricultural commodities from other local businesses. These are business-to-business transactions that can occur both within agricultural industries (for example, fertilizer or farm machinery manufacturers) as well as non-agricultural industries (such as the banking or insurance industry). Those businesses, in turn, may purchase inputs for their operation from other local businesses, generating another round of multiplier effects in the local economy. Indirect multiplier effects continue with each round of business transactions, but occur with a dampening effect. This is due to leakage. When inputs are purchased from suppliers outside of the region, the money has “leaked” from the local economy to other areas and will no longer circulate and generate multiplier effects.

*Induced multiplier effects* measure local economic activity generated when farmers, ranchers, and those employed on-farm spend their earnings at local businesses to purchase typical household goods and services. These are household-to-business transactions that occur in the local retail, healthcare, and restaurant industries, among many others. Like indirect multiplier effects, induced effects are limited by leakage.

Leakage is defined by the region being studied. In the case of a county-level analysis, leakage occurs when inputs or household goods and services are purchased from outside of the county. Similarly, in a state-level analysis, leakage would occur when the supplier is from out of state. This study estimates the economic contribution of agriculture in two separate analyses, the contribution to: (1) the Graham County economy and (2) the Greenlee County economy.

This study uses the IMPLAN input-output model to estimate the total (direct, indirect, and induced multiplier effects) economic contributions of on-farm agriculture in these counties in 2017. On-farm agriculture<sup>7</sup> is the production of raw, unprocessed crops and livestock and their products as well as agricultural support services related to on-farm production, such as hired custom work for field preparation, planting, or harvesting or cotton ginning.

Results are presented using several interconnected metrics: sales, value added, labor income, and employment. Sales, also referred to as gross output, is an easy-to-understand metric that measures cumulative economic activity, accounting for all of the costs and profits of producing a good or service along the supply chain to its final point of sale. While the sales metric is a good measure of cumulative economic activity, it can be misleading when talking about local economic contributions. This is because the value of a product may be double counted—once as an end product and once as an input for another product. This is particularly the case for agriculture because many agricultural products are used

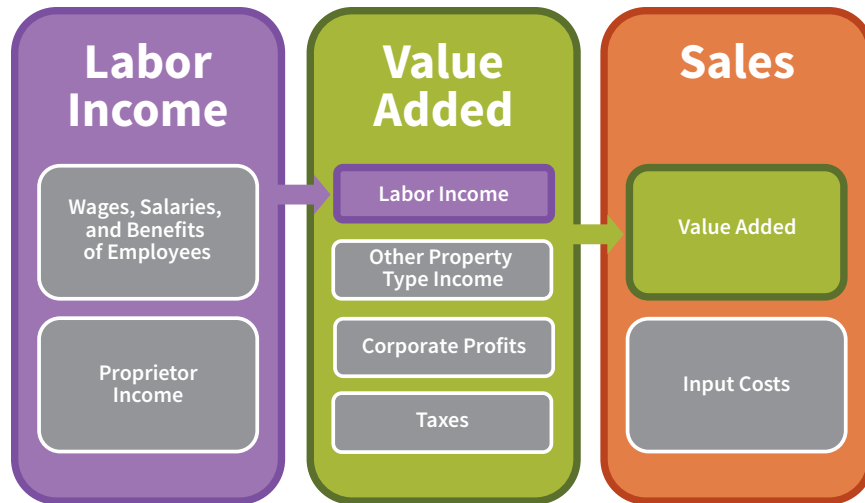
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<sup>7</sup> On-farm agriculture is defined as NAICS codes 111 (crop production), 112 (animal production and aquaculture), and 115 (support activity for agriculture and forestry).

as inputs in the production of other agricultural commodities. For example, feed crops are an end product for some crop producers but they are also inputs used by livestock producers. In this case one business’s revenue is another’s expenditure, leading to double counting the value of the feed when measured by gross sales.

The metric most widely used by economists for characterizing contributions to a local economy is value added, or gross regional product (GRP). This metric is synonymous with gross domestic product (GDP) at the national level and measures the value created by an industry over and above the costs of inputs. Value added includes labor income generated through employment, proprietor income, profits, and taxes (Figure 15). Labor income includes both income generated for proprietors (business owners) as well as income of employees through wages, salaries, and benefits.

Figure 15. Relationship between Labor Income, Value Added, and Sales



Economic contributions can also be described by the number of jobs supported by an industry. However, measuring employment in agricultural industries is particularly challenging. There is no single source of data on U.S. farm labor and estimates from various federal data sources often differ from one another due to differences in definitions and coverage levels. Estimates of on-farm employment reported below are informed by existing data, with detailed information on the available data sources and on-farm employment estimates provided in Appendix B.

The following sections present the results for the separate economic contribution analyses for Graham County and Greenlee County. Model simulations were conducted using IMPLAN Version 3.1 input-output data and software (IMPLAN Group LLC, 2019). Model data were updated to reflect county-level production by commodity and production practices. Details of this process are presented in Appendix A. Results are presented for the 2017 calendar year.

