COLLEGE OF AGRICULTURE & LIFE SCIENCES
COOPERATIVE EXTENSION

WATER RESOURCES RESEARCH CENTER

Watering Irrigated Agricultural in Arizona

WRRC Brown Bag Seminar

September 27, 2018

Tucson, AZ

wrrc.arizona.edu

Dr. Susanna Eden
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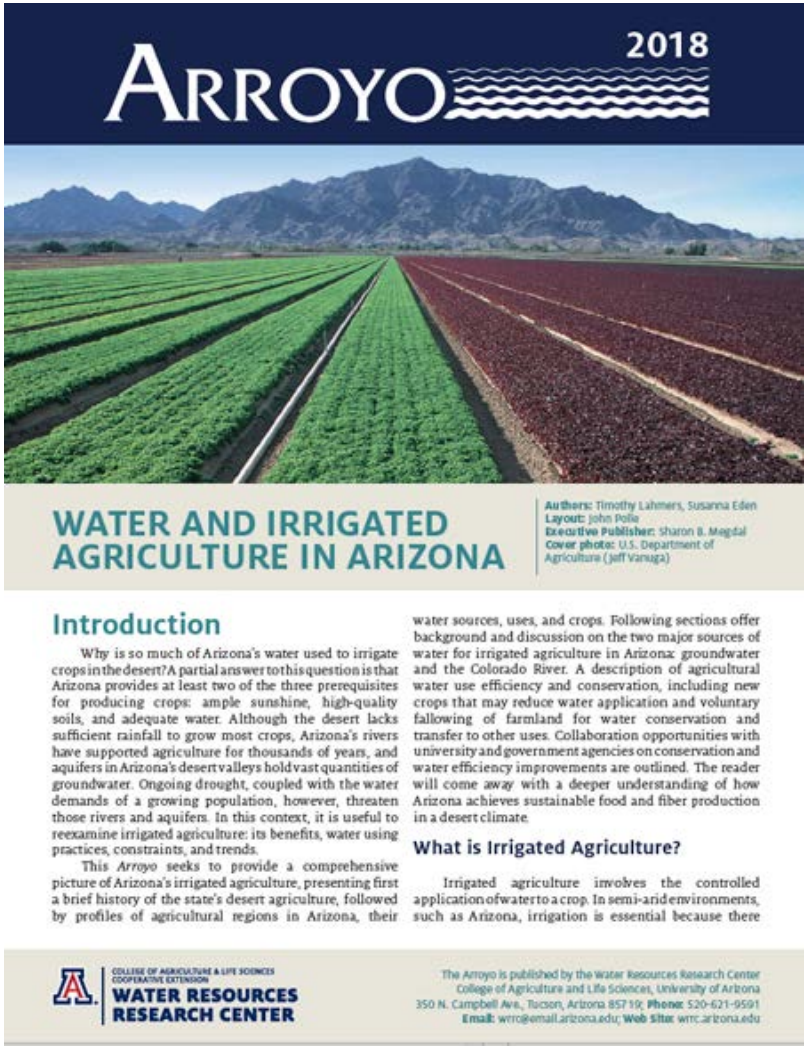
WRRC 2017 Annual Conference

https://wrrc.arizona.edu/conferences/2017

WRRC Arroyo 2018



ARROYO 2018

WATER AND IRRIGATED AGRICULTURE IN ARIZONA

Authors: Timothy Lahmers, Susanna Eden
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Executive Publisher: Sharon B. Megdal
Cover photo: U.S. Department of Agriculture (Jeff Vanuga)

Introduction

Why is so much of Arizona's water used to irrigate crops in the desert? A partial answer to this question is that Arizona provides at least two of the three prerequisites for producing crops: ample sunshine, high-quality soils, and adequate water. Although the desert lacks sufficient rainfall to grow most crops, Arizona's rivers have supported agriculture for thousands of years, and aquifers in Arizona's desert valleys hold vast quantities of groundwater. Ongoing drought, coupled with the water demands of a growing population, however, threaten those rivers and aquifers. In this context, it is useful to reexamine irrigated agriculture: its benefits, water using practices, constraints, and trends.

This *Arroyo* seeks to provide a comprehensive picture of Arizona's irrigated agriculture, presenting first a brief history of the state's desert agriculture, followed by profiles of agricultural regions in Arizona, their water sources, uses, and crops. Following sections offer background and discussion on the two major sources of water for irrigated agriculture in Arizona: groundwater and the Colorado River. A description of agricultural water use efficiency and conservation, including new crops that may reduce water application and voluntary fallowing of farmland for water conservation and transfer to other uses. Collaboration opportunities with university and government agencies on conservation and water efficiency improvements are outlined. The reader will come away with a deeper understanding of how Arizona achieves sustainable food and fiber production in a desert climate.

What is Irrigated Agriculture?

Irrigated agriculture involves the controlled application of water to a crop. In semi-arid environments, such as Arizona, irrigation is essential because there

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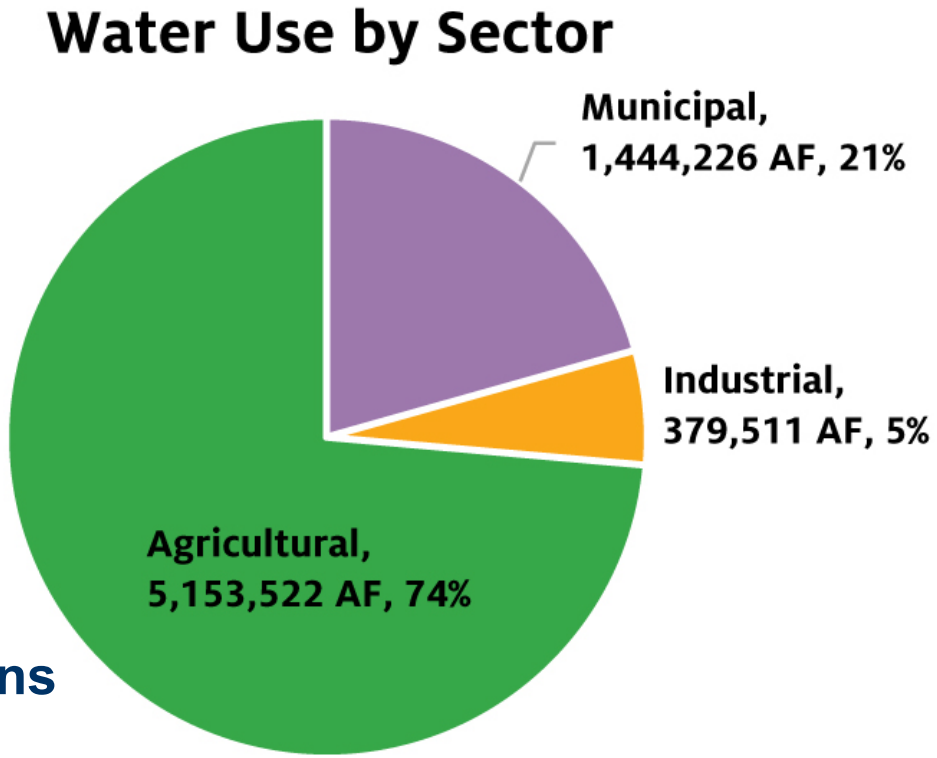
Farms swallowing most of Arizona's water

Shaun McKinnon
The Arizona Republic
Jan. 3, 2005

Arizona's Water Use

- Approx. 74% Agriculture
- Approx. 21% Municipal
- Approx. 5% Industrial

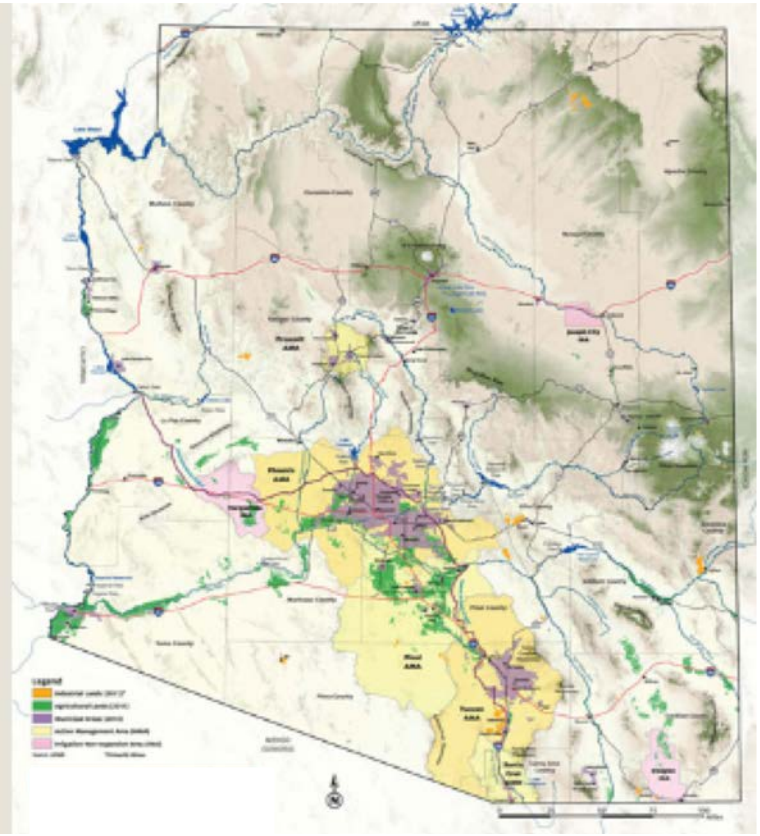


An acre foot is 325,851 gallons

68% in 2017 - ADWR

Source: ADWR 2014 Water Budget

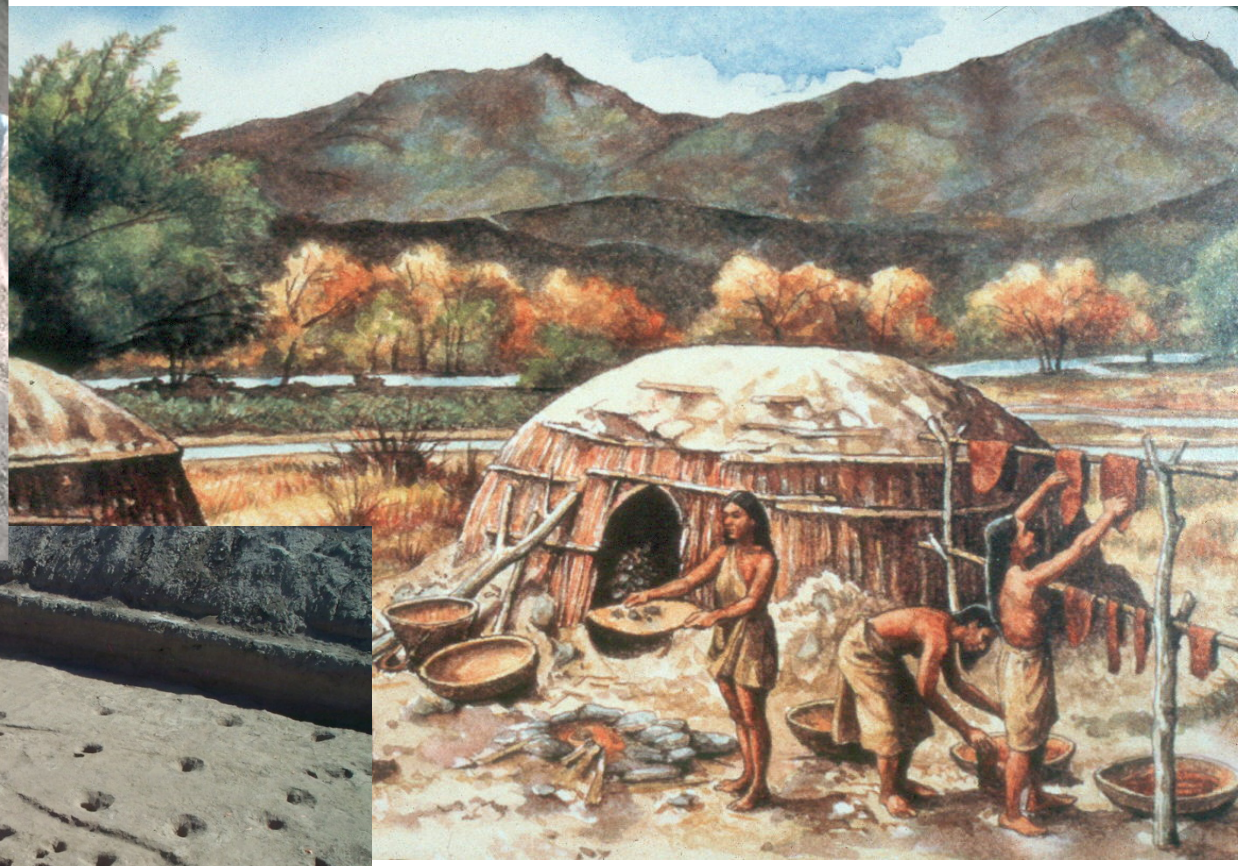
Presentation Outline



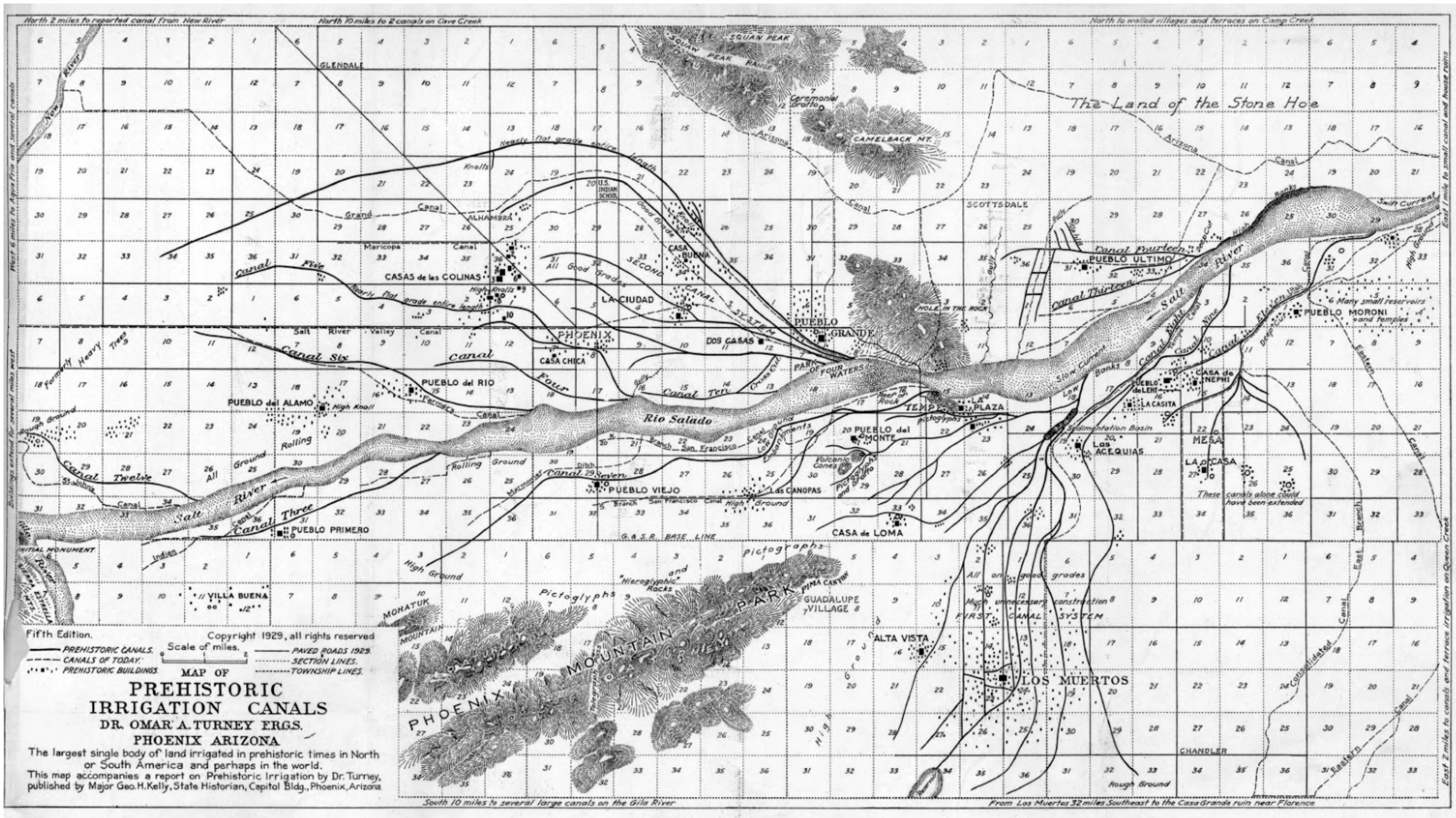
- Arizona Agriculture – Past and Present
- Agricultural Water Uses
- Agricultural Water Sources
- Arizona Water Management
- Economic Impact of Agriculture
- Agricultural Water Issues

HISTORY

Recent archaeological investigations uncovered canals and irrigated fields built in the Santa Cruz floodplain by early farmers between 4,000 and 2,000 years ago.

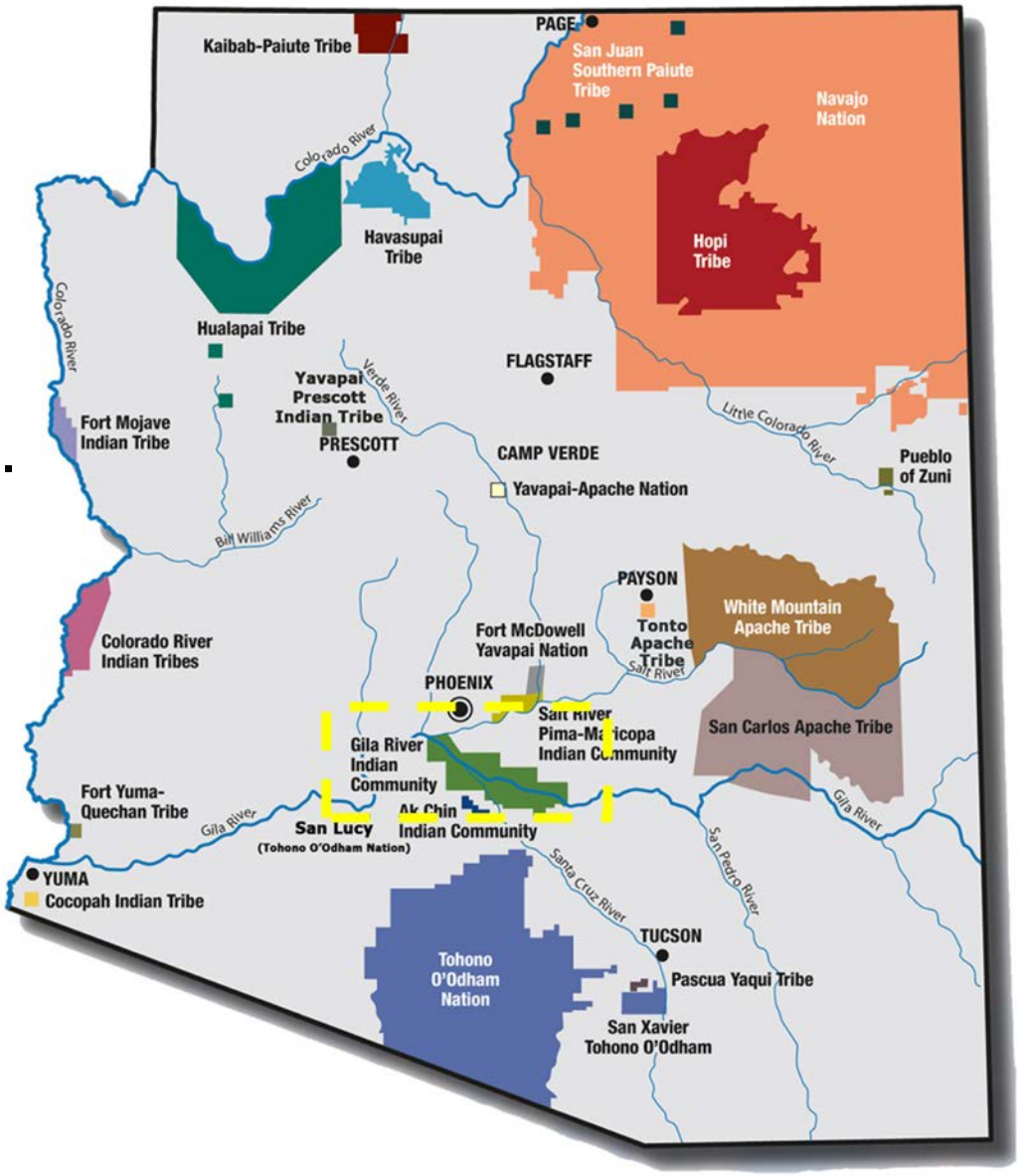


Between 2,300 and 550 years ago, the Hohokam people built a network of canals near the Salt and Gila Rivers in South Central Arizona.

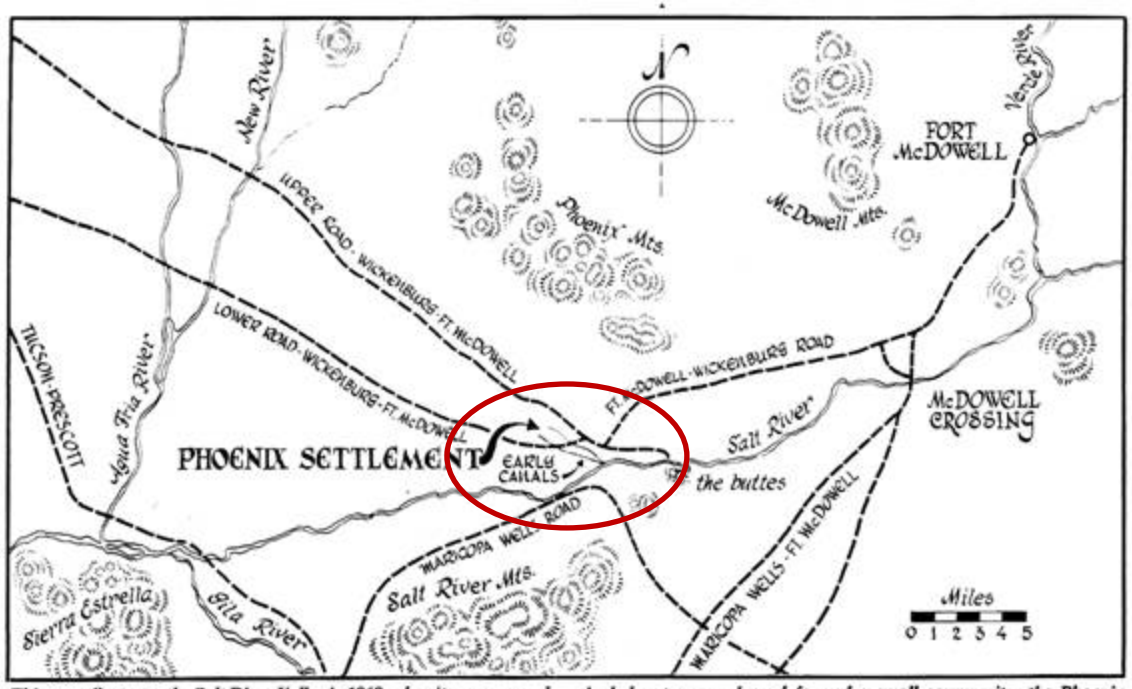


When Americans arrived, the Gila River people, likely successors to the Hohokam, farmed an area described as the breadbasket of Arizona.

By 1860, they farmed nearly 15,000 acres and traded farm products such as wheat, corn, beans and squash to the U.S. military, travelers and settlers.



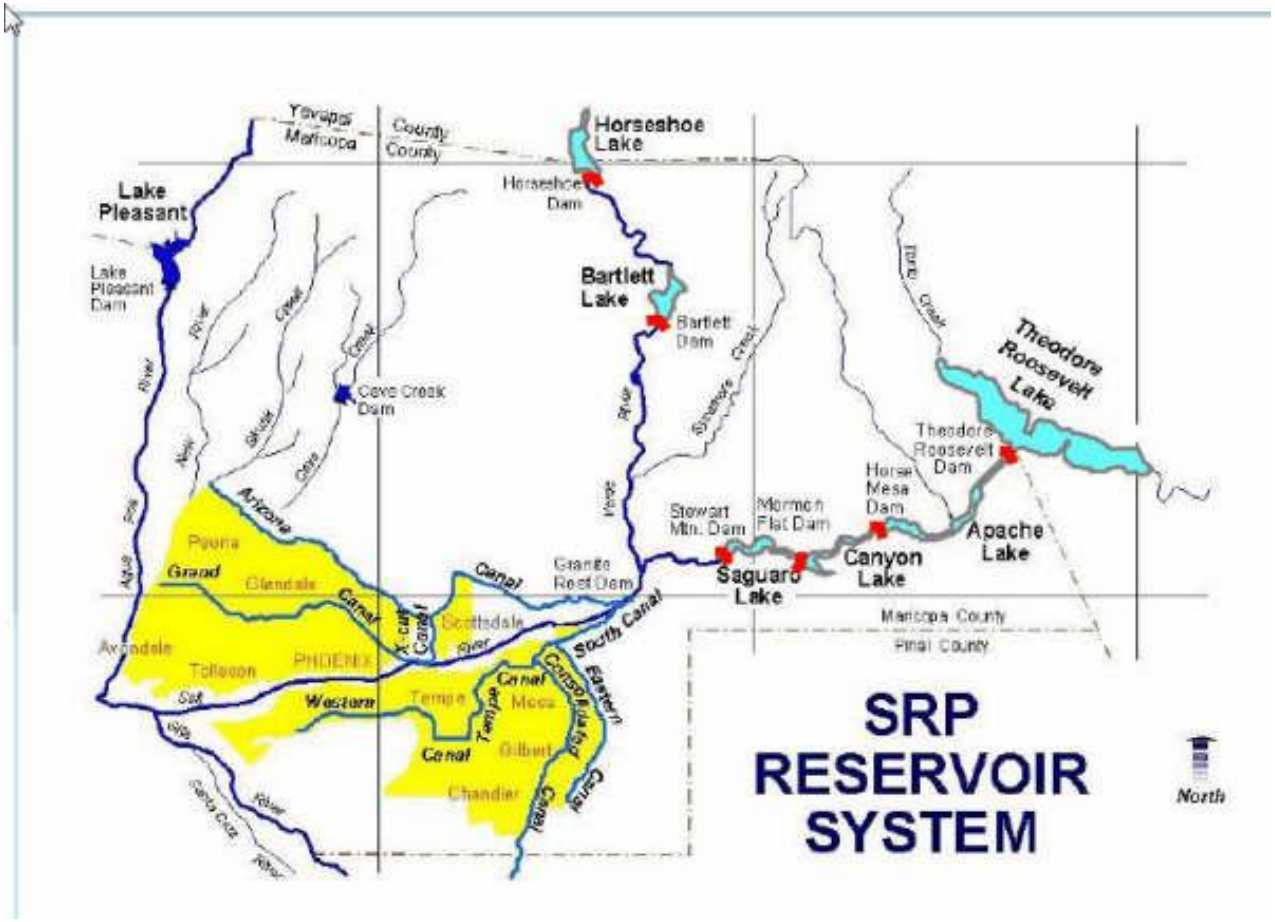
In 1867 Jack Swilling built the first community irrigation ditch in the Phoenix area from the remains of the original Hohokam ditches.



This map illustrates the Salt River Valley in 1868, when it was surveyed by U.S. Deputy Surveyor Wilfred Ingalls, who found that early settlers had dug two canals and formed a small community, the Phoenix Settlement, east of the current downtown area.

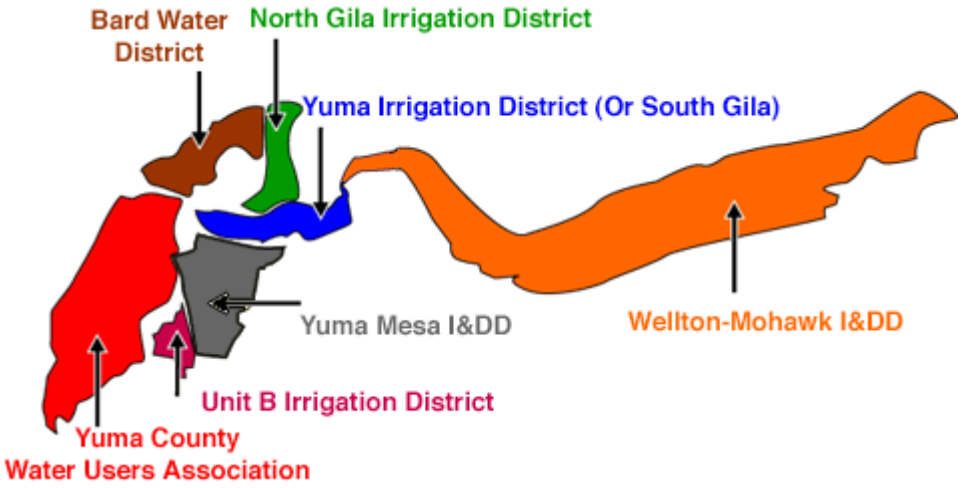
Irrigation enabled 113,000 acres to be brought into production in Maricopa County by 1900.

Under the federal Reclamation Act of 1902, Roosevelt Dam was constructed for the Salt River Valley Water Users' Association (Salt River Project) and completed in 1911.



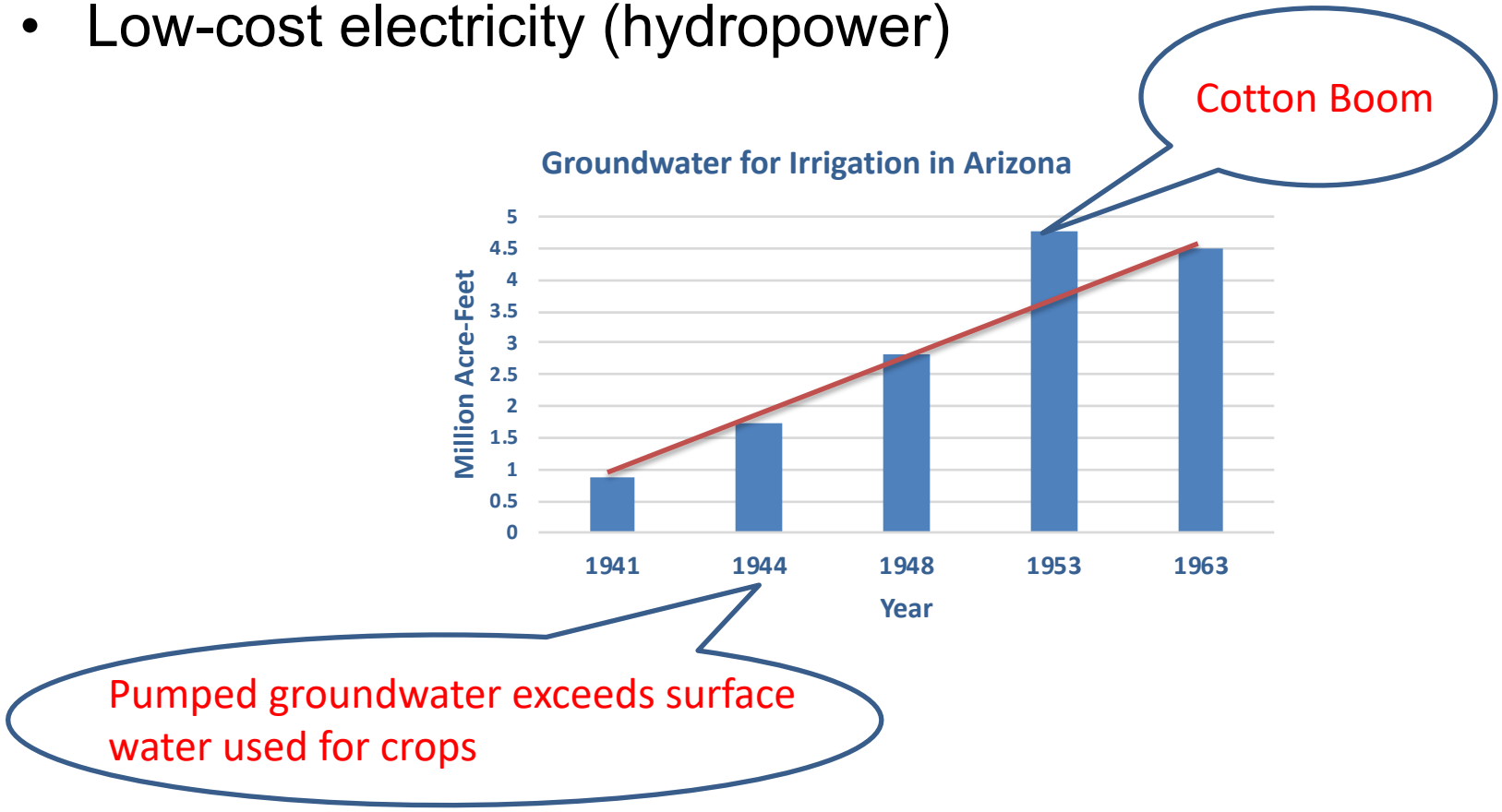
Beginning in the mid 1800's, construction of irrigation infrastructure brought water to Yuma Valley fields from the Colorado River.

The Yuma area's federally funded Reclamation projects were built between 1904 and 1963.

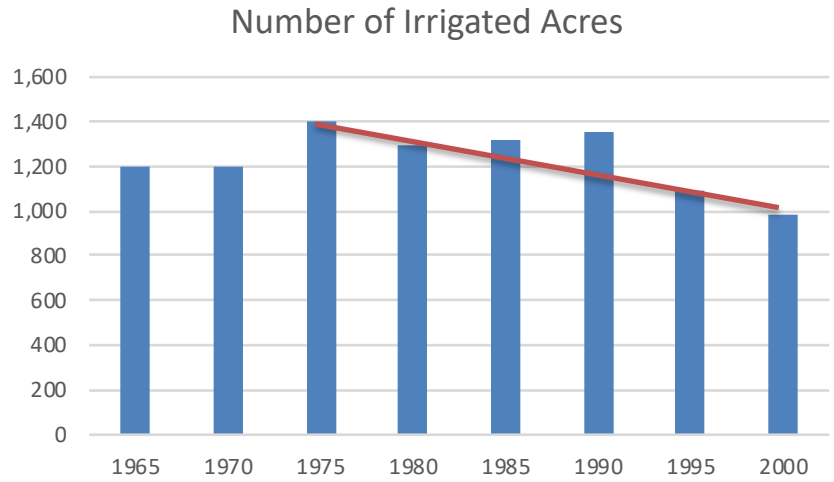


Groundwater dependent irrigated agriculture expanded rapidly after WWII due to –

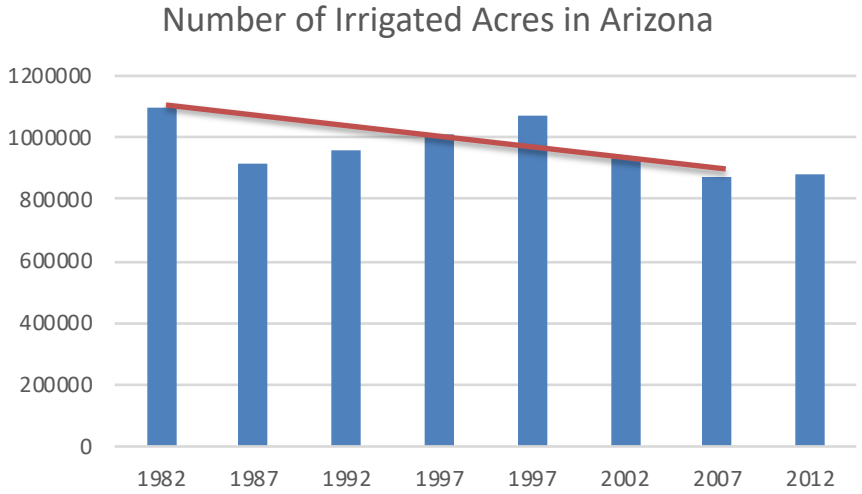
- High cotton prices;
- Development of the vertical centrifugal turbine pump;
- Low-cost electricity (hydropower)



Acres of irrigated agriculture declined starting around 1975 from 1.4 million acres to less than 900,000 acres by 2007.



USGS

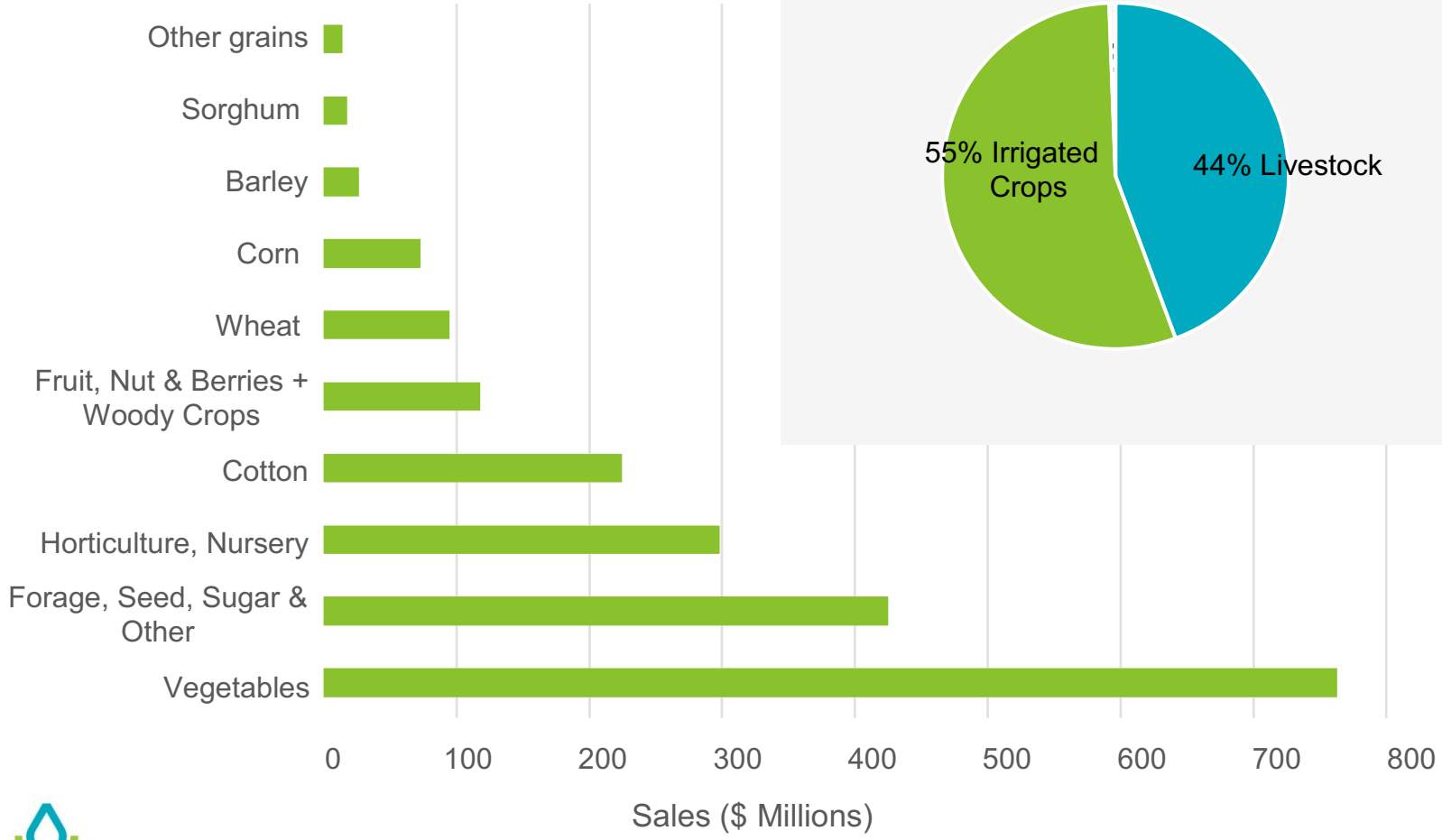


USDA

CURRENT SITUATION

Estimated Ag sector and irrigated crop sales for Arizona, 2012

Irrigated Crop Sales



Arizona Agricultural Sales

Natural Resources Conservation Service

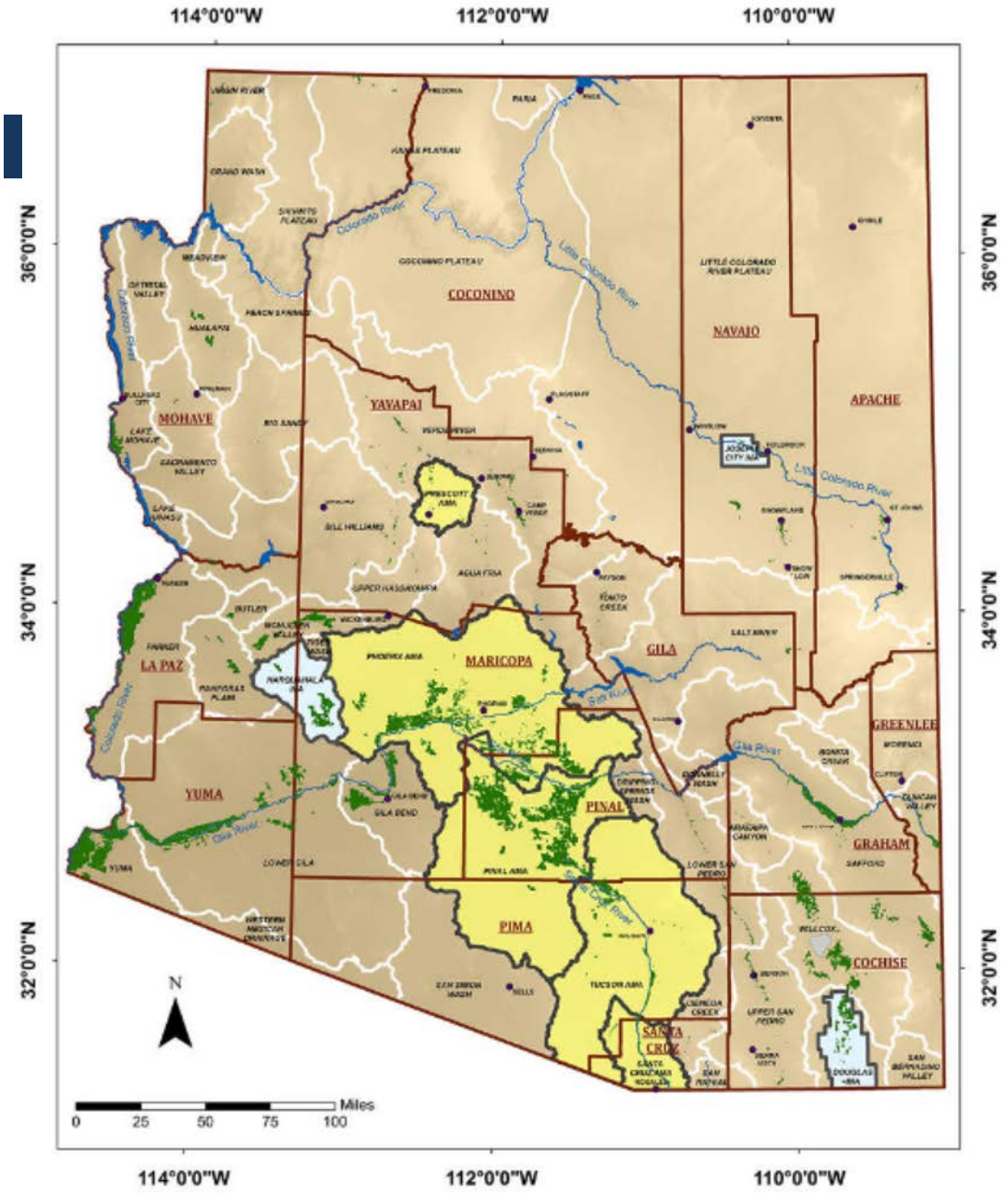
nrcs.usda.gov/

Source: NRCS analysis of NASS 2012 Census of Agriculture data

Arizona Agricultural Lands

Top Agricultural Counties
(Number of Irrigated Acres)