### Economic Contribution of Agriculture in Graham County

In 2017, agriculture contributed \$62.1 million to Graham County sales through agricultural cash receipts for crop and livestock products sold. Of that, approximately \$54.8 million was from the sale of crops and \$7.3 million was from the sale of livestock and livestock products (U.S. Department of Agriculture, 2019a). An additional \$1.4 million in other farm-related income was generated beyond sales of agricultural products, not including government payments (U.S. Department of Agriculture, 2019a). Support services for agriculture and forestry, which includes

## Economic Contribution of Agriculture in Graham and Greenlee Counties

activities such as cotton ginning, is considered as a direct contribution of agriculture and accounted for approximately \$2.8 million in sales (IMPLAN Group, LLC, 2019). Combined, on-farm agriculture represented \$66.2 million in direct sales and directly contributed \$15.0 million to Graham County's gross regional product (Table 7). Agriculture also directly supported an estimated 1,067 full- and part-time jobs<sup>8</sup> and \$16.4 million in labor income in Graham County (Table 7).

**Table 7. Graham County Agriculture Economic Contribution**

Impact Type	Direct Effect	Indirect Effect	Induced Effect	Total Effect
<b>Employment</b>	1,067	54	71	1,192
<b>Labor Income</b>	\$16,385,000	\$1,871,000	\$2,321,000	\$20,578,000
<b>Value Added</b>	\$15,023,000	\$3,733,000	\$4,959,000	\$23,715,000
<b>Output</b>	\$66,235,000	\$9,229,000	\$8,792,000	\$84,256,000

Numbers may not add up due to rounding.

Source: Authors' estimates; IMPLAN Group, LLC, 2019; BEA (2019b, 2019c); USDA (2019a); BLS (2020)

Including indirect and induced multiplier effects occurring within Graham County, an additional \$18.0 million in sales is supported by agriculture, for a total sales contribution of \$84.3 million. This includes \$9.2 million in indirect effects generated from Graham County farmers and ranchers purchasing inputs from other local businesses and \$8.8 million from people employed in farming and ranching spending their income within the county.

The total contribution of on-farm agriculture to Graham County's gross regional product was \$23.7 million, including multiplier effects. Additionally, through multiplier effects, on-farm agriculture supported a total of nearly 1,200 full- and part-time jobs in Graham County, and \$20.6 million in labor income.

Economic activity supported within the county occurs in industries not considered agricultural industries, but that are nonetheless connected through business-to-business and household-to-business transactions. Table 8 presents the top 10 industries in terms of their indirect and induced multiplier effects attributable to agriculture, as measured by sales.

**Table 8. Top 10 Industries Supported by Agriculture in Graham County through Indirect and Induced Multiplier Effects (Sales)**

Industry	Indirect & Induced Sales
Owner-occupied dwellings <sup>1</sup>	\$2,034,100
Wholesale—Other nondurable goods merchant wholesalers	\$1,930,700
Other real estate	\$1,775,500
Other local government enterprises	\$1,494,000
Hospitals	\$1,060,300
Insurance agencies, brokerages, and related activities	\$839,500
Water, sewage, and other systems	\$678,200
Electric power transmission and distribution	\$477,800
Accounting, tax preparation, bookkeeping, and payroll services	\$384,800
Full-service restaurants	\$349,200

<sup>1</sup> Owner-occupied dwellings is an industry constructed by IMPLAN to represent the costs of home ownership. Source: Authors' estimates; IMPLAN Group, LLC (2019)

<sup>8</sup> A more thorough discussion of how on-farm employment was estimated is provided in Appendix B.

### Economic Contribution of Agriculture in Greenlee County

In 2017, agriculture contributed \$8.7 million to Greenlee County sales through its agricultural cash receipts for crop and livestock products sold. Of that, approximately \$6.5 million was from the sale of livestock and their products and \$2.2 million was from the sale of crops (U.S. Department of Agriculture, 2019a). An additional \$2.0 million in other farm-related income was generated beyond sales of agricultural products, not including government payments (U.S. Department of Agriculture, 2019a). The agricultural support services industry had estimated sales of \$202,000 in Greenlee County (IMPLAN Group, LLC, 2019). Combined, on-farm agriculture represented \$10.9 million in direct sales in 2017 and directly contributed \$5.5 million to Greenlee County’s gross regional product. Agriculture directly supported 225 jobs<sup>9</sup> and \$3.8 million in labor income in Greenlee County.

Including indirect and induced multiplier effects taking place within Greenlee County, agriculture supported an additional \$973,000 in sales, \$236,000 of which was supported through business supplier relationships and \$737,000 of which was supported by household spending. Agriculture’s total contribution to county sales, including multiplier effects, was \$11.8 million. The total contribution of on-farm agriculture to Greenlee County’s gross regional product was an estimated \$6.2 million, including multiplier effects. Finally, including multiplier effects, \$4.0 million in labor income and a total of 230 full- and part-time jobs were supported by agriculture in Greenlee County (Table 9).

**Table 9. Greenlee County Agriculture Economic Contribution**

Impact Type	Direct Effect	Indirect Effect	Induced Effect	Total Effect
<b>Employment</b>	225	1	4	230
<b>Labor income</b>	\$3,761,000	\$89,000	\$144,000	\$3,995,000
<b>Value added</b>	\$5,533,000	\$143,000	\$482,000	\$6,158,000
<b>Output</b>	\$10,852,000	\$236,000	\$737,000	\$11,826,000

Numbers may not add up due to rounding.

Source: Authors’ estimates; IMPLAN Group, LLC (2019); BEA (2019b, 2019c); USDA (2019a); BLS (2020)

<sup>9</sup> A more thorough discussion of how on-farm employment was estimated is provided in Appendix B.



## Economic Contribution of Agriculture in Graham and Greenlee Counties

Economic activity supported within the county occurs in industries not considered agricultural industries, but that are still connected through business-to-business and household-to-business transactions. Table 10 presents the top 10 industries in terms of their indirect and induced multiplier effects attributable to agriculture, as measured by sales.