- Pinal
- Maricopa
- Yuma
- La Paz (Colorado River Indian Tribes)
- Cochise
- Graham
- Pima

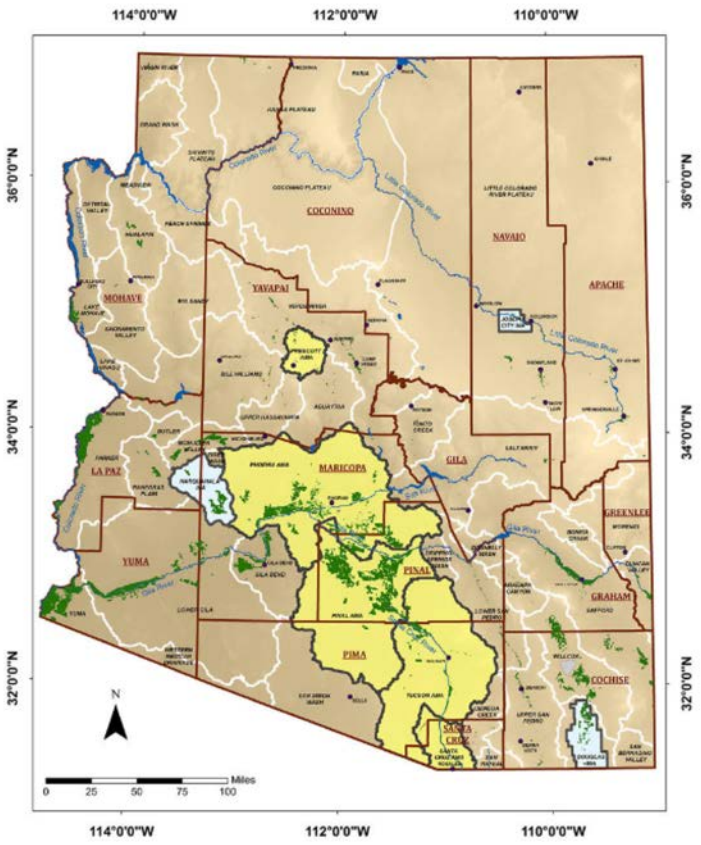


https://www.usgs.gov/media/images/agricultural-lands-arizona-0

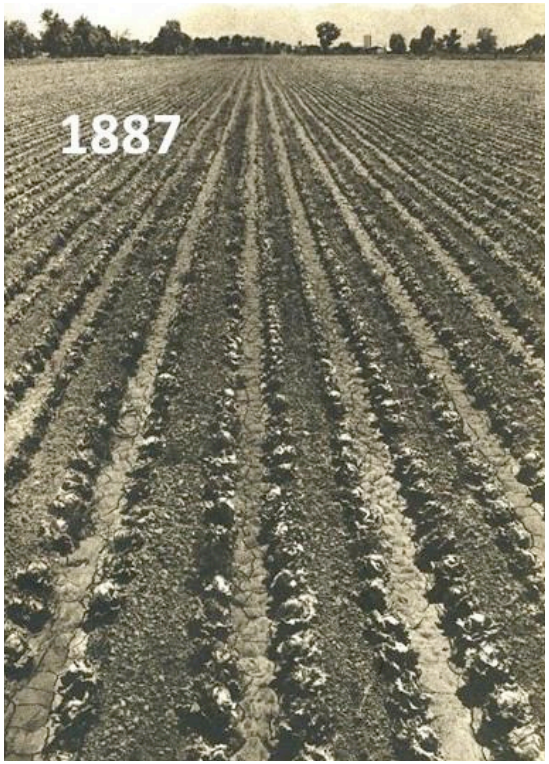
75% - Share of Arizona's agricultural sales from Maricopa, Pinal and Yuma Counties

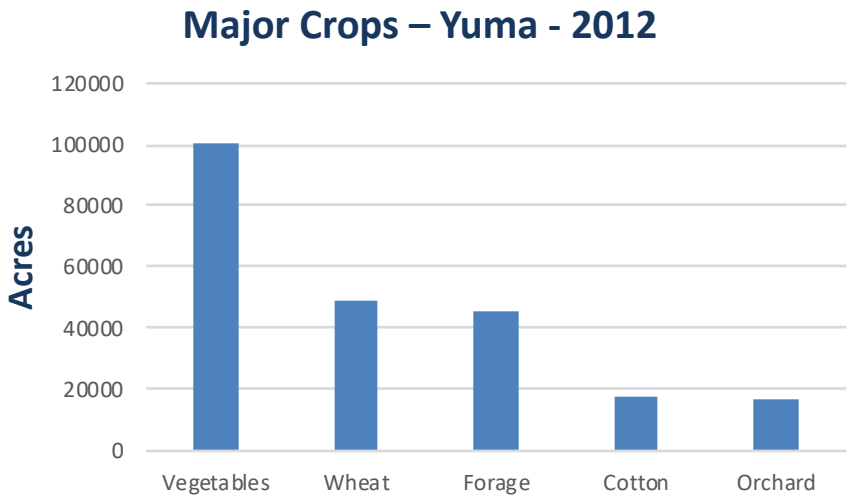
Region	Irrigated Acres	Crop Sales
Maricopa/Pinal	412,569	$762M
Yuma	181,197	$985M

USDA 2012 Census of Agriculture



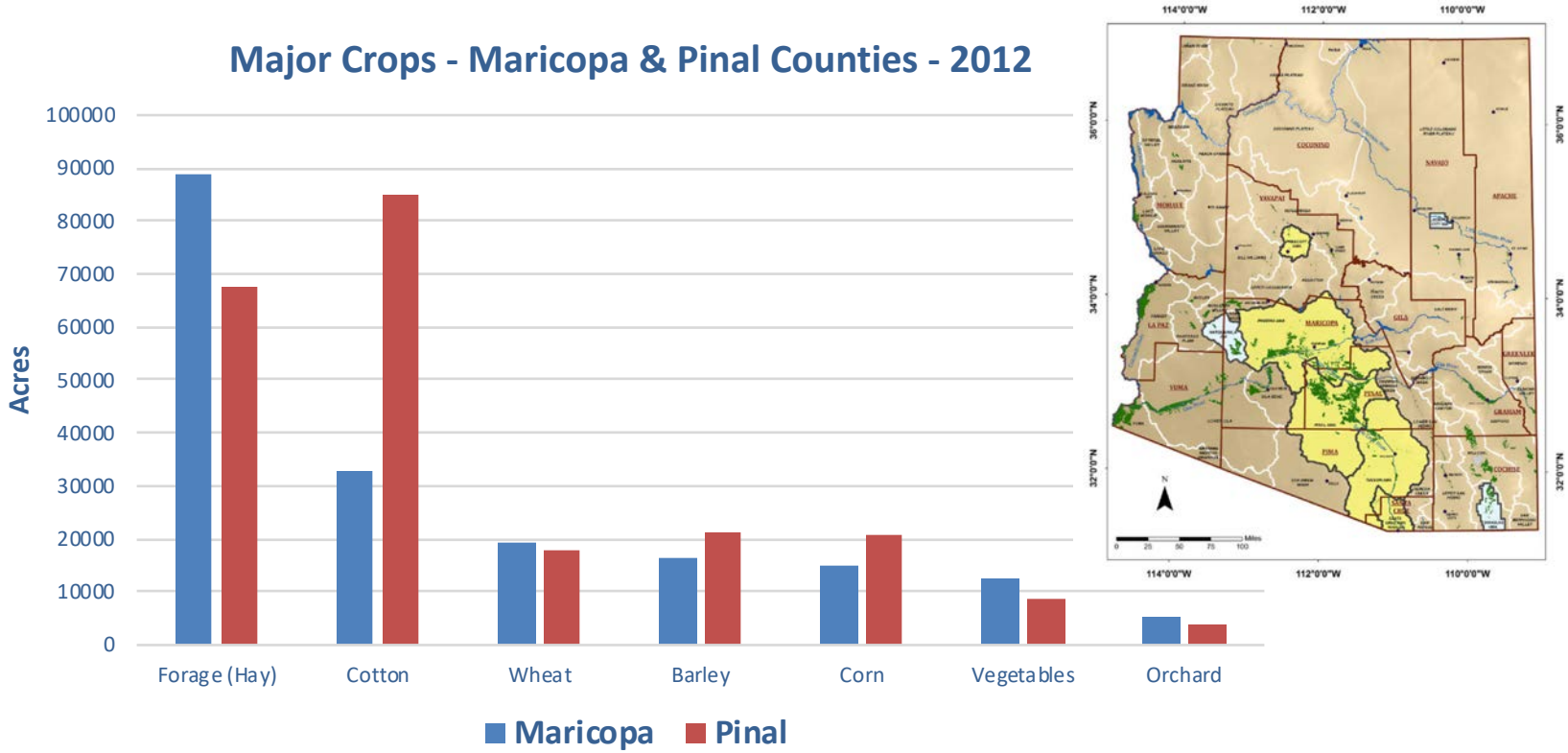
"Yuma is to U.S. agriculture what Silicon Valley is to U.S. computer and electronics production, what Detroit is to U.S. automobile production, and what Napa is to U.S. wine sales." G. Frisvold



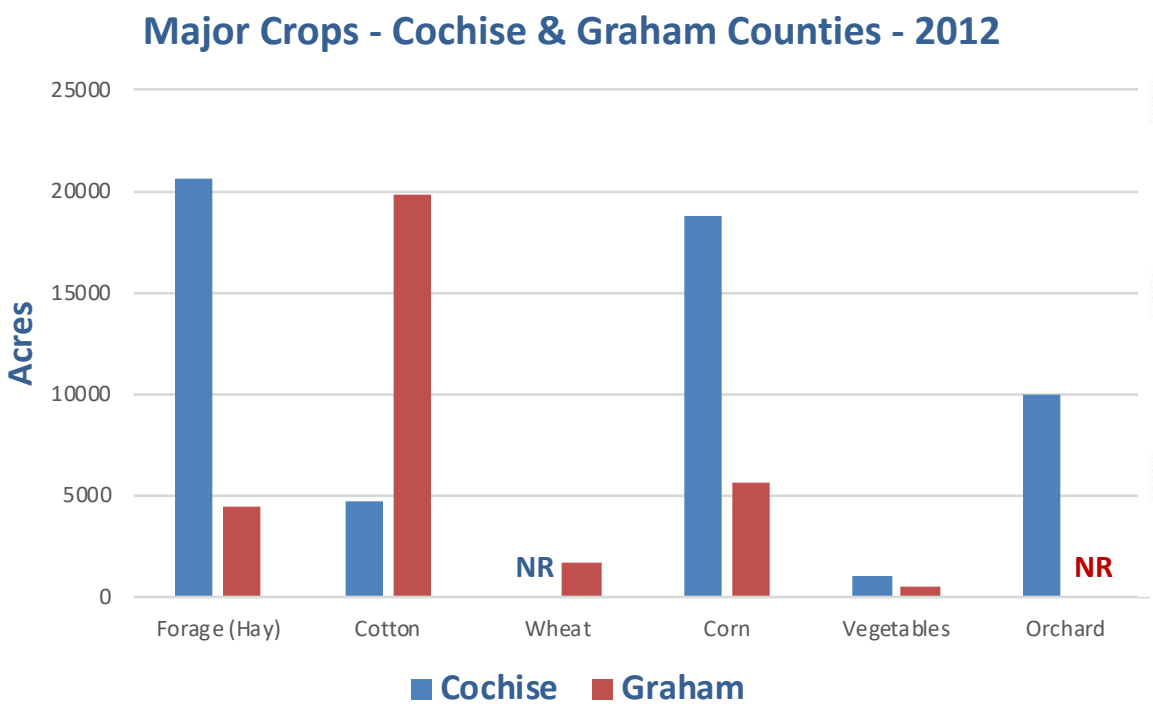


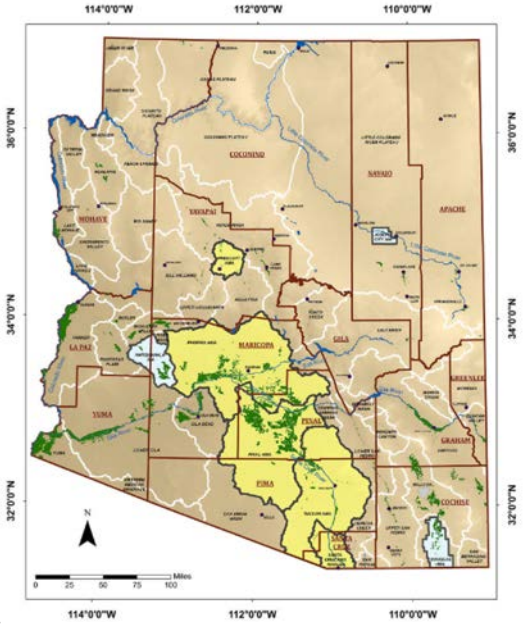
The Yuma region used about 0.75 million AF/year (excluding use on Native American Reservations) 2001-2005 mostly for agriculture.

Maricopa and Pinal Counties' non-Indian agriculture used 1.7 million AF/year, mostly for alfalfa/hay, cotton, wheat, barley, corn, vegetables, and citrus, 2001 – 2005.



Cochise, Graham, and Greenlee Counties in SE Arizona used ~0.28 million AF/year groundwater and ~0.13 million AF/year surface water for alfalfa/hay, cotton, wheat, corn, vegetables, and orchards, 2001-2005.

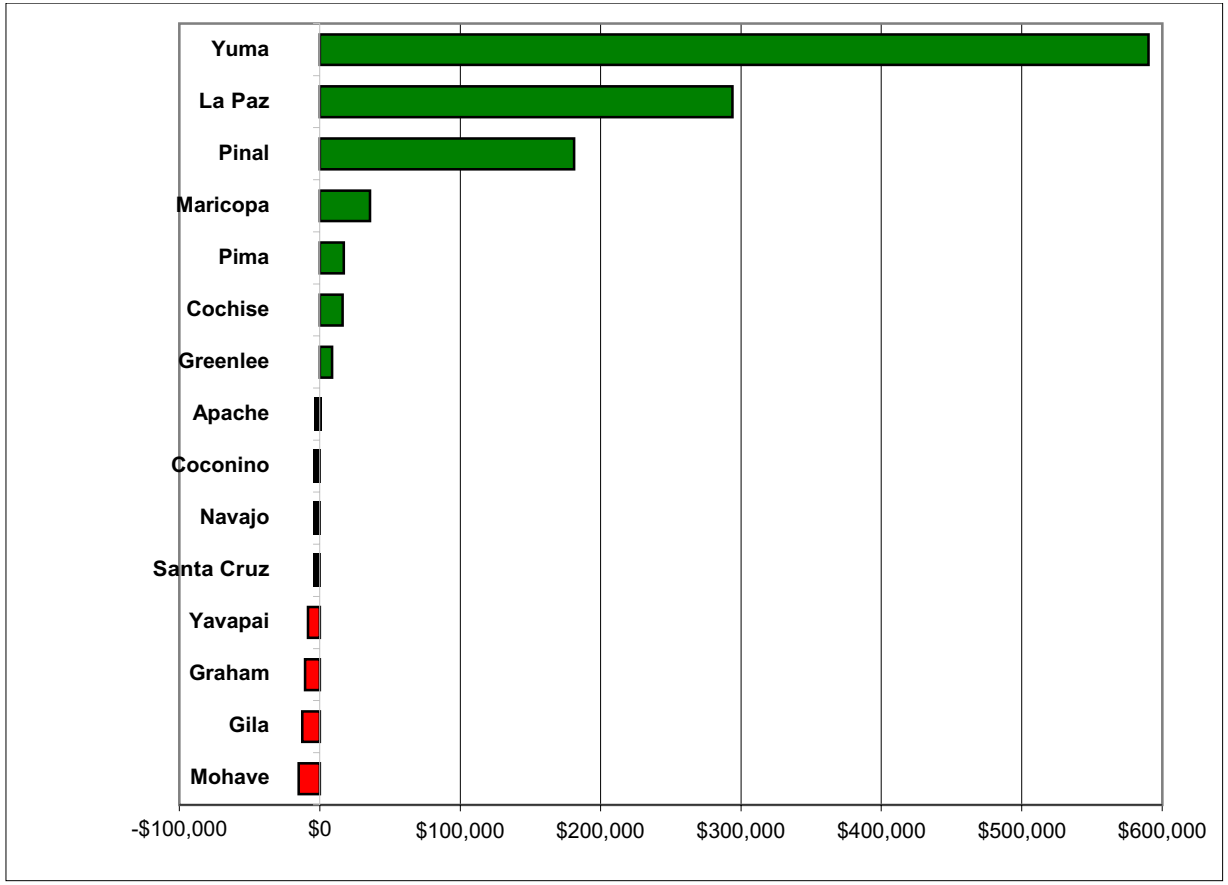




Little agriculture exists in Pima County except Farmers Investment Company (FICO) pecans near Green Valley and cotton, grains, and alfalfa near Marana.

FICO is the world's largest irrigated pecan orchard, with ~7,000 acres near Green Valley.

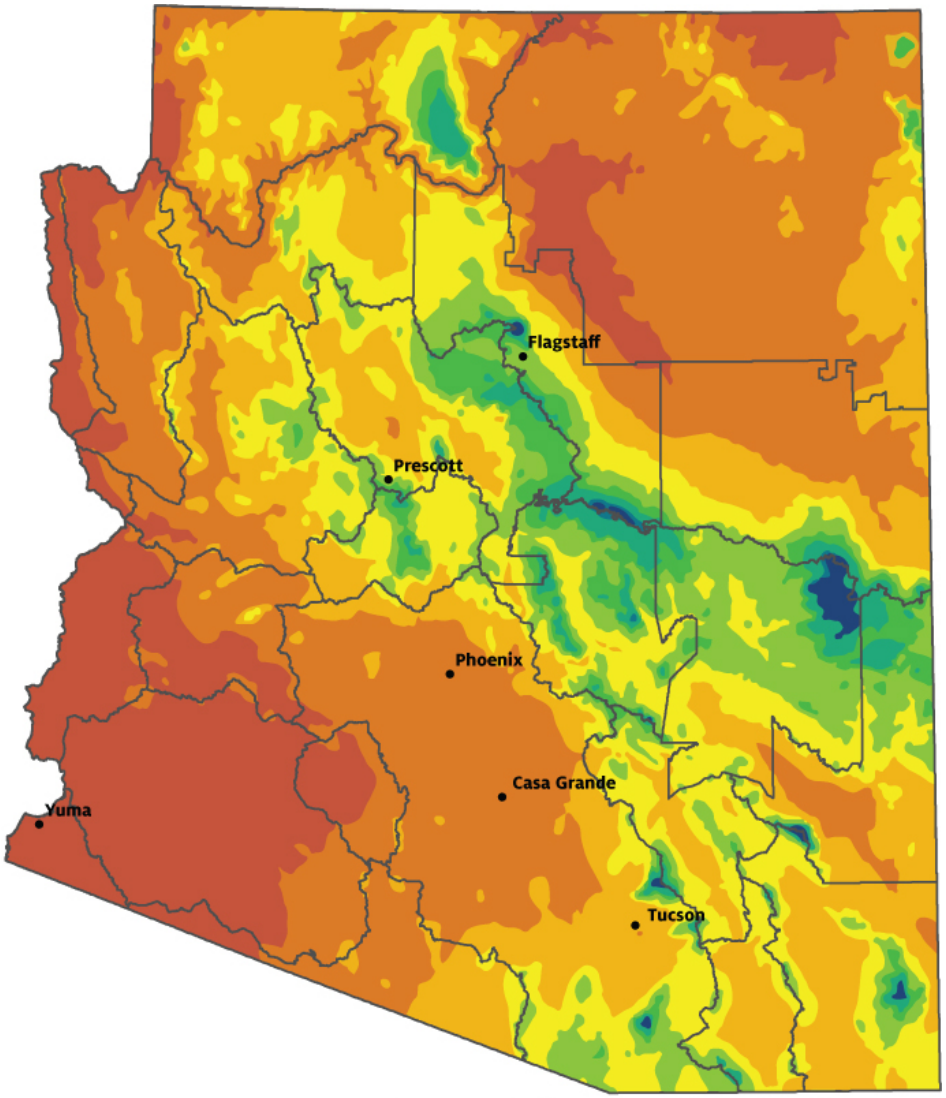
Net Cash Income Per Farm by Arizona County 2012

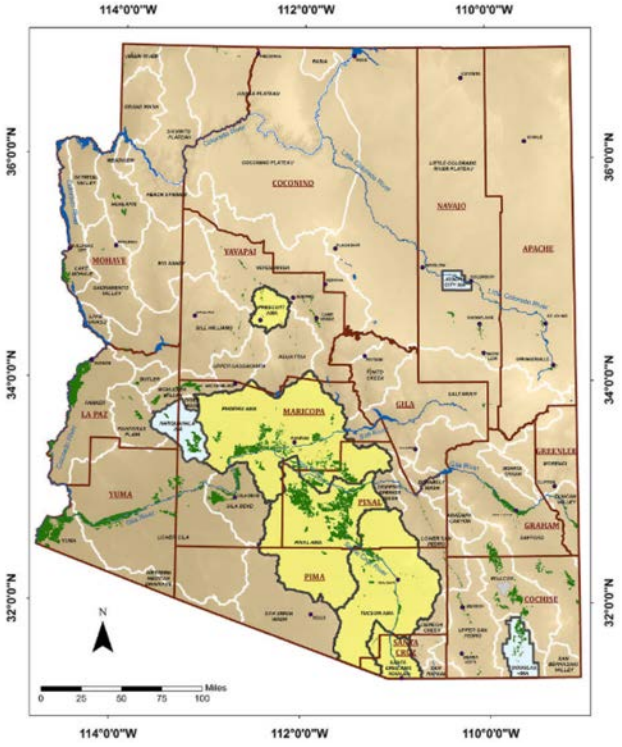


Source: USDA, NASS, *2012 Census of Agriculture*

WATER SOURCES

Where it Rains and Snows
Arizona Precipitation





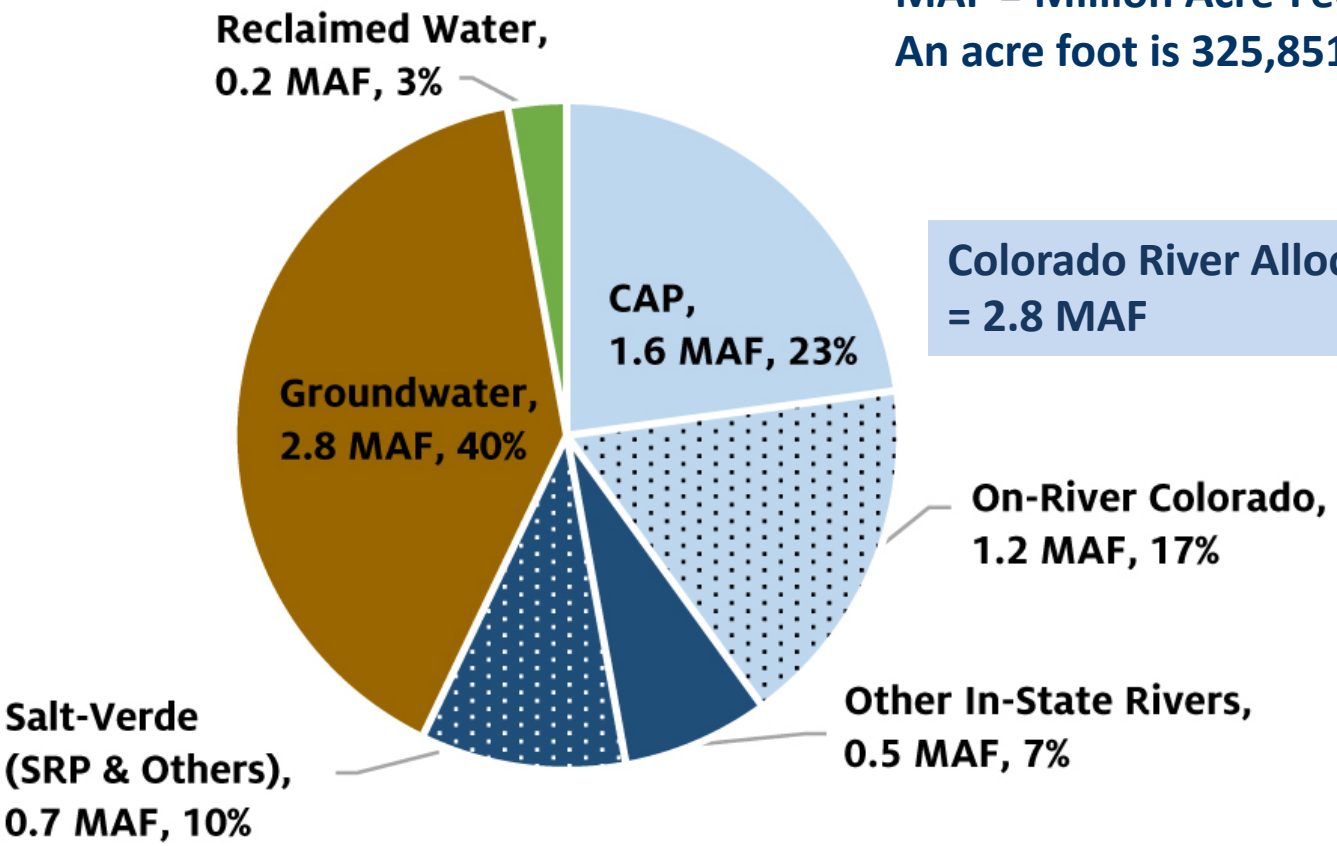
Average Annual Precipitation (Inches)
Period of Record: 1981-2010

3 - 7	15 - 19	27 - 33
7 - 11	19 - 23	33 - 35
11 - 15	23 - 27	35 - 50

Sources: 2016 PRISIM Climate Group,
Oregon State University, http://prisim.oregonstate.edu

Arizona Water Sources

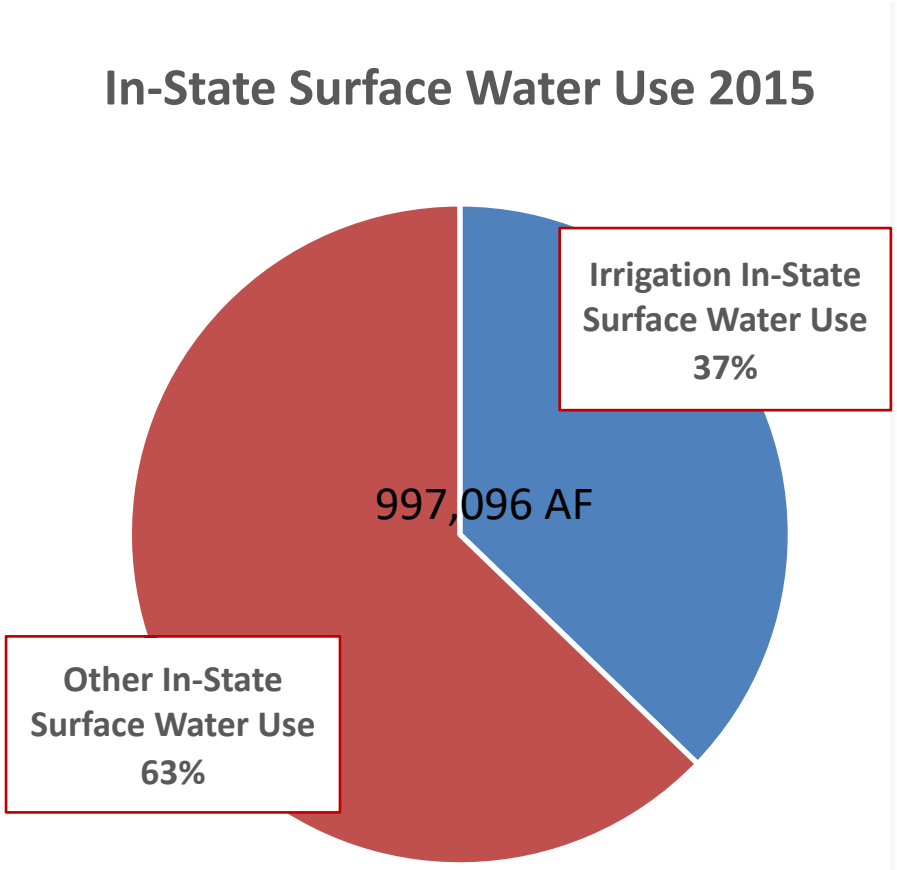
7 MAF Total
MAF = Million Acre-Feet
An acre foot is 325,851 gallons



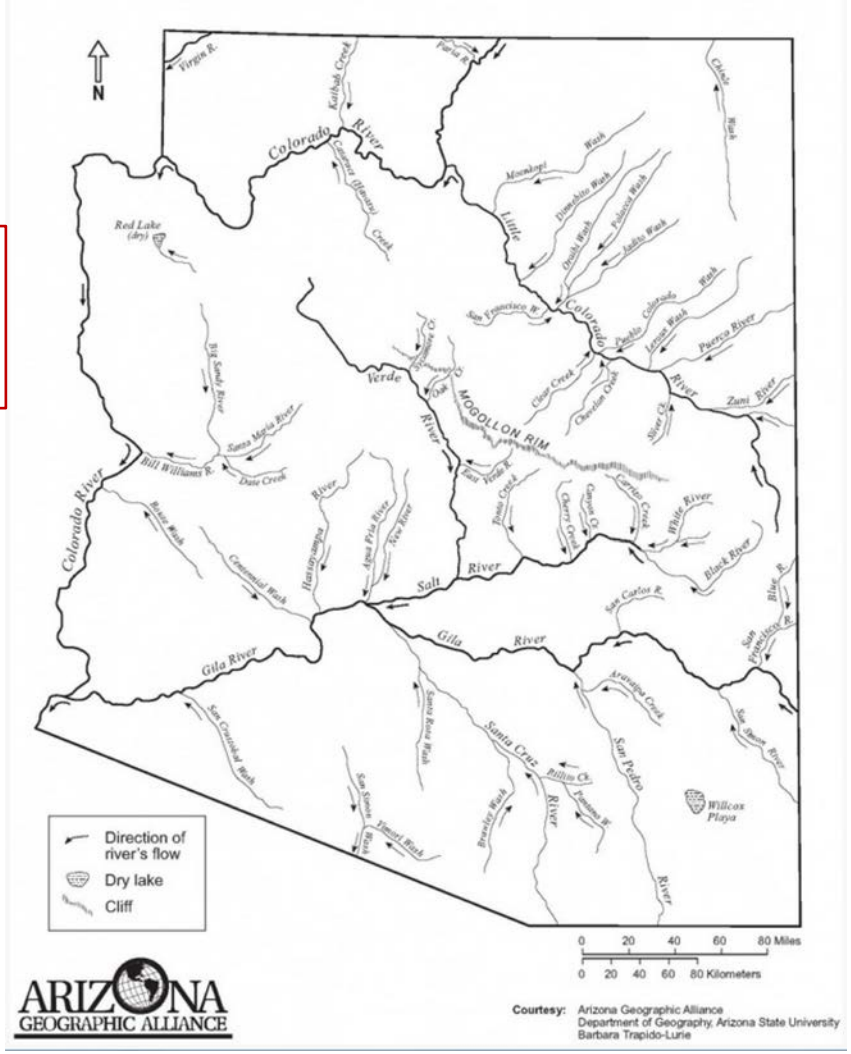
Colorado River Allocation = 2.8 MAF

Source: ADWR 2014 Water Budget

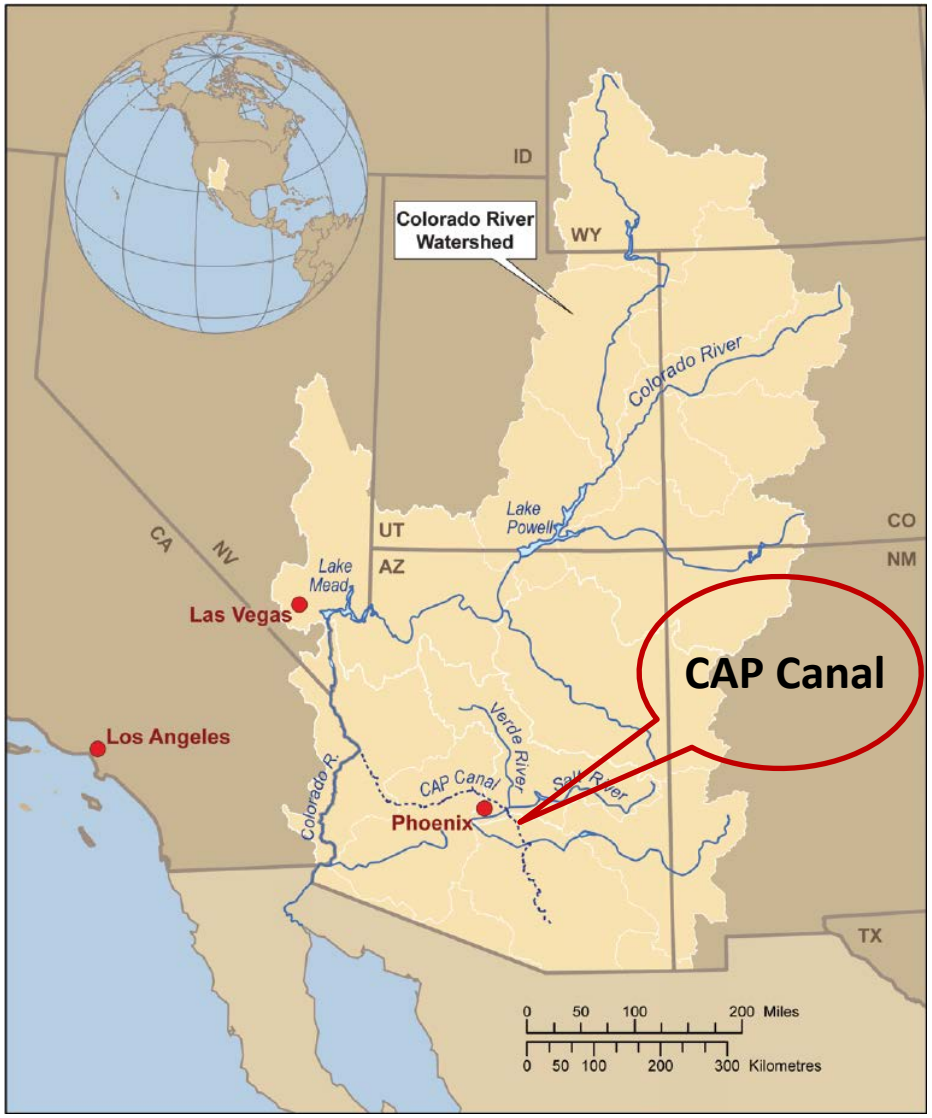
In-State Surface Water



Data: USGS, CAP & US Bureau of Reclamation



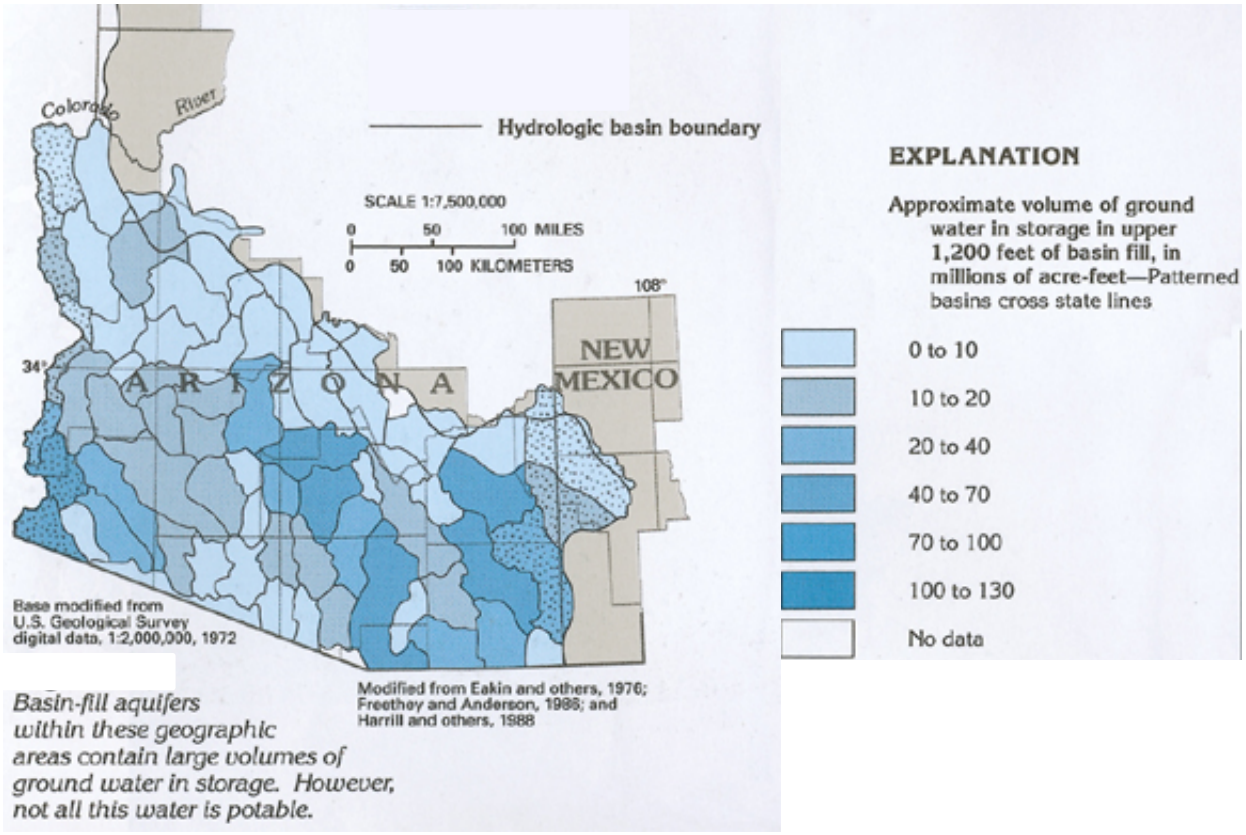
7 states share the Colorado River.



~1.9 MAF for irrigation of 2.6 MAF withdrawn in 2015 (73%)

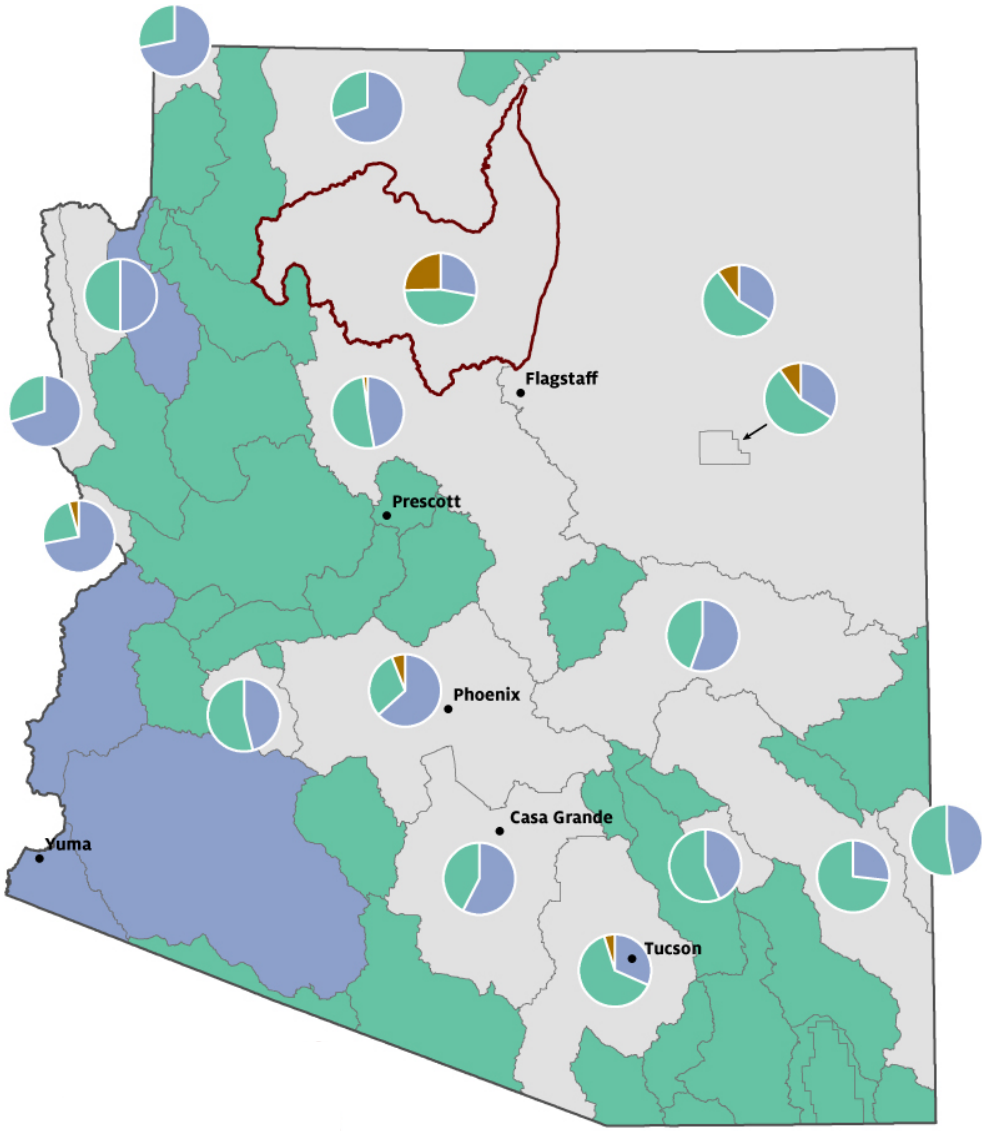
The Central Arizona Projects serves Maricopa, Pinal and Pima Counties.