**Table 10. Top 10 Industries Supported by Agriculture in Greenlee County through Indirect and Induced Multiplier Effects (Sales)**

Industry	Indirect & Induced Sales
Owner-occupied dwellings <sup>1</sup>	\$343,100
Other real estate	\$45,100
Wholesale—grocery and related product wholesalers	\$41,900
Retail—Food and beverage stores	\$38,900
Water, sewage, and other systems	\$37,100
Retail—gasoline stores	\$27,900
Monetary authorities and depository credit intermediation	\$26,300
Electric power transmission and distribution	\$25,800
Outpatient care centers	\$25,800
Funds, trusts, and other financial vehicles	\$21,900

<sup>1</sup> Owner-occupied dwellings is an industry constructed by IMPLAN to represent the costs of home ownership.

Source: Authors' estimates; IMPLAN Group, LLC (2019)

## Potential Economic Effects of Reduced Crop Production

The final section of this study examines the potential effects of reduced crop production on the Graham and Greenlee county economies. Reduced crop production could be the result of a variety of factors including unfavorable market prices or lower yields, but this analysis examines reductions in crop production due to fallowing (taking land out of production) in response to hypothetical irrigation water cutbacks.

While the potential economic effects of reduced crop production would primarily be concentrated in agricultural industries, other industries in Graham and Greenlee counties may be affected through multiplier effects. When farmers fallow land they forego revenues (and any profits) from crop production, but they also forego the expenses related to producing that crop. In other words, they are not purchasing inputs (or hiring labor) to plant and harvest the crop. If these inputs and workers are typically purchased or hired locally, a reduction in crop acreage results in decreased economic activity in other sectors of the local economy.

Hypothetical water supply cutbacks used for this study are based on supply scenarios developed by University of Arizona Cooperative Extension that assume a 20% reduction in current irrigation water supplies<sup>10</sup> for the Gila Valley in Graham County and the Duncan Valley in Greenlee County (Lacroix et al., 2016). For the Gila Valley, this means a reduction of 27,436 acre-feet (AF) of irrigation water. In the Duncan Valley, where most irrigated crop acreage is in Greenlee County, the scenario assumes a reduction of 2,550 acre-feet (AF) of water. Agriculture is assumed to absorb these water supply reductions entirely.

While predicting how individual farmers or irrigation districts would respond to water cutbacks is multi-faceted, a common assumption is that agriculture would respond to reductions in irrigation water supplies by fallowing irrigated cropland, or taking acreage dedicated to crops out of production (Sunding et al., 1994, 2002; Dale and Dixon, 1998; U.S. Bureau of Reclamation, 2007; Bickel et al., 2018, 2019). In the long run, farmers may make other, more extensive adjustments, such as changing crop mix or investing in new irrigation technology or infrastructure. Sunding et al. (2002), though, argue that water supply reductions “are likely to be met in the short run with the only response available to growers: reducing the amount of land cultivated while retaining the existing production technology on the land remaining in production” (p. 219). Similar to previous studies cited, this analysis examines land fallowing as a response to water cutbacks. We do not consider other potential grower responses including shifting crop production to lower-water use crops or changes to irrigation practices and equipment, such as investment in well infrastructure for additional groundwater pumping.

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<sup>10</sup> Current irrigation water supplies are based on 2013-2017 average total water use for the Franklin Irrigation District and the Gila Valley Irrigation District as reported in the Gila Water Commissioner's Distribution of Waters of the Gila River annual reports (Doyle, multiple years). Additional information on hypothetical water supply assumptions is provided in Appendix D.

## Potential Economic Effects of Reduced Crop Production

Several simplifying assumptions are made for this analysis. First, we assume that farmers will follow the least profitable crops first. In reality, less productive and less profitable lands would most likely be fallowed first, which could include acreage in a wide range of crops and could vary significantly from farm to farm. Given the complexities of individual farm-level conditions, we use updated, unpublished representative cost and return budgets to identify crops taken out of production and assume that growers will follow all acreage of the crop that has the lowest net returns. Again, this follows the approach taken in earlier studies (Sunding et al., 1994, 2002; Dale and Dixon, 1998; U.S. Bureau of Reclamation, 2007; Bickel et al., 2018, 2019). If fallowing all acreage of the least profitable crop is not sufficient to meet the water cutback, growers would move on to the crop with the next lowest net returns.

Based on available crop budgets, cotton (specifically upland cotton) is identified as the crop to be fallowed first in Graham County and alfalfa hay is identified as the crop to be fallowed first in Greenlee County. The analysis then estimates reductions in cotton and hay acreage (and subsequent economic activity) resulting from a hypothetical reduction in irrigation water supply of 27,436 AF and 2,550 AF for Graham and Greenlee County agriculture, respectively. As total acreage in each county exceeds the acreage required to meet the water cutback, only cotton and alfalfa hay acreage are assumed to be fallowed in Graham and Greenlee counties, respectively.

Production losses due to fallowing are estimated assuming average quality, average county yield, and average Arizona prices for fallowed crops. Again, these are simplifying assumptions as acreage with lower yields and quality would likely be fallowed first. Table 11 presents the fallowing scenarios, modeling assumptions, and estimated crop acreage or sales reductions.