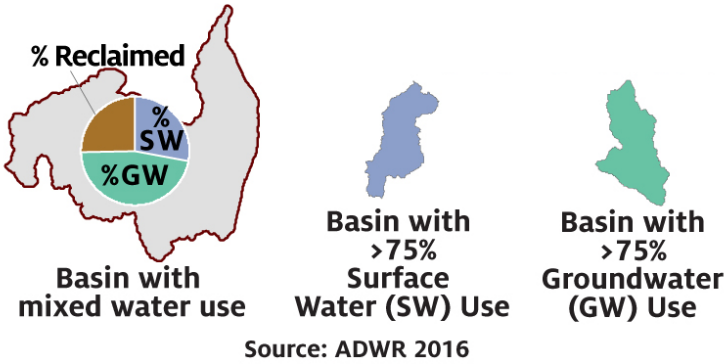
Much of Southern Arizona is favorable for groundwater pumping, with deep aquifers and substantial amounts of water.



Basin-fill aquifers within these geographic areas contain large volumes of ground water in storage. However, not all this water is potable.

Arizona Water Sources





Distribution of water supplies varies substantially across Arizona.

ARIZONA WATER MANAGEMENT

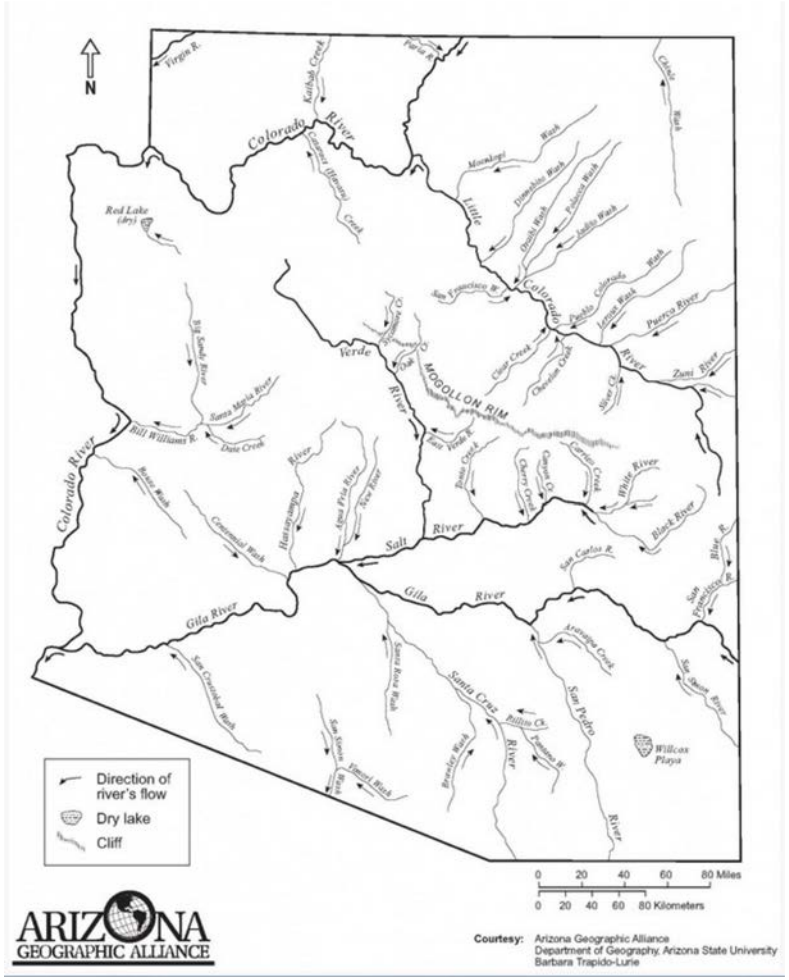
Arizona Water Management

Groundwater and surface water systems are managed separately

Surface Water

Arizona's surface water use is governed under the doctrine of Prior Appropriation.

"First in time, first in right"



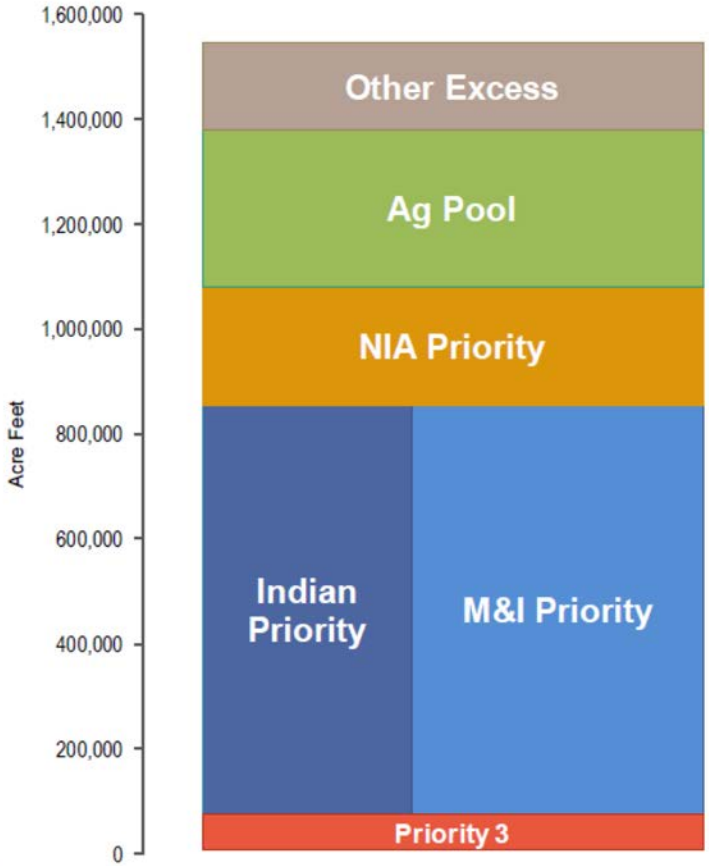
Colorado River Water

The priority of water rights for Colorado River water varies based on when they were acquired.

- 1st Priority water rights - established before Reclamation projects were built on the Colorado River.
- 2nd and 3rd Priority water rights - established before September 30, 1968 (pre-CAP Reclamation projects).
- 4th Priority water rights - established by contract after September 30, 1968 (most CAP water).

CAP water is important to Central Arizona agriculture, but -

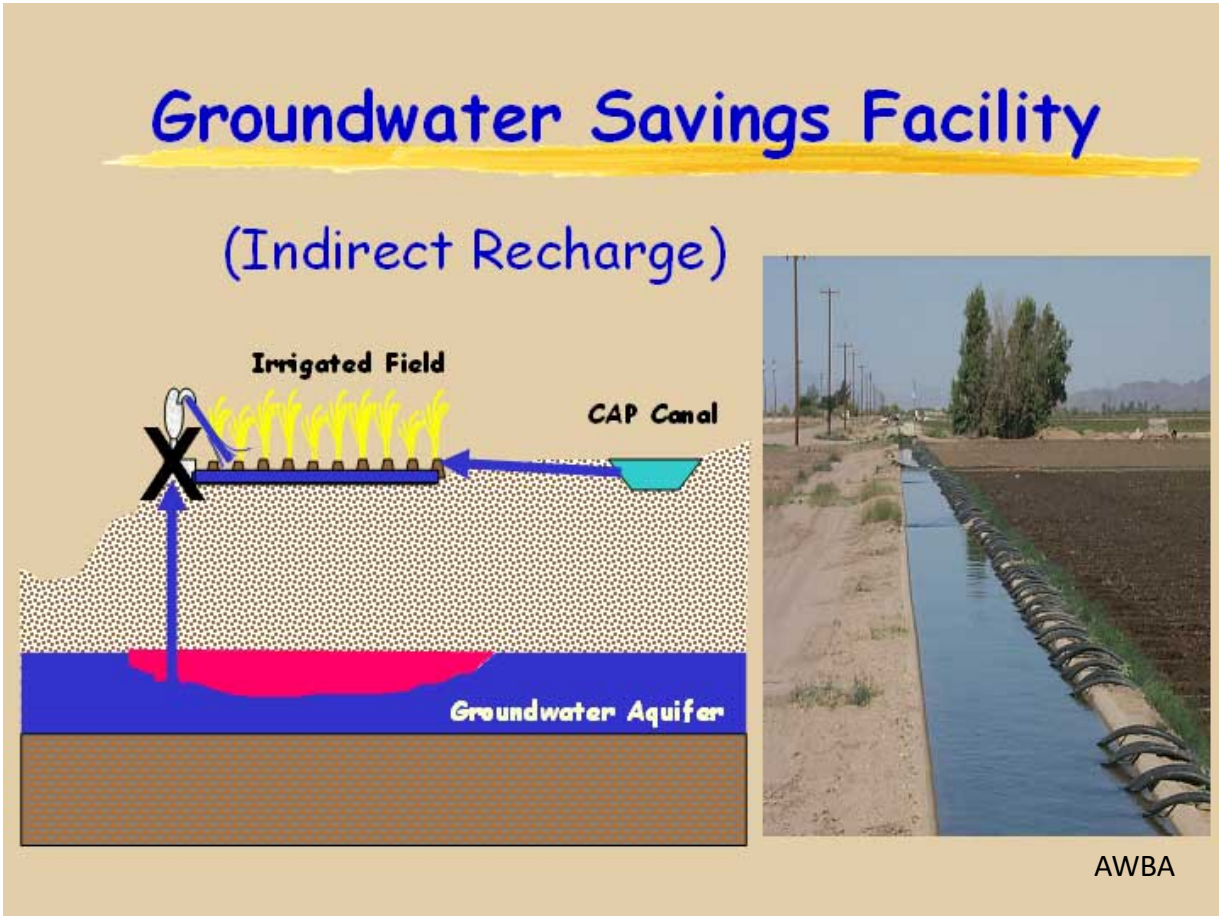
Most irrigators cannot afford CAP subcontracts and have needed rate reductions to use CAP water.



CAP 2014

Much of the CAP water sold to farms and irrigation districts comes from the “Agricultural Settlement Pool”, which is subject to availability, decreases over time, and will be eliminated in 2030.

Some farms and irrigation districts receive CAP water as Groundwater Savings Facilities (GSF): CAP water used in lieu of groundwater.

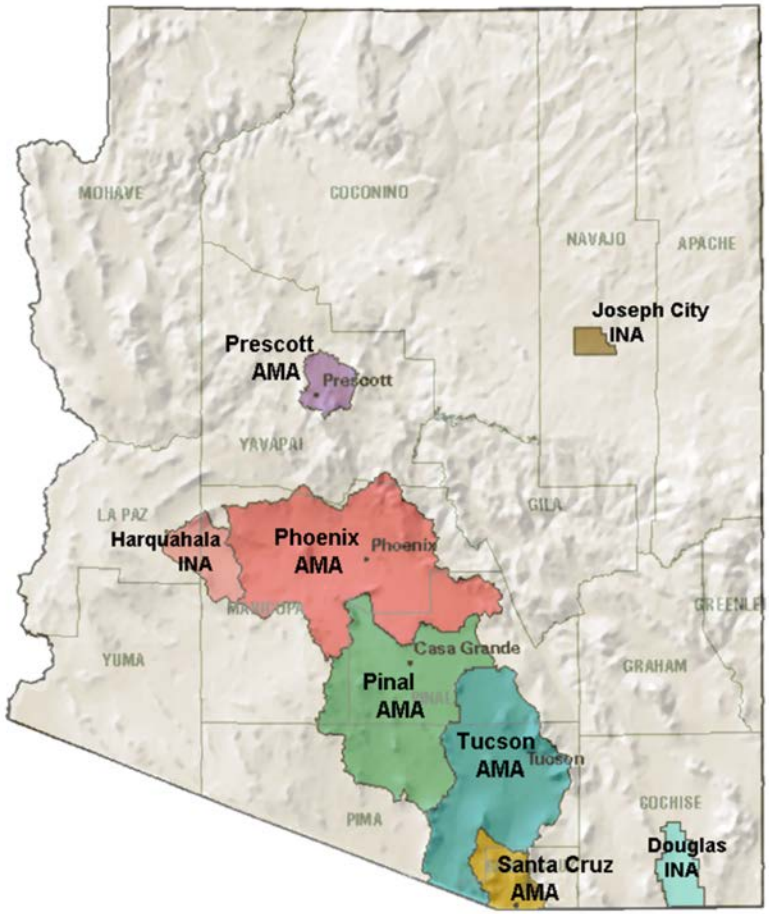


Groundwater

Outside AMAs groundwater withdrawal is not regulated.

Groundwater use outside AMAs is governed under the doctrine of Reasonable Use.

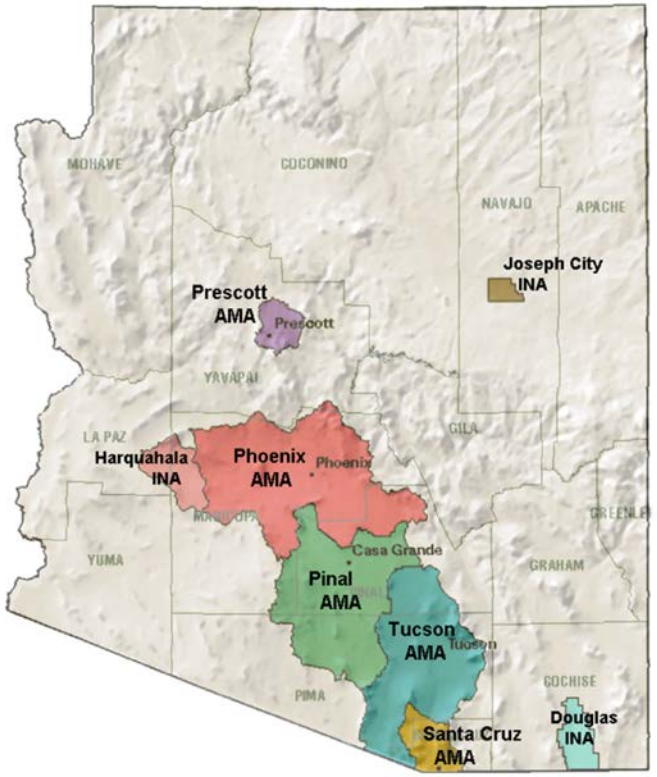
Most groundwater management activities are focused in 5 Active Management Areas (AMAs).



Within an AMA, irrigators have quantified grandfathered irrigation rights based on the water use and crop types grown on irrigated land between 1975 and 1980.

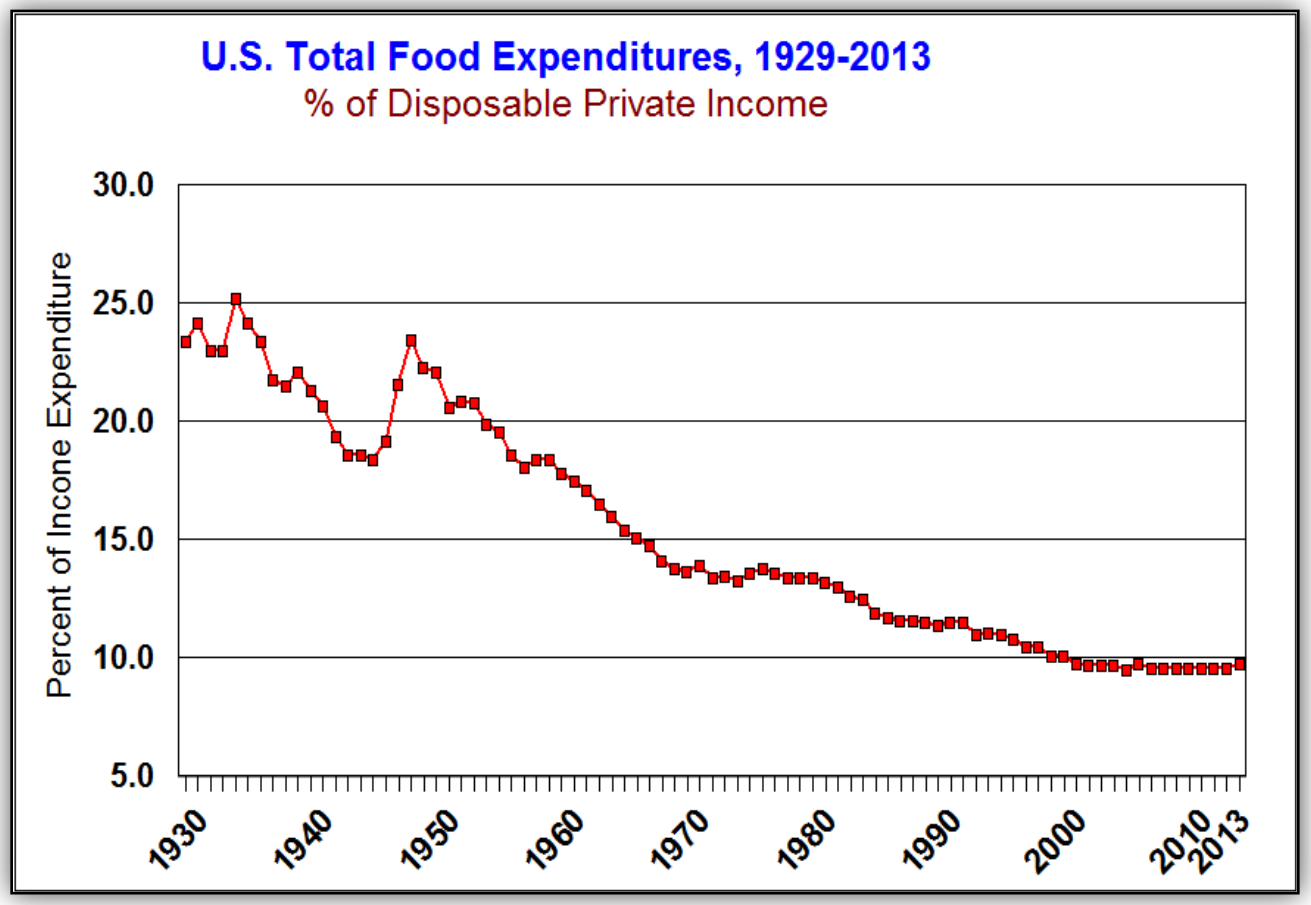
No new land in an AMA may be brought into production using pumped groundwater.

In Irrigation Non-Expansion Areas (INAs) no new lands may be brought into agricultural production.



ECONOMIC IMPACTS

Keeping Food Prices Low



2013 Home Food $:	
U.S:	6.6 %
U.K:	9.3 %
Germany:	12.0 %
Japan:	13.6 %
Brazil:	15.7 %
Greece:	16.6 %
Iran:	25.0 %
China:	26.1 %
India:	29.6 %
Russia:	30.5 %
Egypt:	37.4 %
Pakistan:	48.1 %

Family Farm Alliance

Arizona is a national leader in the production of many agricultural commodities

In 2014, Arizona

- Ranked **2nd** in the nation for the production of **lettuce** (head, leaf, Romaine), **spinach**, **broccoli**, and **cauliflower** (72,100 acres for all types of lettuce)
- Produced **28%** of the nation's **cantaloupe** and **22%** of the nation's **honeydew melons**
- Ranked **4th** in the nation for the production of **pecans**, accounting for **8%** of national production (17,061 acres of pecan trees)

G. Frisvold

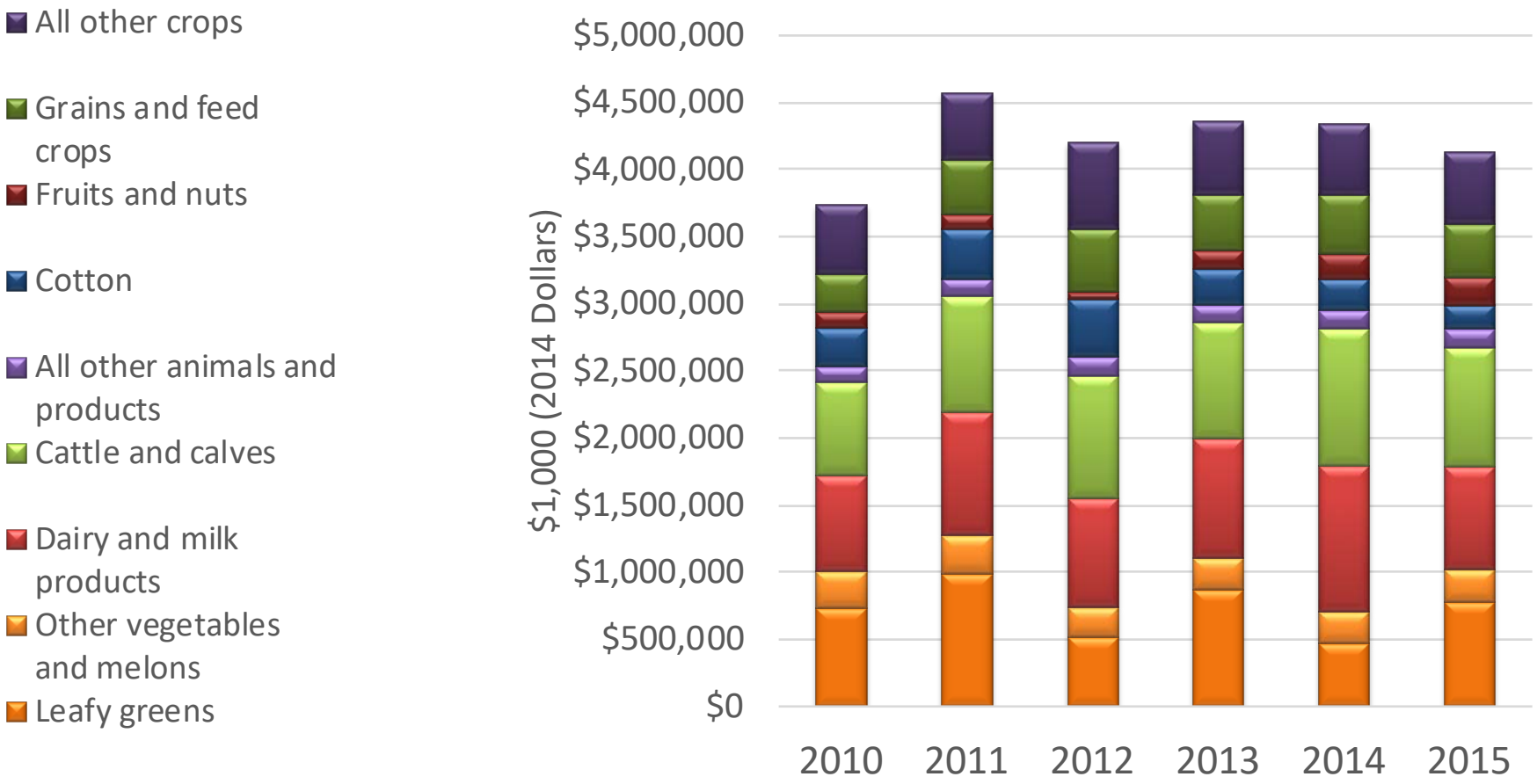
Economic Contribution to Arizona

- **$23.3 billion** – Agriculture's estimated total contribution to Arizona's sales in 2014 (8% GDP)
  - **$14.8 billion** - Contributed directly by crop and livestock production and support service industries, and by agricultural processing, marketing, distribution and input manufacturing
  - **$8.5 billion** - Generated through indirect (farm inputs) and induced (ag incomes spent) effects.

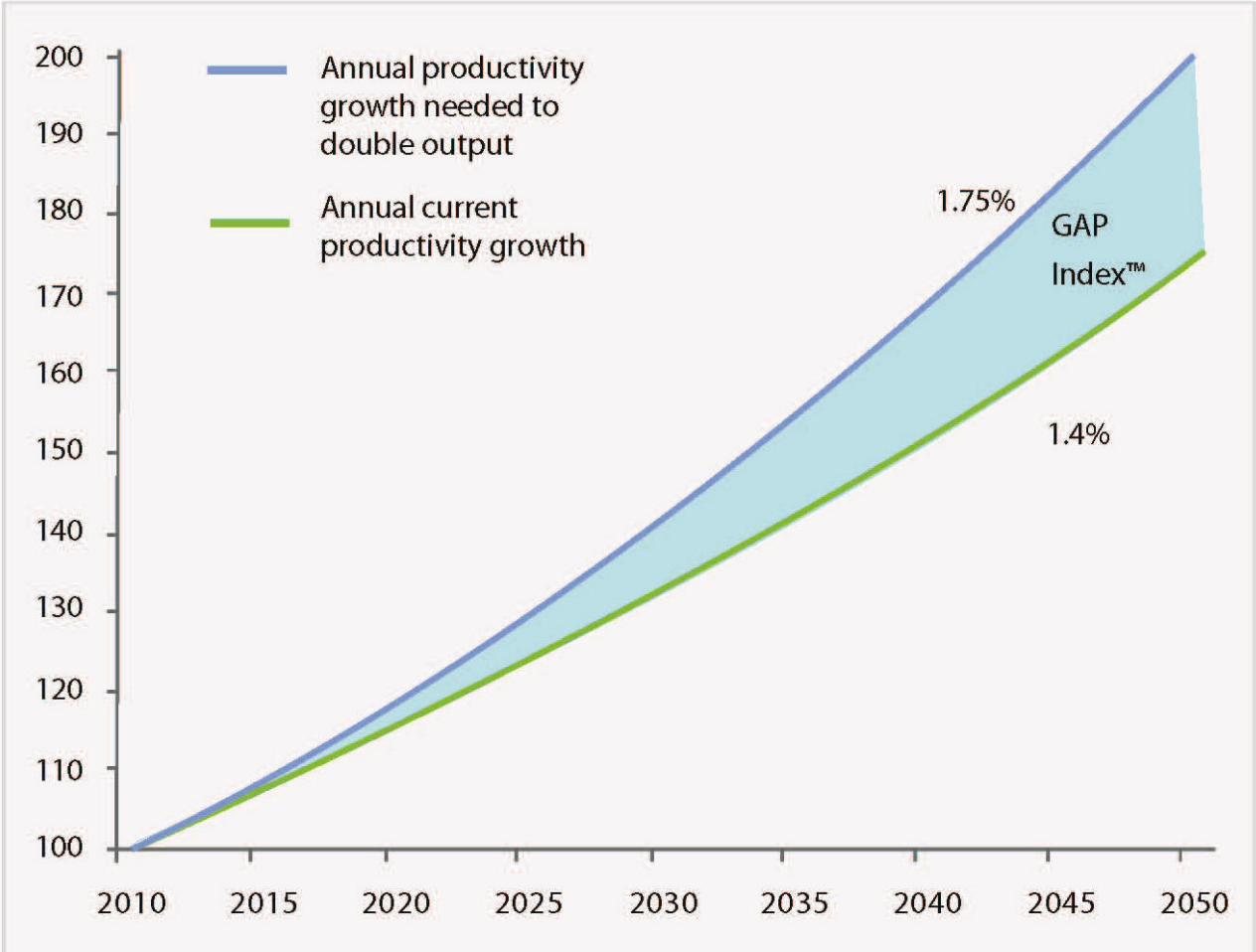
(Bickel, Duval and Frisvold 2017)

- **$281 billion** – Arizona's Gross Domestic Product (GDP) in 2014

AZ Farming Cash Receipts 2010-2015

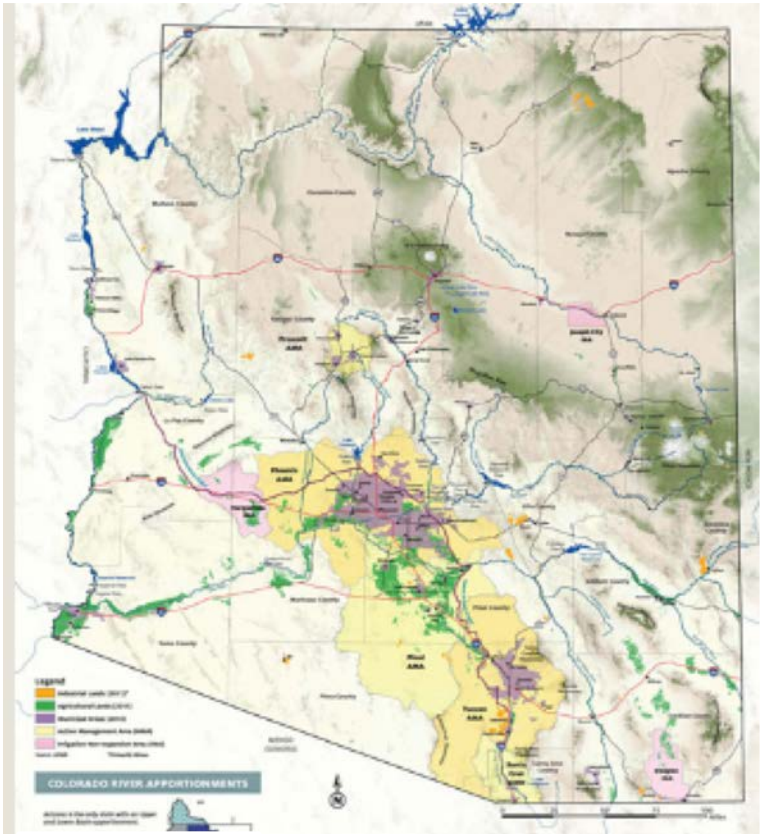


The World Food Supply "GAP"



The UN projects that farmers will need to produce 70% more food by 2050 to keep up with population growth.

Agricultural Water Issues

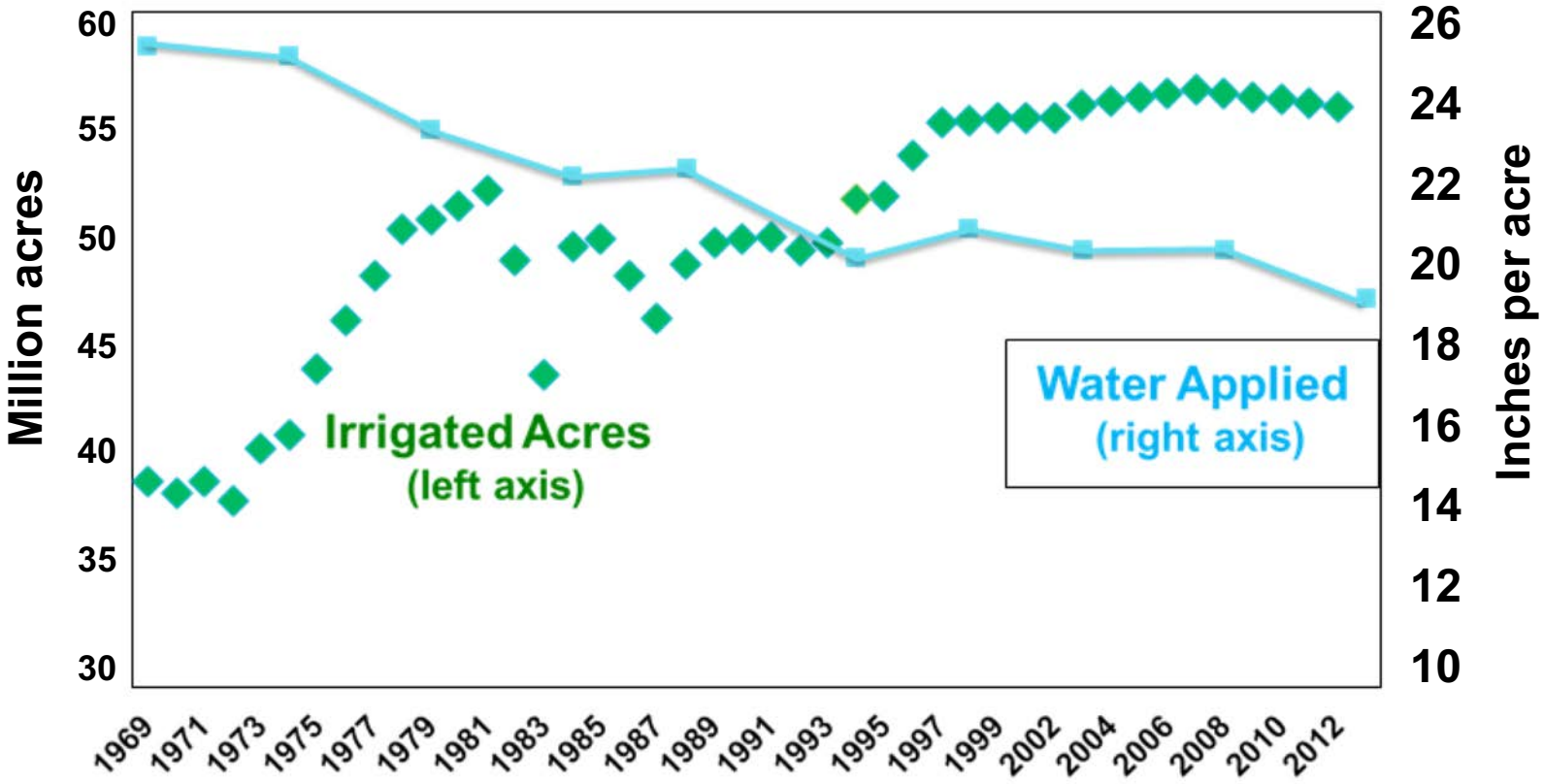


- Conservation and Efficiency
- Groundwater Depletion
- Colorado River Shortage
- Fallowing
- New Groundwater Regulation
- General Stream Adjudications
- Water Quality

Conservation and Efficiency

United States Department of Agriculture

U.S. irrigated acres & water applications



Irrigation system improvements have helped reduce water use without sacrificing yield.

Major types of irrigation systems include

- Surface irrigation (flood and furrow)
- Sprinklers
- Drip systems

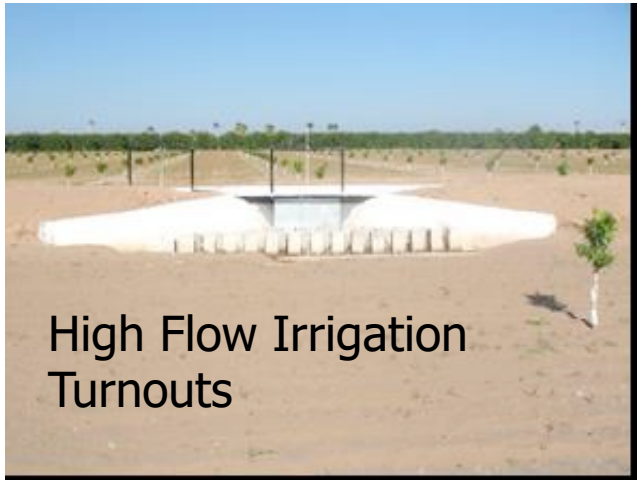
Innovative gravity-flow systems can be water-conserving

Evaluating Gravity-Flow Irrigation with Lessons from Yuma, Arizona, USA, Frisvold et al. 2018

GPS-based Laser Leveling

"Bolas" Furrows pressed into tight trapezoidal shape

Concrete Lined Ditch



High Flow Irrigation Turnouts

Sprinkler irrigation is more efficient than flood irrigation, especially to germinate vegetable crops.

Water use in the Yuma region to establish vegetable crops has decreased 50-75%.

The practice of “subbing up” has been replaced by sprinklers, reducing the amount of water needed to establish vegetable crops.

In Drip Irrigation, low pressure water lines release water at or below the land surface.

For most crops, Drip Irrigation provides more crop per drop, because less water evaporates or runs off.


Water Deeply


Ewing Irrigation

Drip irrigation is used on <2% of agricultural land in the Yuma area.

- high installation cost ($500-$1500 per acre).
- cannot be easily changed or moved once installed to vary spacing for crop rotation.
- wetting is insufficiently uniform to establish the crop

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Challenges to Improved Water Efficiency

Barriers to Irrigation Improvements	Farms	Land (a)	Water (a-ft)
Landlord will not share costs	297	192,388 (23%)	919,114 (17%)
Improvement won't cover install. costs	560	124,760 (15%)	572,066 (11%)
Cannot finance improvements	1209	121,436 (14%)	519,227 (10%)
Will not be farming long enough	243	97,354 (10%)	520,142 (10%)
Uncertainty about water future	598	114,054 (13%)	443,406 (8%)

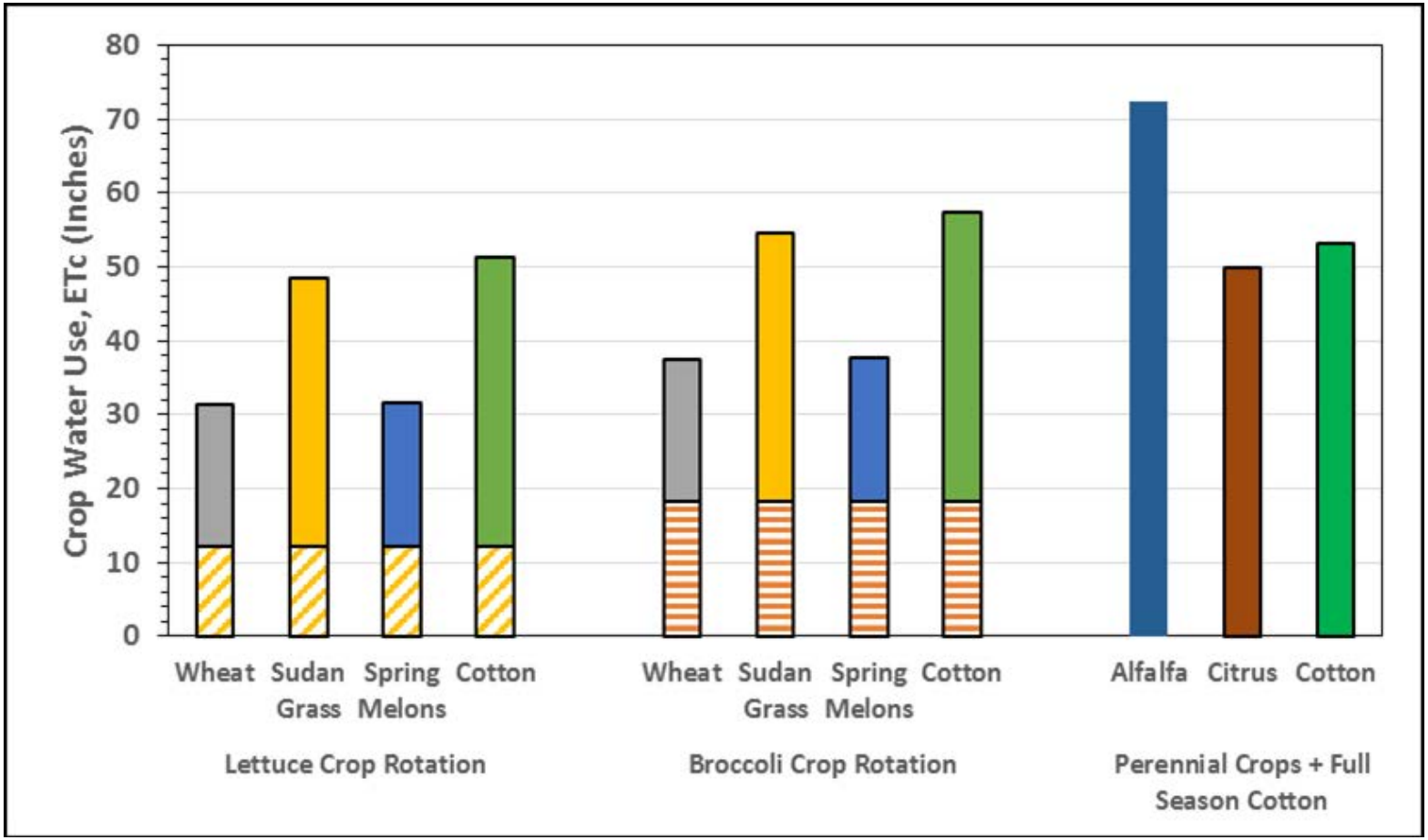
2013 Farm and Ranch Survey, USDA, NASS

Values in ( ) represent % of irrigated land or % of ag water use

- Decisions regarding what irrigation system to use depend on many factors including crop type, soil, water quality, and degree of flexibility needed, as well as cost.

- Decisions regarding crop mix depend on market factors such as buyers, prices, and infrastructure for processing and distribution.