**Table 11. Yield, Price, and Water Application Assumptions, Fallowing Scenarios, and Estimated Acreage and Sales Reductions**

	Graham County	Greenlee County
Annual water supply reduction (AF)	27,436	2,550
Crop fallowed	Cotton	Alfalfa
Arizona average water application rate (2018)	4.6 AF/acre	5.8 AF/acre
Estimated acreage fallowed	5,964	440
2017 acreage	26,179 <sup>1</sup>	2,396
Percentage of 2017 acreage	23%	18%
County yield (2017)	1,213 lbs./acre <sup>2</sup>	4.3 tons/acre <sup>3</sup>
Arizona average price (2017)	\$0.73/lb.	\$172/ton
Estimated sales reduction	\$5.3 million	\$323,000

<sup>1</sup> Includes all Graham County cotton acreage.

<sup>2</sup> Graham County average yield for upland cotton.

<sup>3</sup> Greenlee County average yield for alfalfa hay is not disclosed for 2017; yield estimates based on Greenlee County acreage and dry tons harvested for 2017.

Source: Authors' estimates; USDA (2019a); USDA (2019c); USDA (2020).

### Potential Economic Effects of Reduced Cotton Production in Graham County

Considering a water supply reduction of 27,436 AF and the simplifying assumptions presented, Graham County producers would fallow nearly 6,000 acres of cotton, or about 23% of 2017 cotton acreage. Based on Graham County’s average yield per acre and Arizona’s average price per pound in 2017, this would result in approximately 15,000 fewer bales of cotton and \$5.3 million in reduced cotton sales (Table 11).

Given reduced cotton sales of \$5.3 million and indirect and induced multiplier effects, the total estimated reduction to Graham County sales in 2017 would be \$6.6 million. A total sales reduction of this magnitude corresponds to approximately \$1.0 million less labor income and approximately 23 fewer jobs, as well as a decrease in Graham County’s gross regional product of \$1.1 million (Table 12).

**Table 12. Estimated Graham County Economic Impacts from Reductions in Cotton Acreage, 2017**

Impact Type	Direct Effect	Indirect Effect	Induced Effect	Total Effect
<b>Employment</b>	-14	-6	-3	-23
<b>Labor income</b>	-\$672,800	-\$173,500	-\$104,900	-\$951,200
<b>Value added</b>	-\$534,600	-\$347,200	-\$223,700	-\$1,105,500
<b>Output</b>	-\$5,259,700	-\$934,200	-\$400,800	-\$6,594,600

Numbers may not add up due to rounding.

Source: Authors’ estimates; IMPLAN Group, LLC (2019); BLS (2020)

### Potential Economic Effects of Reduced Alfalfa Production in Greenlee County

Considering a water supply reduction of 2,550 AF and the simplifying assumptions presented, Greenlee County producers would fallow an estimated 440 acres of alfalfa, or 18% of the county’s hay acreage. Based on estimated average yield per acre and Arizona’s average price per ton in 2017, this would result in approximately 1,900 fewer tons of alfalfa and approximately \$323,000 in reduced hay sales.

Given reduced alfalfa sales of \$323,000 and indirect and induced multiplier effects, the total estimated reduction to Greenlee County sales in 2017 is nearly \$350,000. A sales reduction of this magnitude corresponds to \$98,500 less in labor income and approximately 1 fewer job, as well as a decrease in Greenlee County’s gross regional product of nearly \$175,000 (Table 13).

**Table 13. Estimated Greenlee County Economic Impacts from Reductions in Alfalfa Acreage, 2017**

Impact Type	Direct Effect	Indirect Effect	Induced Effect	Total Effect
<b>Employment</b>	-1	0	0	-1
<b>Labor income</b>	-\$92,800	-\$2,700	-\$3,000	-\$98,500
<b>Value Added</b>	-\$158,900	-\$6,200	-\$9,900	-\$175,000
<b>Output</b>	-\$322,900	-\$10,200	-\$15,300	-\$348,500

Numbers may not add up due to rounding.

Source: Authors’ estimates; IMPLAN Group, LLC (2019); USDA (2019a)

## Conclusions

Graham and Greenlee counties are closely linked through strong economic relationships including the trade of goods and services, and a labor force that commutes heavily between them for employment and access to goods and services. Agriculture in the two counties is distinct, with Graham County specializing in cotton production and Greenlee County engaged most heavily in cattle ranching. On-farm agriculture contributes an estimated \$23.7 million to Graham County's gross regional product and \$6.2 million to Greenlee County's gross regional product, including multiplier effects. As measured by sales, the total economic contribution in Graham County was \$84.3 million and in Greenlee County it was \$11.8 million. Approximately, 1,200 and 230 total full- and part-time jobs were supported by agriculture and its multiplier effects in Graham and Greenlee counties, respectively. This includes an estimated 1,067 and 225 direct full- and part-time jobs in Graham and Greenlee county agriculture, respectively.

Considering hypothetical water supply reductions equal to 20% of current water use (27,436 AF in Graham County and 2,550 AF in Greenlee County) and assuming growers would fallow crops with the lowest net returns per acre, nearly 6,000 acres of cotton would be fallowed in Graham County and 440 acres of alfalfa would be fallowed in Greenlee County. Reductions of this magnitude would result in reduced cotton sales of \$5.3 million in Graham County and \$323,000 of reduced alfalfa sales in Greenlee County. Including indirect and induced multiplier effects, the total sales reduction in Graham County is an estimated \$6.6 million and corresponds to approximately \$1.0 million less in labor income, a decrease in Graham County's gross regional product of \$1.1 million, and 23 fewer jobs. Considering fallowing of alfalfa acreage in Greenlee County, the total sales reduction in the county, including indirect and induced multiplier effects, is nearly \$350,000, corresponding to \$98,500 less in labor income, a decrease in Greenlee County's gross regional product by nearly \$175,000, and 1 fewer job.