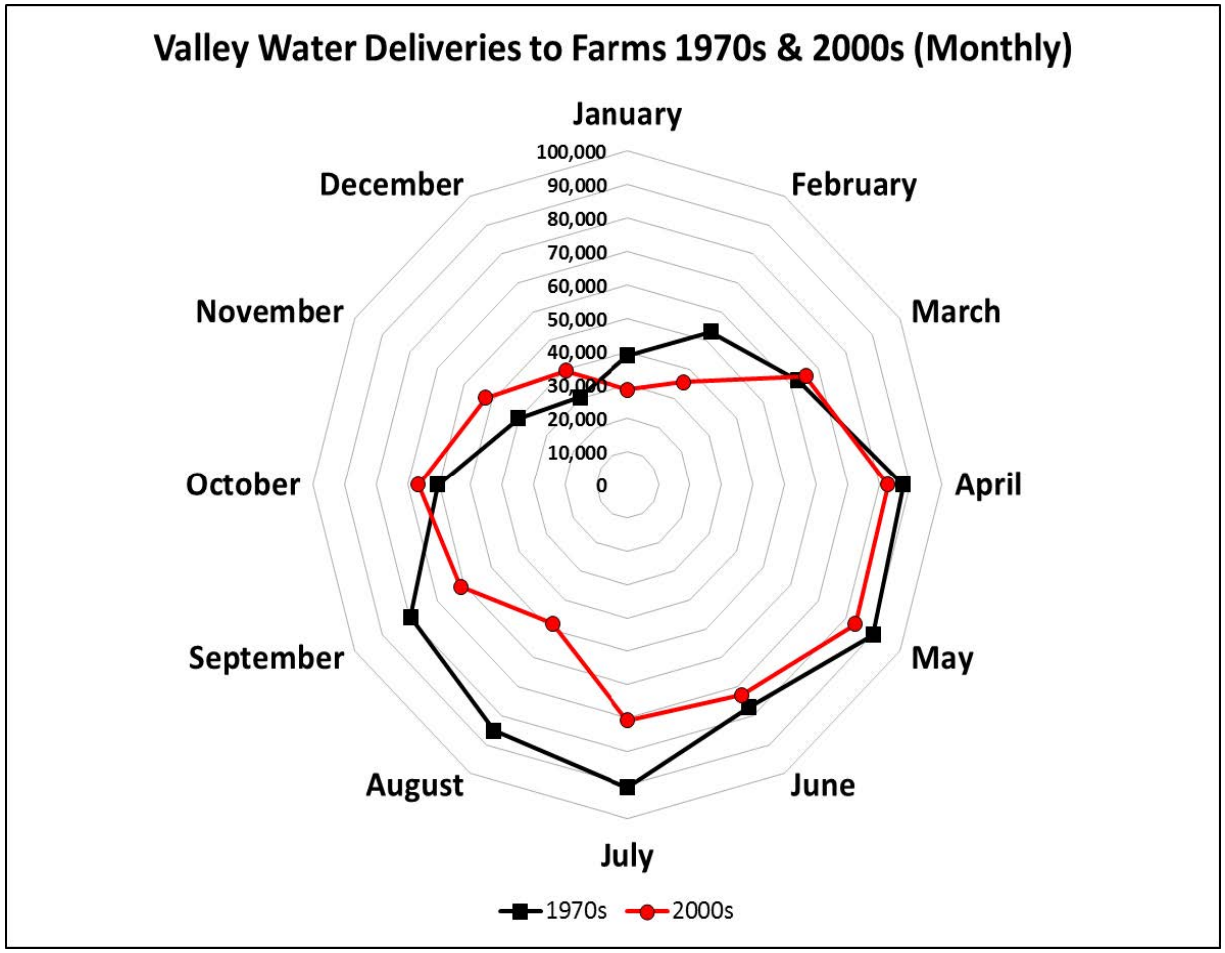
In Arizona, seasonal crop rotation has been replacing perennial/full-season crops that must be irrigated during late summer.



In the Yuma area,

- Leafy green crops grown in the winter are rotated with warm season crops that reach maturity by early summer.
- Since 1970, acres planted to vegetables increased 600%, while acres in full-season crops declined 43%.

In the Yuma area, irrigation water use decreased 15% since 1990, while irrigated acreage and yields have increased.



2015 Yuma Water Study

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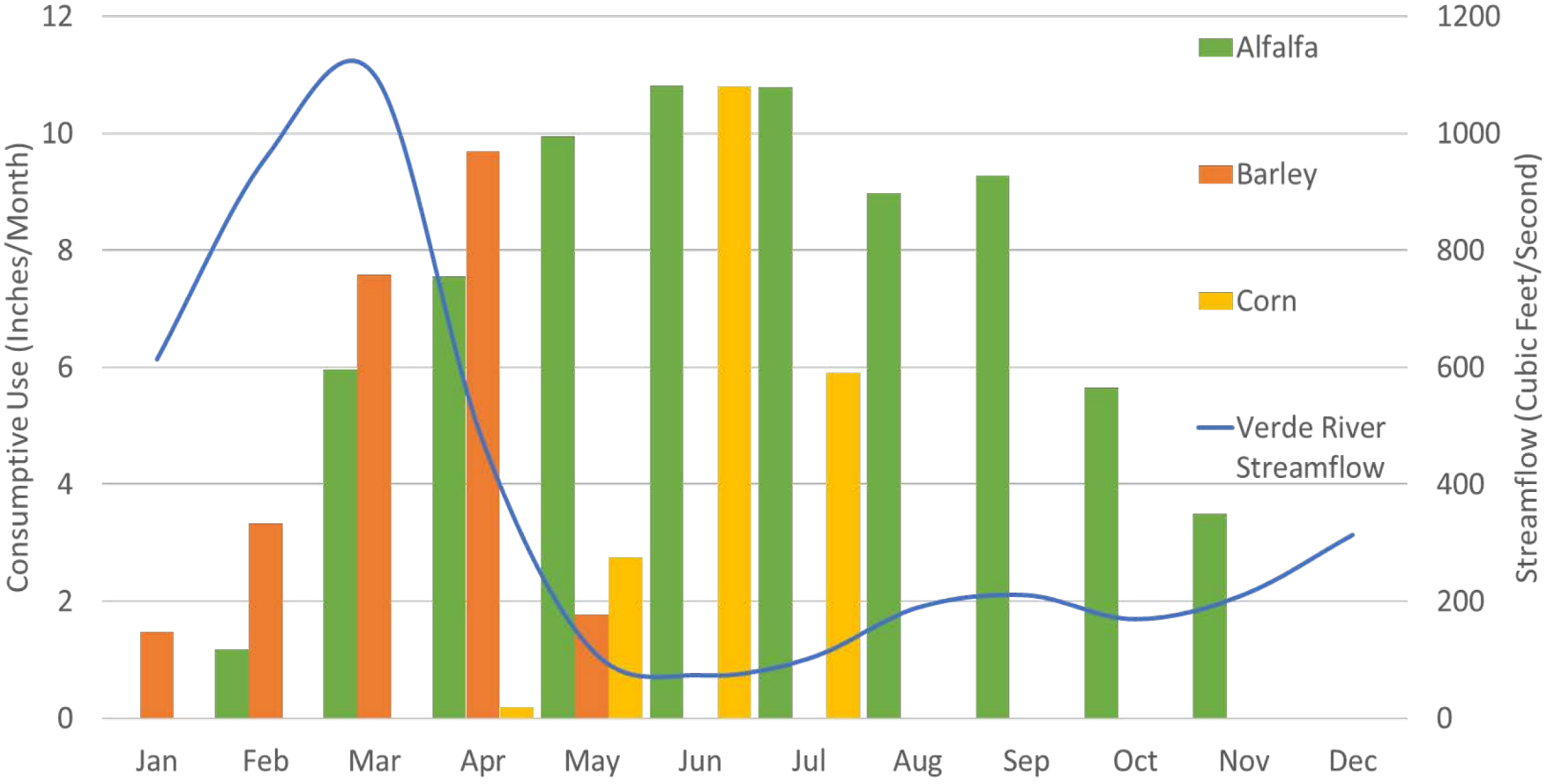
Southeast Arizona
Tree Nut Production

Nut trees have replaced cotton & alfalfa in Southeast AZ.
Most new plantings use drip/micro-irrigation.

Water Requirements for barley compared to alfalfa and corn



ARIZONA WILDERNESS BREWING CO

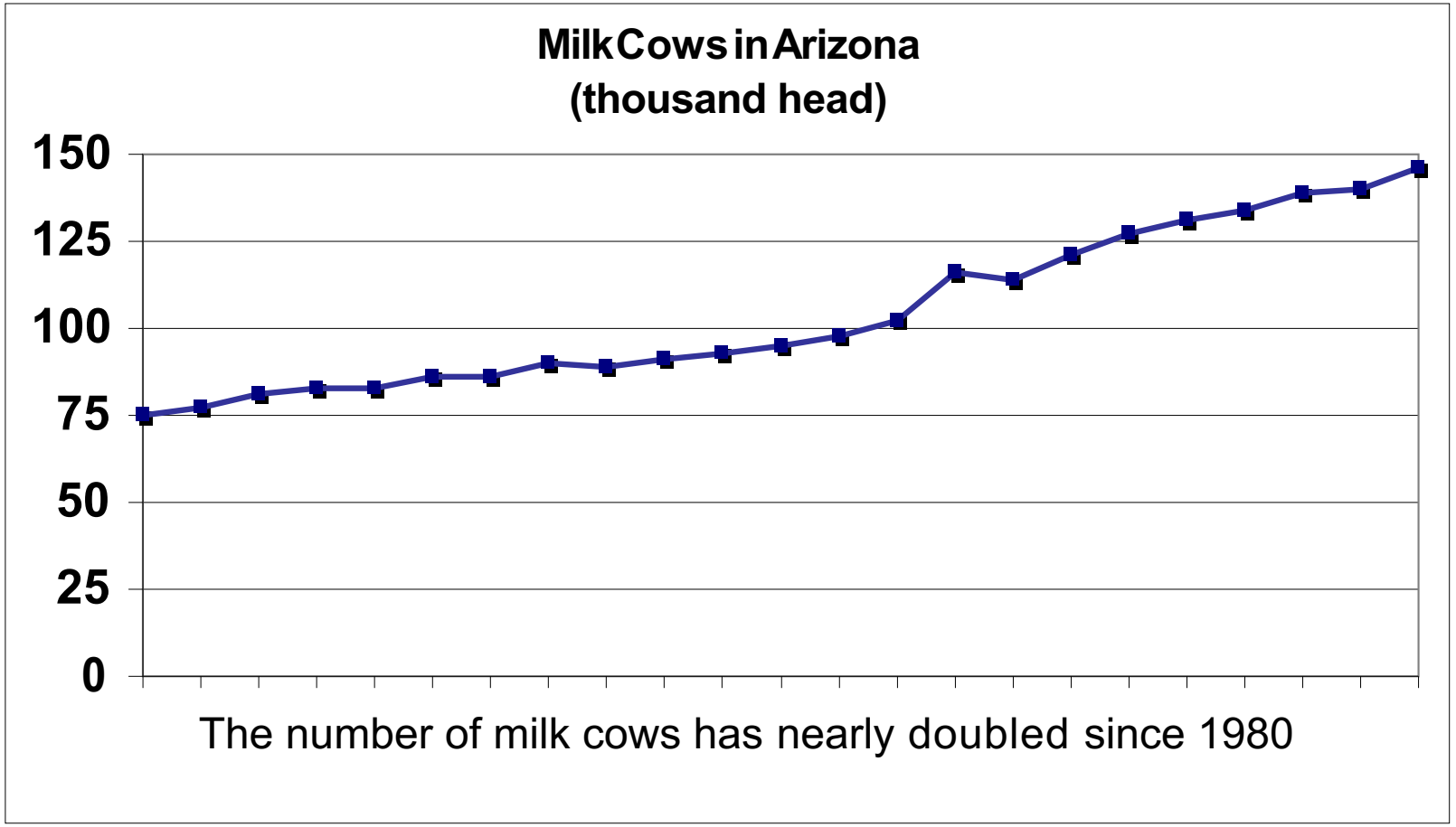
Chase Saraiva, Head Brewer

Why is so much alfalfa grown in Arizona?

325,000 acres in 2012

Out of 881,000 acres of irrigated cropland (37%)

Growth of the state's dairy industry is driving growth of alfalfa and hay acreage in Arizona



HOWEVER - Most alfalfa grown in Arizona is exported, a large portion going to China.

Saudi Arabia purchased 10,000 acres of farmland in La Paz County Arizona, to grow alfalfa for that country's dairy industry.

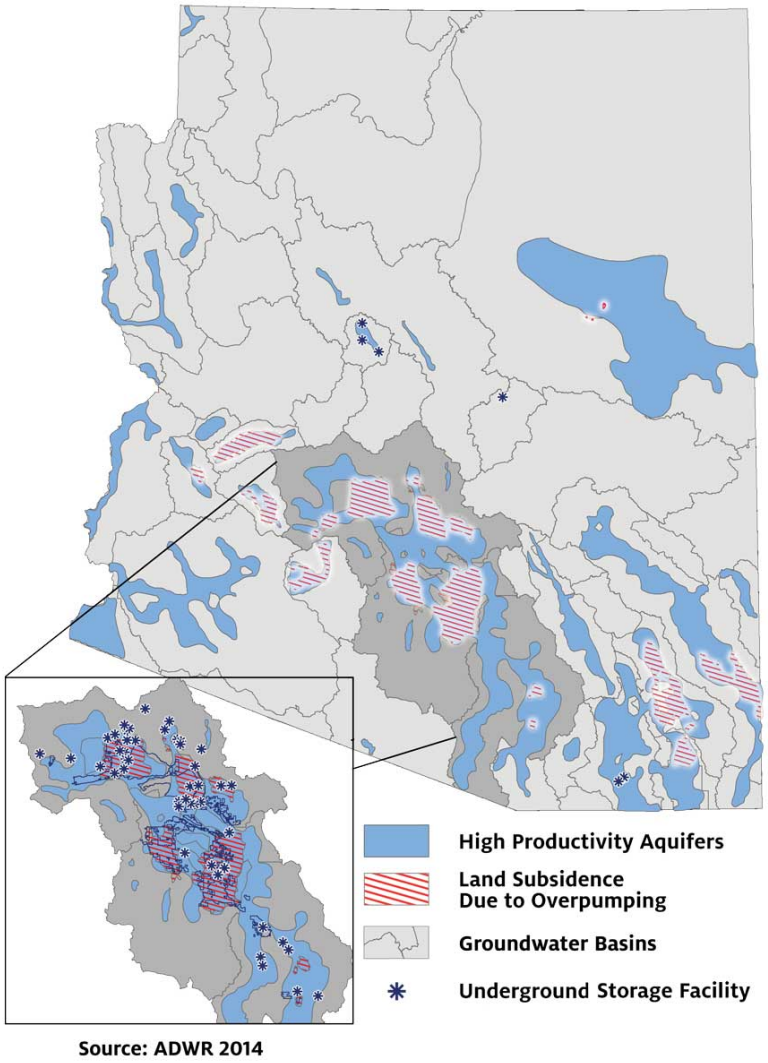
How do you feel about this?

Tom Buschatzke, Director, Arizona Department of Water Resources: We have some of the highest-quality cotton in the world, and it is highly sought after in the Far East. Our larger pecans are prized in China; our plumper pistachios are sought after in Europe, our durum wheat grown in Pinal County is in high demand in Italy for pasta production, and our specialty beef is shipped to Japan.

Holly Irwin, Chairman, La Paz County Board of Supervisors: We're not getting oil for free, so why are we giving our water away for free? We're letting them come over here and use up our resources. It's very frustrating for me, especially when I have residents telling me that their wells are going dry and they have to dig a lot deeper for water. It's costly for them to drill new wells.

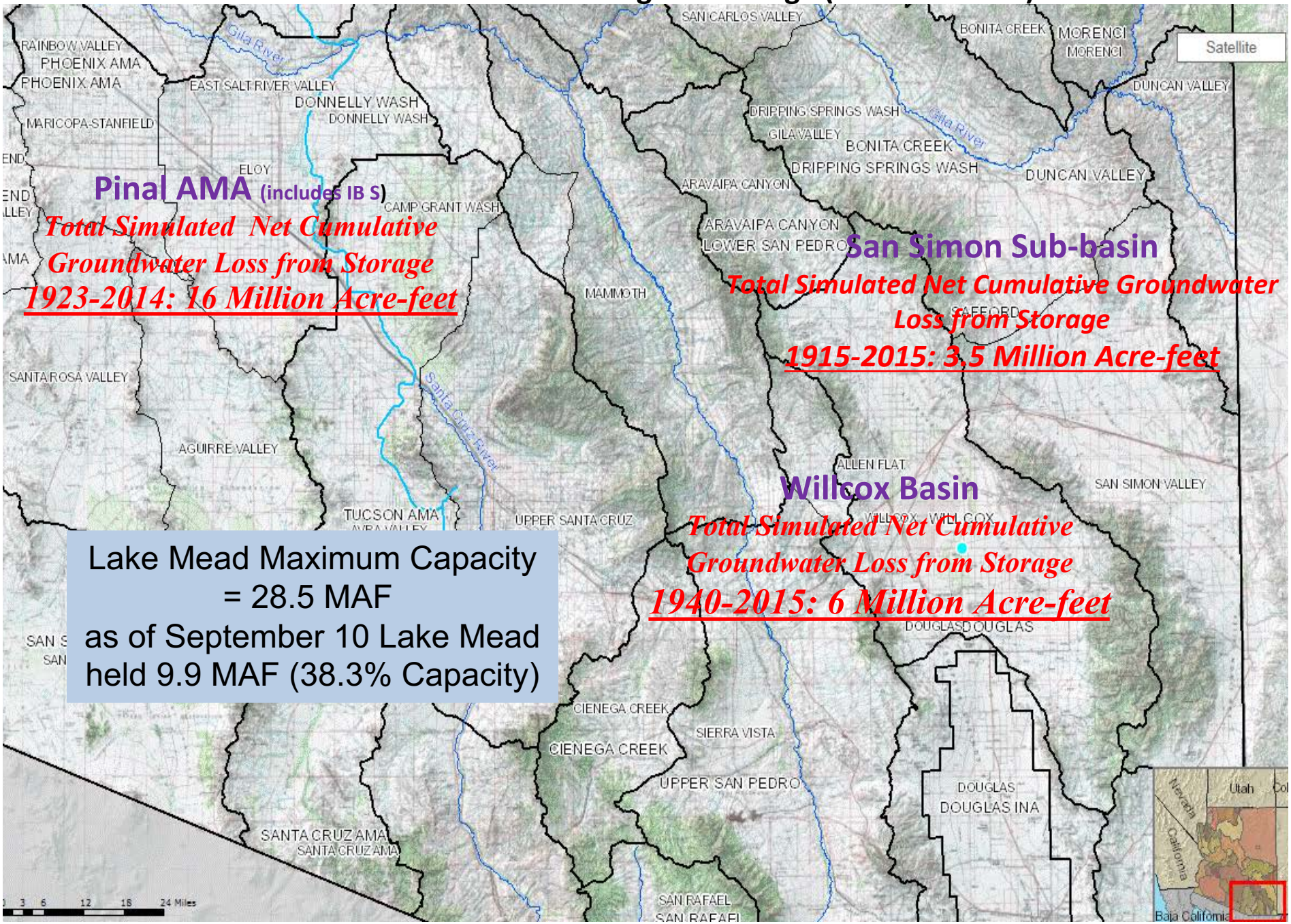
Groundwater Depletion

Land subsidence and earth fissuring can result from pumping groundwater in excess of natural (or artificial) recharge.