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## Appendices

### Appendix A. Data and Research Methods

There are several challenges to estimating the economic contribution of agriculture at the county level. This is particularly the case for counties that have components of agricultural data that are not disclosed in order to protect the privacy of individual operations, as is the case for Graham and Greenlee counties.

This study relies heavily on the 2017 Census of Agriculture for estimates of sales and value added. Individual crop and livestock industries were modified in IMPLAN to match cash receipt data reported by the Census of Agriculture. Sales for nondisclosed commodities are estimated utilizing 2017 county-level rankings and previous Census sales, acreage, and inventory data. For each county, total agricultural cash receipts for crops and livestock match the 2017 Census of Agriculture (U.S. Department of Agriculture, 2019a). Income from farm-related sources also comes from the Census of Agriculture. Finally, sales for the agricultural support service industry are estimated using two different methodologies. Given that cotton ginning falls within the agricultural support services industry and Graham County's specialization in cotton production, agricultural support service sales for Graham County are estimated using data from the Census of Agriculture, the USDA Economic Research Service's cost and return estimates, and a local farm budget (U.S. Department of Agriculture, 2019a; U.S. Department of Agriculture ERS, 2020). For Greenlee County, agricultural support service sales are provided by baseline IMPLAN data. Combined, on-farm agricultural sales were an estimated \$66.2 million in Graham County and \$10.9 million in Greenlee County.

Value-added estimates are also heavily informed by the 2017 Census of Agriculture, with intermediate expenditure and value-added shares modified using Census-reported county-level farm production expenses, particularly for Graham County. On-farm value-added estimates from this study are higher than estimates reported by the Bureau of Economic Analysis (BEA) for 2017. Results from this study suggest agriculture's direct value added in Graham County was approximately \$15.0 million and approximately \$5.5 million in Greenlee County. In Graham County, labor income estimates exceed value-added estimates, suggesting that the cumulative measure of taxes on production, other property income, and profits is negative. BEA data reports value added for agriculture, forestry, fishing, and hunting as \$11.8 million for Graham County and \$4.4 million for Greenlee County in 2017 (BEA, 2019c). Similar to study results, BEA data reports Graham County farm earnings exceeding value added for 2017.

As mentioned previously, additional modifications were made to the cotton industry spending pattern for Graham County. These modifications were made using data from the Census of Agriculture, the USDA Economic Research Service's cost and return estimates for cotton,<sup>11</sup> and a local farm budget (U.S. Department of Agriculture, 2019a; U.S. Department of Agriculture ERS, 2020). Modifications are necessary because baseline IMPLAN data reflect a national average spending pattern for cotton, which is not reflective of irrigated cotton production in the region.

Employment supported through indirect and induced multiplier effects is estimated using IMPLAN. Direct on-farm employment estimates rely on data from multiple sources, detailed in Appendix B. Additionally, an examination of historical annual employment and production in Graham County identified discrepancies in reported crop employment, with this information detailed in Appendix C.

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<sup>11</sup> Although Arizona is located in the Fruitful Rim region, this study uses the cost and return estimates for the Heartland region due to significant differences in irrigated acreage. In the Fruitful Rim, only 54% of cotton is irrigated while in the Heartland region 84% is irrigated.

### Appendix B. Estimating On-Farm Employment

There are several challenges to measuring on-farm employment. There is no single source of data on U.S. farm labor and estimates from various federal data sources often differ from one another due to differences in definitions and coverage levels. Key data sources for on-farm employment include the USDA Census of Agriculture, the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics (BLS), and the Bureau of Economic Analysis (BEA). The following section outlines the data sources available and their estimates for on-farm employment in Graham and Greenlee counties. On-farm employment includes farm proprietors, directly hired labor, and agricultural support service labor, which includes farm labor contract labor.

The USDA Census of Agriculture, available every 5 years, reports the total number of producers, total number of hired farm workers, and total number of unpaid family workers, with some statistics available at finer levels of detail. For example, the Census also reports the total number of producers by primary occupation and place of residence.

**Table 14. On-Farm Labor in Graham and Greenlee Counties According to the Census of Agriculture, 2017**

	Graham	Greenlee
<b>Producers</b>		
Total producers	742	242
Total principal producers	587	182
Primary occupation is farming	199	105
Place of residence on farm operated	364	152
<b>Hired Farm Labor</b>		
Farms	133	29
Workers	652	94
Worked 150 days or more	351	48
Worked less than 150 days	301	46
<b>Unpaid workers</b>		
Farms	256	73
Unpaid workers	663	204

Source: USDA (2019a)

In 2017, there were a reported 652 workers hired for on-farm labor in Graham County and 94 in Greenlee County in 2017 on 133 farms and 29 farms, respectively (Table 14). The Census also reports the total number of producers. A producer is anyone that is involved in decisions for the operation (such as planting, harvesting, livestock management, or marketing) and can include the owner, a member of the owner’s household, a hired manager, a tenant, a renter, or a sharecropper, but does not include hired workers unless those hired workers are also characterized as a hired manager or family member. Thus, a family member or hired manager could be both a hired worker and producer, potentially resulting in double counting. In 2017, there were 742 producers in Graham County and 242 producers in Greenlee County. The Census also reports the number of principal producers. Each farm has at least one principal producer, but can have more than one principal producer. If an operation has more than one principal producer, additional data on principal producers reflect the producer

that makes most of the decisions for the farm or the producer that worked off farm the least. In Graham County, 199 principal producers reported their primary occupation as farming and, in Greenlee County, 105 principal producers reported their primary occupation as farming. Finally, the Census reports the number of unpaid workers. In 2017, there were 663 unpaid workers in Graham County and 204 unpaid workers in Greenlee County. Again, unpaid workers could also be counted as producers if they were involved in decisions for the operation.

The Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) reports monthly and annual employment by NAICS code. However, the QCEW only includes data for operations large enough to pay into the unemployment system and does not include data on farm proprietors. According to 2017 QCEW data, annual average employment in crop production was 390, 73 in agricultural and forestry support activities, and data were not disclosed for animal



**Table 15. On-Farm Labor in Graham and Greenlee Counties According to the Bureau of Labor Statistics QCEW, 2017**

Sector by NAICS	Graham	Greenlee
NAICS 111 Crop production	390	(ND)
NAICS 112 Animal production	(ND)	(ND)
NAICS 115 Agriculture and forestry support activities	73	(ND)
Total NAICS 11 Agriculture, forestry, fishing, and hunting	(ND)	43

Source: U.S. Bureau of Labor Statistics QCEW (2020 ); (ND) denotes information not disclosed.

production in Graham County (Table 15), though 2016 data report 17 workers employed in livestock production. Employment data in Greenlee County are sparse, though 2017 annual average employment at the 2-digit NAICS code suggests that employment in agriculture, forestry, fishing, and hunting (NAICS 11) was 43 workers (Table 15). An examination of historic BLS QCEW employment data for Graham County identified significant discrepancies in reported crop employment and production data, with differences in estimates potentially due in part to reporting discrepancies within the greenhouse industry. The results of this examination are presented in Appendix C.

Finally, the Bureau of Economic Analysis reports total full-time and part-time farm employment, using data from both the BLS QCEW and Census of Agriculture to produce their estimates. According to the BEA, there were a total of 734 full- and part-time jobs in Graham County in 2017, 370 of which were farm proprietors. In Greenlee County, there were a total of 171 full- and part-time farm jobs in 2017, with a large majority of those farm proprietors. The BEA also reports employment in agricultural and forestry support activities, but data are not disclosed for Graham or Greenlee counties.

**Table 16. On-Farm Labor in Graham and Greenlee Counties According to the Bureau of Economic Analysis, 2017**

On-Farm Employment	Graham	Greenlee
Farm proprietors' employment	370	136
Hired laborers	364	35
Total farm employment	734	171

Source: BEA (2019a)

An important caveat on the employment statistics above is that they do not report the number of unique individuals filling those jobs nor the extent to which the jobs constitute full-time employment. This presents significant challenges in what constitutes a “job,” and is exacerbated by the highly seasonal nature of agricultural industries. Bickel et al. (2017) ask the question, “if one person works at three jobs lasting for three months each and is unemployed for three months, is this three jobs or three-quarters of a job?” (p. 23). Similar questions can be asked in relation to producers. For example, if a family member of the owner is involved in decisions for the operation, but their primary occupation is off-farm, does their involvement constitute a job in agriculture?

This study relies on data from the BLS QCEW and Census of Agriculture for on-farm employment estimates of hired labor, farm proprietors, and agricultural support service workers. Hired labor and agricultural support service worker estimates are derived from the QCEW. Assuming employment in animal

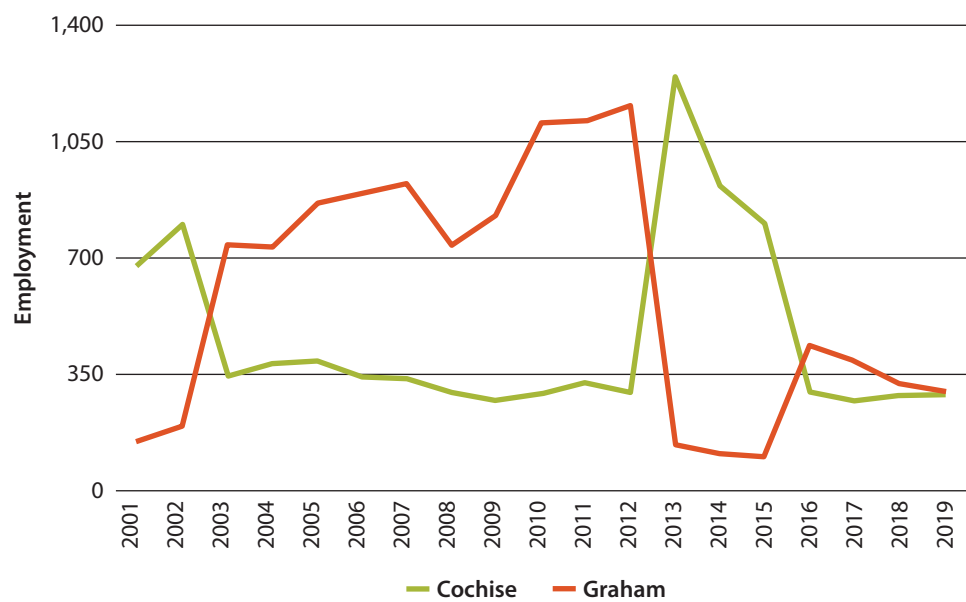
production in 2017 is the same as reported in 2016 as noted above, estimated employment of hired farm workers and agricultural support service workers in Graham County in 2017 was 480 full- and part-time jobs. Estimated employment for Greenlee County in 2017 was 43 full- and part-time jobs. Farm proprietor estimates were derived from the Census of Agriculture, referencing the total number of principal producers. This was 587 producers in Graham County and 182 producers in Greenlee County. Summing producers and the number of hired on-farm and agricultural support workers, annual average on-farm employment in 2017 was 1,067 in Graham County and 225 in Greenlee County.