Source: ADWR 2014

DRAFT Transient Net Cumulative Change-in-Storage (Volumes in AF)



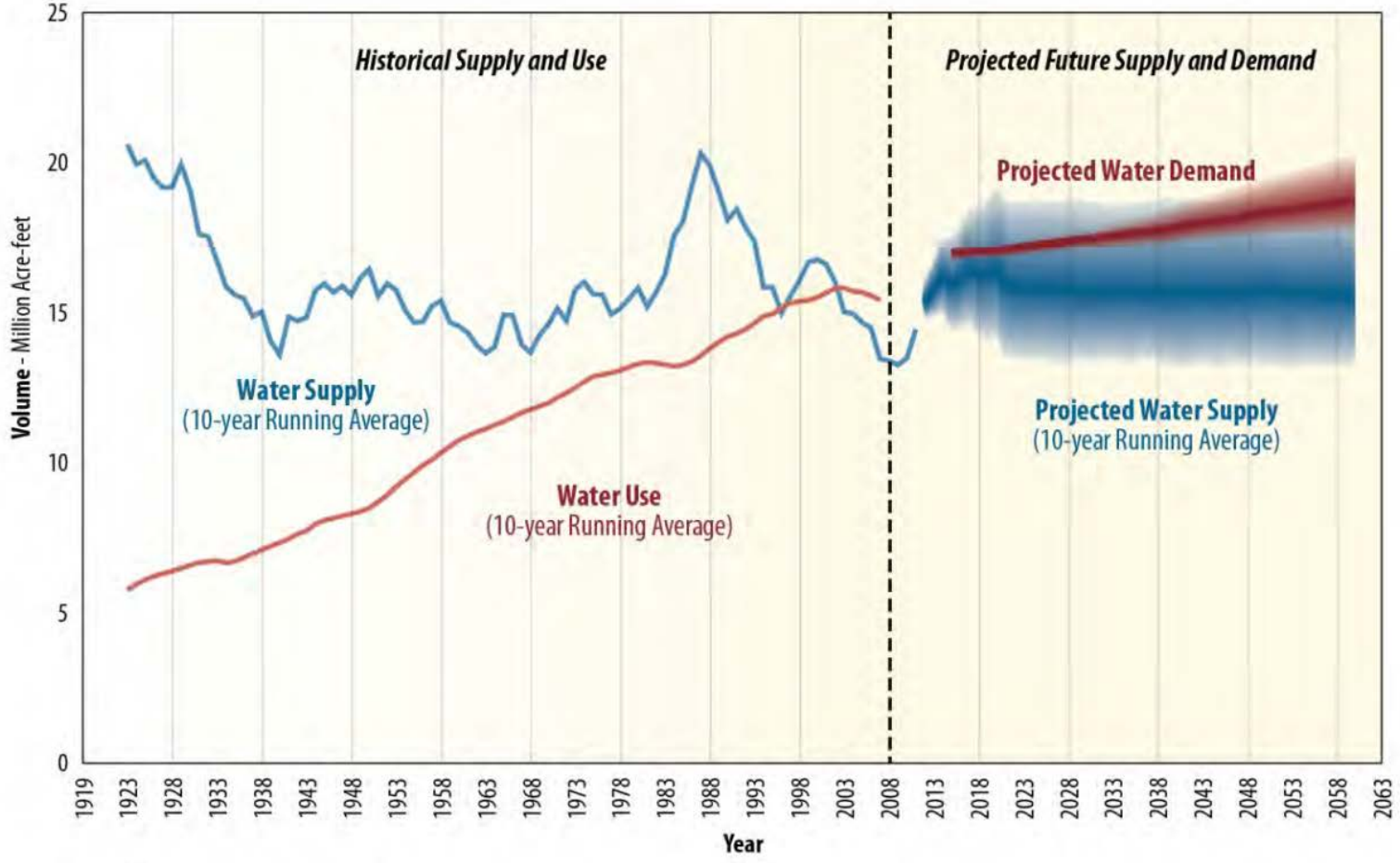
In eastern Cochise County, overdraft is causing subsidence and earth fissures.

Pumping costs may soon be too high for farmers and domestic wells have already gone dry. Well owners reported 18 wells had gone dry 2008 - 2014, underestimates the actual number.

A boom in tree nut orchards is increasing groundwater withdrawals. Pecan acreage in Arizona doubled in the past 6-7 years to 25,000 acres, most in Willcox area.

Colorado River Shortages

Colorado River



As the water level in Lake Mead falls, the chances of a shortage increase.

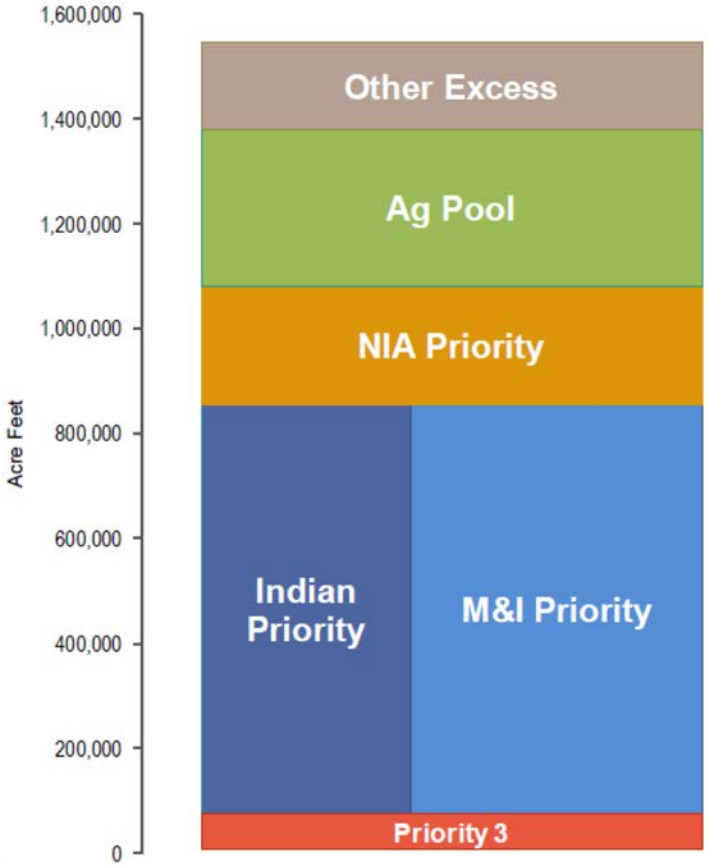
Photograph: Rodolfo Peon, June 2015

August 2018

Year	Probability of Shortage
2019	None
2020	57%
2021	68%
2022	70%
2023	65%

In a shortage on the Colorado River, the Central Arizona Project will bear the brunt of the water cuts.

- When CAP's water allocation is reduced, the Agricultural Settlement Pool will be cut.



- Central Arizona agriculture will be the first to feel the effects of a shortage on the Colorado River.
- If Lake Mead drops below 1025 feet, Arizona's senior water rights holders could be affected.

Lower Colorado River Drought Contingency Plan

- Purpose to forestall shortages that would trigger draconian supply reductions
- Arizona would take larger reductions sooner
- Central Arizona agriculture wants assurances that their water supply will be preserved

Estimated Change in Income as a Result of a 500,000 AF Shortage to Agricultural Lands in Arizona - 2017

	INCOME		
COUNTY	DIRECT	INDIRECT+INDUCED	TOTAL
Maricopa	3,528,482	2,018,338	5,546,820
Pinal	10,598,009	5,939,280	16,537,289
Pima	487,150	214,065	515,647
Mohave	289,494	102,518	392,012
La Paz	218,743	76,874	279,104
Yuma	215, 957	168,664	384,621
Total	15,321,321	8,519,739	23,841,060

Total Losses: $24 **million**

AZ total personal income >$250 **billion**

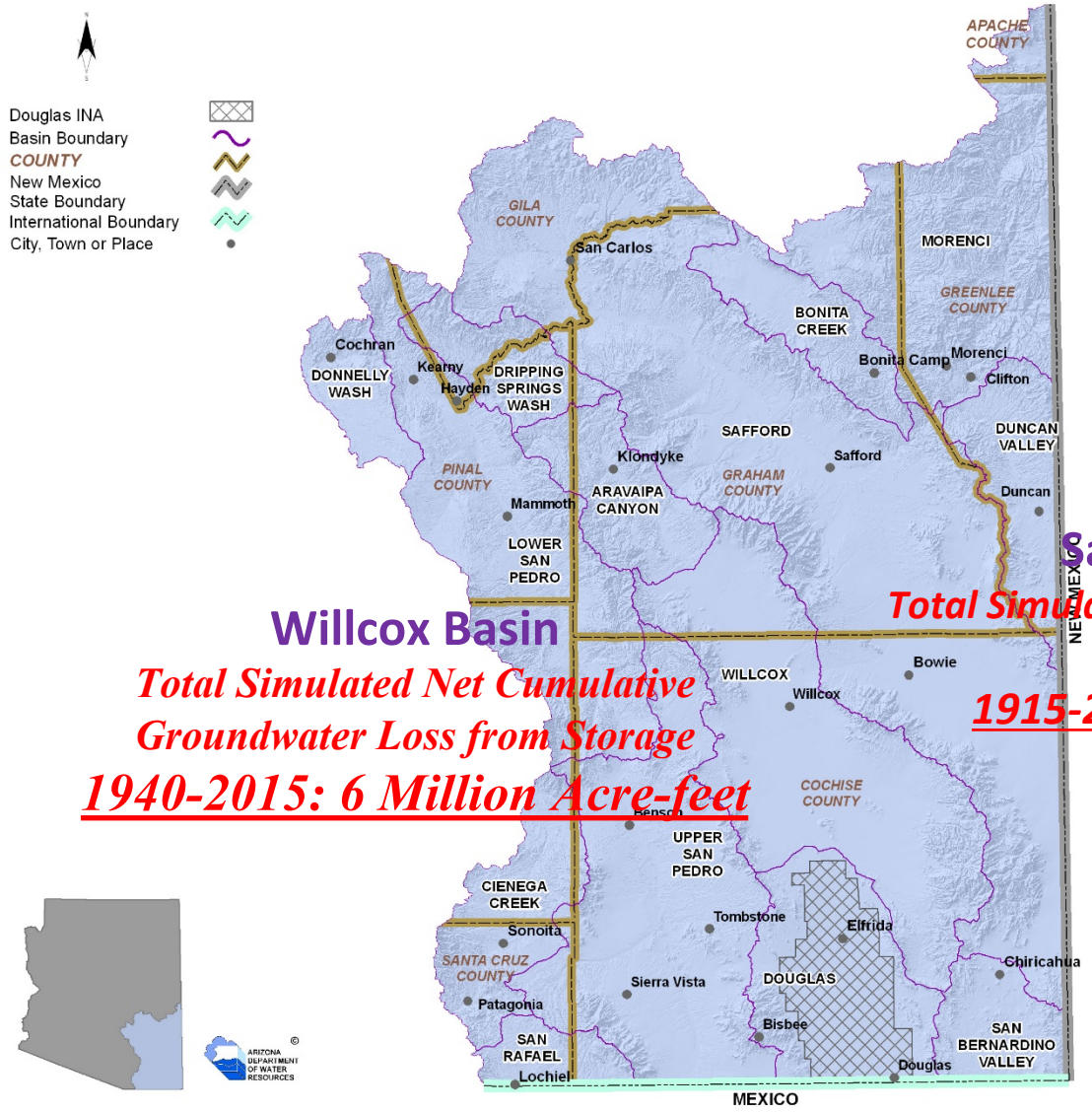
Maricopa & Pinal County personal Income >$175 **billion**

(Bickel, Duval and Frisvold 2017)

Fallowing

- Higher value use sector (cities) pays farmers not to use their water to grow crops.
- Agriculture is considered insurance in case of drought.
- Inequities relating to land ownership complicate transactions.
- Secondary effects hurt agricultural communities through loss of jobs and income (e.g. truck dealership)
- People in agriculture maintain that fallowing should not be used to support the growth of urban areas.

Groundwater Regulation



Willcox Basin

Total Simulated Net Cumulative Groundwater Loss from Storage

1940-2015: 6 Million Acre-feet

San Simon Sub-basin

Total Simulated Net Cumulative Groundwater Loss from Storage

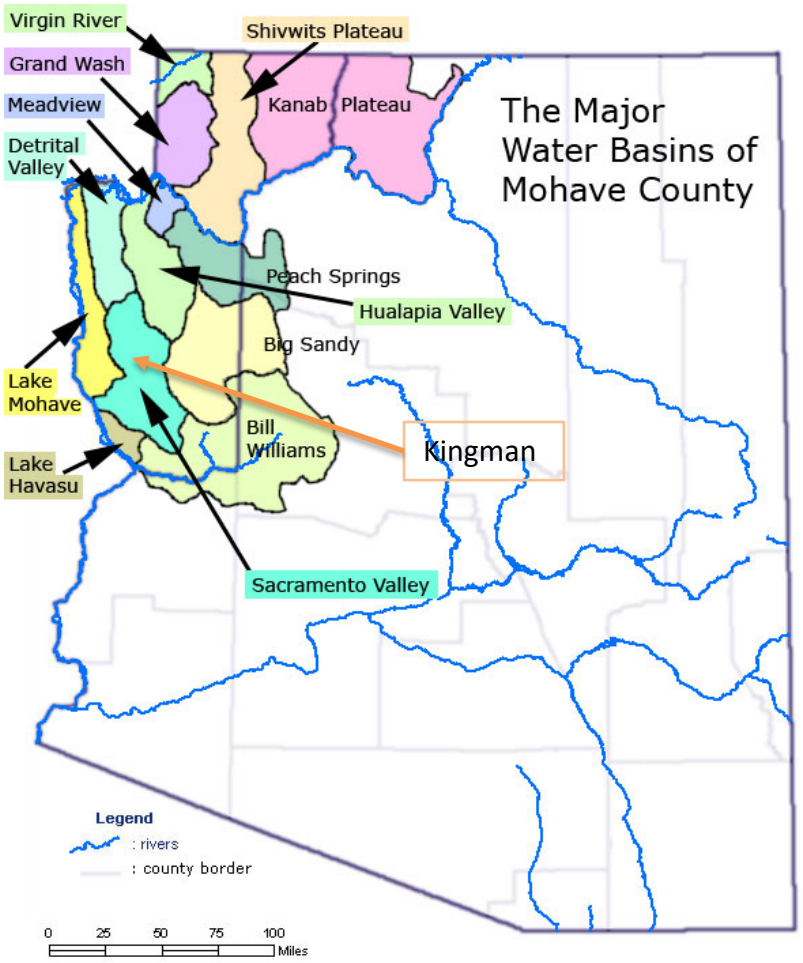
1915-2015: 3.5 Million Acre-feet

The GMA allows creation of new AMAs and INAs where needed to protect the groundwater supply.

- In 2015, residents of the San Simon Valley sub-basin within the Safford groundwater basin petitioned ADWR for an INA. ADWR declined to designate an INA after evidence showed sufficient groundwater at the current rates of withdrawal
- In the Willcox groundwater basin, residents rejected both options because they would restrict growth of the wine industry. The potential for economic growth and limited water needs of grapes make this crop desirable (950 acres in 2013). A new concept for a “Willcox Basin Groundwater Conservation Area” was also rejected.

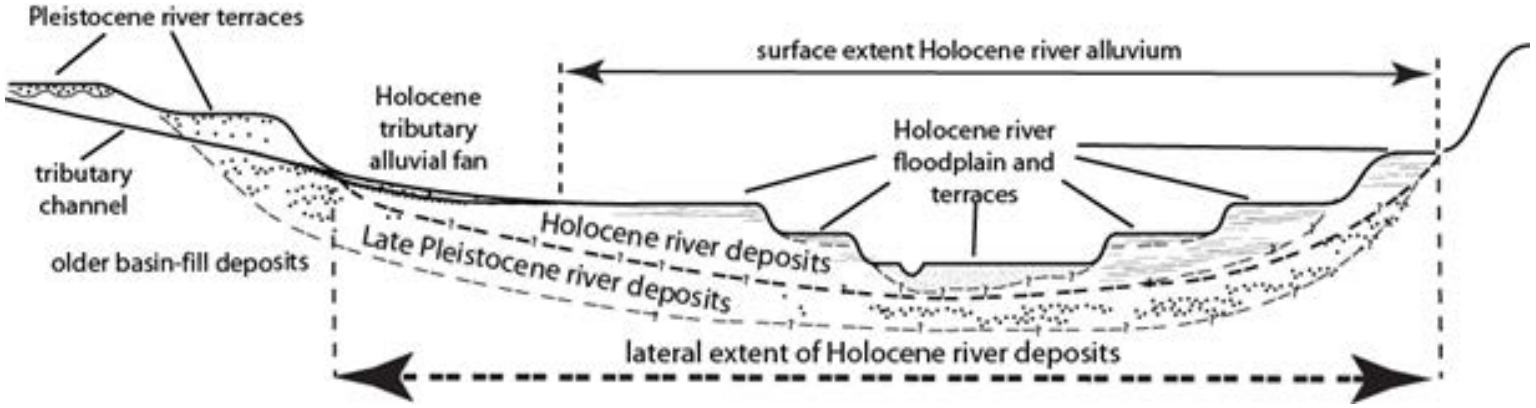
In Mohave County, irrigated agriculture in the Hualapai and Sacramento Basins has grown on groundwater, increasing water use from 0 in 2001-2005 to >32,000 acre-feet in 2016.

- Residents in Kingman worry that the increased pumping threatens their wells and property values and that the area could run out of water.
- To forestall explosive growth in water demand, Mohave County asked ADWR to designate the Sacramento Valley Hualapai Valley groundwater basins as separate INAs.
- ADWR found that the evidence it possessed did not support the initiation of INA designation.



Adjudications

How will the adjudications affect farmers whose wells may be pumping water deemed to be Gila River or Little Colorado River water?



AZ Geological Survey

Water Quality

Since January 2018, water quality requirements are part of the **Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR)**

- Water used during growing activities can have a limited amount of *E. coli* present in the water
- Water used during or after harvest must have no detectable *E.coli* present in the water.

The FDA thinks that *E. coli* in **manure from cattle** in a ditch-side feedlot probably **washed or blew** into the irrigation ditch and was carried into vegetable fields by **irrigation water**.

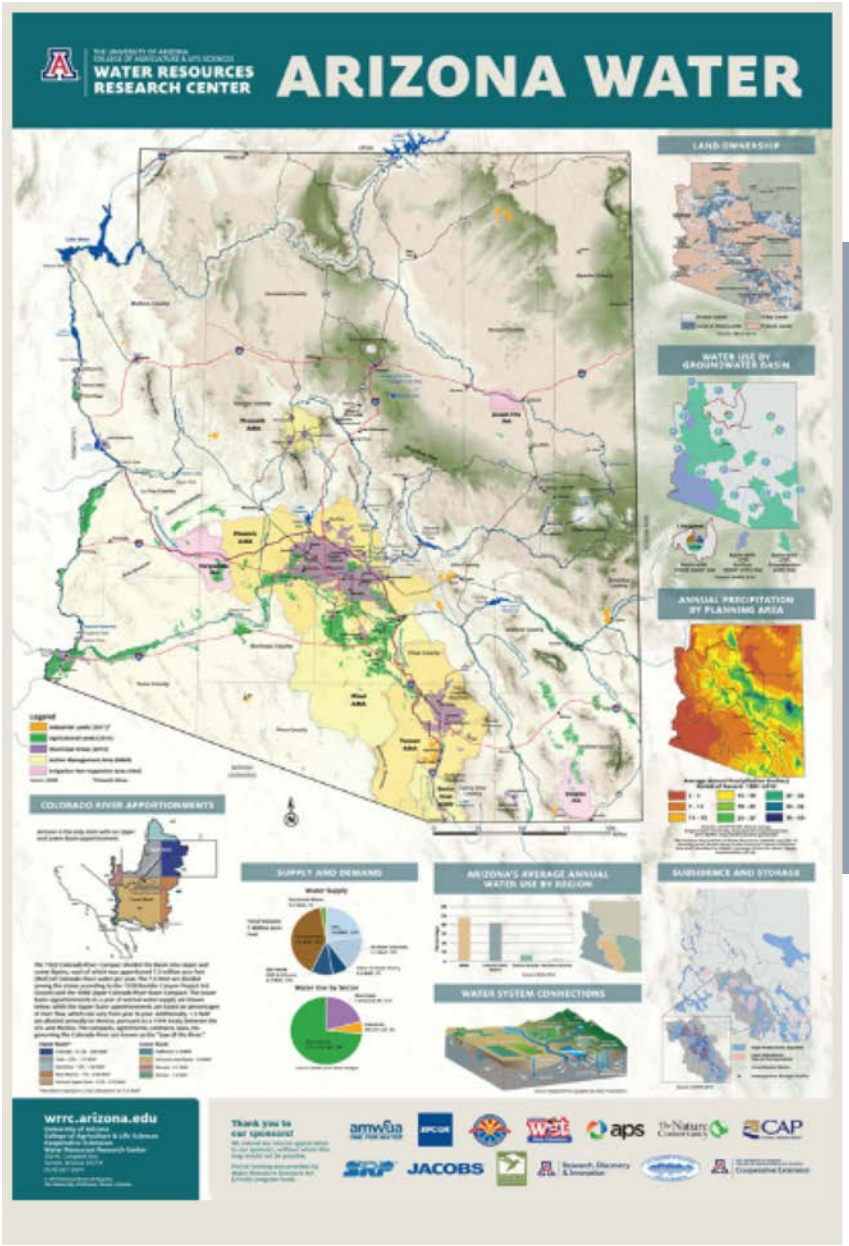
However, irrigation water doesn't typically touch the lettuce leaves, so how did the contamination happen? Why did it affect romaine lettuce and not the other kinds of lettuce and vegetables growing in those fields? And what happened this spring? After all, the cattle have been there for decades.

Channah Rock, a water quality specialist at the University of Arizona, says that **wind-blown dust** from the feedlot might have **settled on romaine leaves** that had been damaged by **an unusual freeze**, causing the leaves to "blister." Perhaps, she says, those damaged leaves were particularly vulnerable to *E. coli* contamination.

August 29, 20184:58 AM ET
Dan Charles – NPR Morning Edition

Information Resources

- 2017 WRRC Annual Conference “Irrigated Agriculture in Arizona: A Fresh Perspective” https://wrrc.arizona.edu/conferences/2017
- WRRC Brown Bag Seminar “Agriculture in Arizona’s Economy: The Role of Modeling and Implications for Water” https://wrrc.arizona.edu/events/brown-bag/wrrc-brown-bag-agriculture-arizonas-economy-role-modeling-and-implications-water
- Spring 2018 – *Arroyo* - Water and Irrigated Agriculture in Arizona. https://wrrc.arizona.edu/publications/arroyo/arroyo-2018-water-and-irrigated-agriculture-arizona



Thank you!

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