### Appendix C. Graham County Crop Employment and Output Discrepancies

Significant discrepancies exist between agricultural production and employment data in recent years for Graham County between sources such as the Census of Agriculture, the Bureau of Economic Analysis, and USDA’s Economic Research Service. As detailed in this section, the differences in estimates may be due in part to reporting discrepancies within the greenhouse industry.

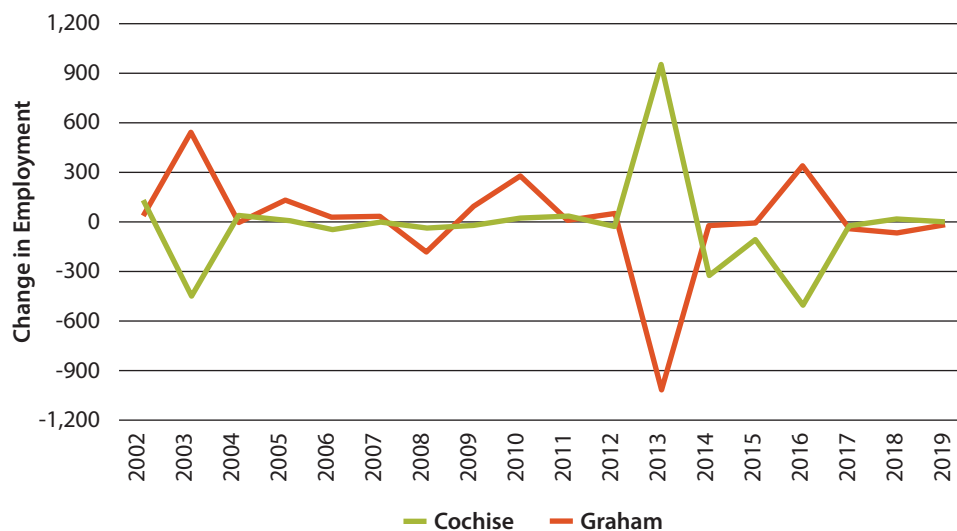
Data regarding greenhouse production in Graham County are difficult to obtain due to the very small number of operations active within the county. Due to reporting discrepancies, however, it is possible to uncover estimates of employment over time within the industry. U.S. Bureau of Labor Statistics county employment data for Graham and Cochise counties reveal a pattern of agricultural employment shifting between Graham and Cochise counties (Figure 16). A large greenhouse operation is located in Graham County on the Graham-Cochise county line. The operation has changed ownership a number of times, and those changes coincide with the shifts in employment from one county to another.

Figure 16. Crop Employment in Graham and Cochise Counties, 2001–2019



Source: U.S. Bureau of Labor Statistics QCEW County Crop Employment (NAICS111)

Figure 17. Change in Crop Employment in Graham and Cochise Counties, 2001–2019



Source: Authors' calculations, U.S. Bureau of Labor Statistics QCEW County Crop Employment (NAICS111)

The changes between counties mirror each other in direction and magnitude, suggesting the changes are a result of inconsistent reporting of the operation between years (Figure 17).

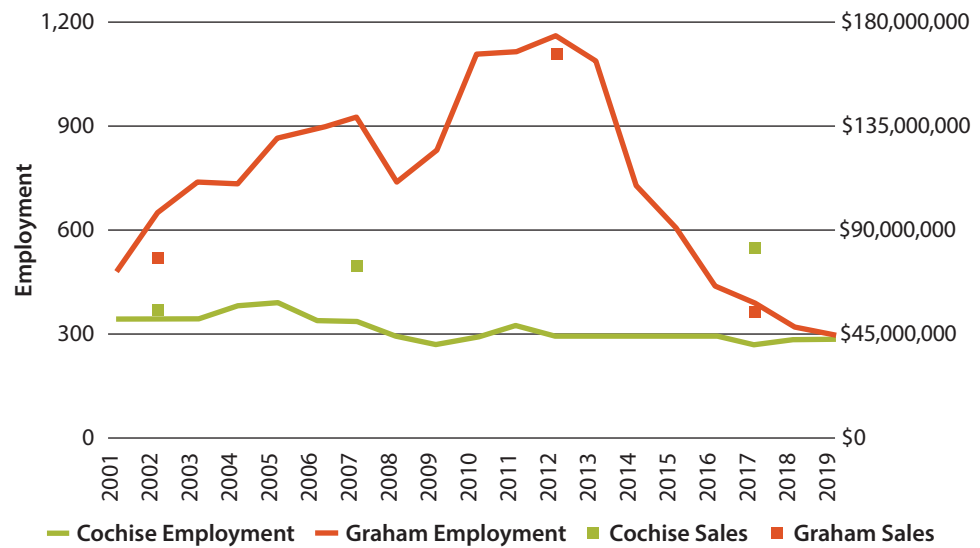
Though employment data are not available by crop at the county level, the sheer size of the facility and the reporting discrepancies between Graham County and Cochise County over time allow for the estimation of greenhouse employment (Figure 18). Allocating greenhouse employment to Graham County, where the facility is physically located, results in less drastic fluctuations in crop employment in Graham County. Crop employment estimates instead range from about 300 in 2019 to 1,200 in 2012.

Figure 18. Estimated Greenhouse Employment in Graham County, 2001–2019



Source: Authors' calculations, U.S. Bureau of Labor Statistics QCEW County Crop Employment (NAICS111)

**Figure 19. Estimated Crop Employment and Sales in Graham and Cochise Counties (Corrected Greenhouse Estimates), 2001–2019**



Source: Authors' calculations, U.S. Bureau of Labor Statistics QCEW County Crop Employment (NAICS111)

Comparing new corrected county crop employment with value of county crop sales reported by the Census of Agriculture, both follow a similar trajectory for both counties, which implies a more consistent output per worker (Figure 19).

### Appendix D. Hypothetical Water Supply Assumptions

Hypothetical water supply cutbacks used for this study are based on water supply scenarios developed by University of Arizona Cooperative Extension that assume a 20% reduction in current water supply. (Lacroix et al., 2016). In defining current water supply, Lacroix et al. (2016) explore discrepancies between water legally available (“paper water”) and water physically available (“wet water”). While one might expect these to be the same thing, the authors are quick to note that “one may have a legal water right, but whether that resource is actually available in the river or stream, or accessible from a groundwater well, may be a different story” (Lacroix et al., 2016, p. 3). Given these discrepancies, current water supply is based on water that is physically available.

Data on current water supply for irrigation are available from the USGS and annual reports from the Gila Water Commissioner. USGS estimates are provided at the county level, and report 2015 irrigation water use in Greenlee County as 10,394 AF and water use in Graham County as 205,166 AF (Dieter, et al., 2018). Alternatively, total water use data for lands subject to the Arizona Water Settlements Act (AWSA) of 2004, the Globe Equity Decree, and the Upper Valley Forbearance Agreement are reported by the Gila Water Commissioner’s *Distribution of Waters of the Gila River* annual reports, where both surface water and groundwater use is monitored (Doyle, multiple years). Specifically, these are lands within the Franklin Irrigation District in Greenlee County and the Gila Valley Irrigation

Table 17. Arizona Irrigation Districts Provisional Total Water Use, 2013–2017

Year	Franklin Irrigation District			Gila Valley Irrigation District		
	SW	GW	Total	SW	GW	Total
2013	2,622	10,613	13,235	45,897	73,507	119,404
2014	3,692	9,070	12,762	62,146	78,606	140,752
2015	3,868	6,701	10,568	82,319	64,725	147,044
2016	6,344	7,226	13,570	64,351	72,177	136,528
2017	5,404	8,214	13,618	64,259	77,913	142,172
<b>Average (2013–2017)</b>	4,386	8,365	12,751	63,794	73,386	137,180

Source: Doyle, multiple years

District in Graham County. Table 17 presents the provisional annual total water use for these two irrigation districts. As irrigated crop acreage in Greenlee County is concentrated in the Duncan Valley with many served by the Franklin Irrigation District, 2015 estimates are closely aligned with USGS estimates. In contrast, while much of Graham County's irrigated crop production is concentrated in the Gila Valley and served by the Gila Valley Irrigation District, other irrigated crop acreage exists throughout the county resulting in 2015 USGS water use estimates significantly higher than those reported by Gila Water Commissioner annual reports.

Following Lacroix et al. (2016), this analysis focuses on the Duncan Valley and Gila Valley and assumes a 20% reduction in current water supply, with updated estimates of current water supply. Estimates of current water supply based on 2013–2017 average total water use for the Franklin Irrigation District and the Gila Valley Irrigation District as reported above (Doyle, multiple years). For the Gila Valley, the supply scenario assumes a reduction of 27,436 acre-feet (AF) of water. For the Duncan Valley, the supply scenario assumes a reduction of 2,550 acre-feet (AF) of water.

Based on available crop budgets, cotton (specifically upland cotton) is identified as the crop to be fallowed first in Graham County and alfalfa hay is identified as the crop to be fallowed first in Greenlee County. The analysis then estimates reductions in cotton and hay acreage (and subsequent economic activity) resulting from a hypothetical reduction in irrigation water supply of 27,436 AF and 2,550 AF for Graham and Greenlee County agriculture, respectively.

Given Arizona's average water application rates for cotton (4.6 AF/acre) and alfalfa (5.8 AF/acre) reported by the 2018 Census of Agriculture Irrigation and Water Management Survey (USDA, 2019c), the estimated acreage fallowed is 5,964 cotton acres (23% of 2017 acreage) in Graham County and 440 alfalfa acres (18% of 2017 acreage) in Greenlee County. Production losses, in the form of reduced sales, due to fallowing are estimated assuming average yield in Graham County reported by USDA National Agricultural Statistical Service (NASS), average yield in Greenlee County estimated from Census of Agriculture production and acreage data, and average Arizona price received for fallowed crops (USDA, 2020). Table 11 presents the fallowing scenarios, modeling assumptions, and estimated crop sales reductions.

## *Appendices*

Direct employment effects (included in Tables 12 and 13) are estimated considering income (employee compensation) losses to hired workers and annual average wage per employee in cotton farming and all other crop farming in 2017 as reported by the BLS QCEW (U.S. Bureau of Labor Statistics QCEW, 2020). Wages were converted to employee compensation using the IMPLAN conversion worksheet (Clouse, 2020). Graham County direct employment estimates rely on county-level cotton farming wage data from the BLS QCEW. County-level data are not available for Greenlee County therefore the state-level average wage per employee for all other crop farming is used. While income losses to proprietors are considered in this analysis and modeled to assess the multiplier effects of reduced proprietor spending, this study assumes that all farm proprietors would continue farming.





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