WRRC 2022 Annual Conference:

Arizona’s Agricultural Outlook: Water, Climate, and Sustainability

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Water is Life

Photo Credit: Jon Dinsmore
Water
Colorado River Watershed

- 1,450 mile river channel
- 244,000 sq. mile drainage
- greatest elevation drop in North America
- budgeted volume = 15 million acre-ft/year
  - Columbia River: 192 million acre-ft/year
  - Mississippi River: 400 million acre-ft/year
- covers portions of 7 states and 2 nations
- 40M people
- 5.5M acres of farmland
Upper Basin 7.5 MAF
Upper Basin allocation established by Upper Colorado River Basin Compact (1948)

Mexico 1.5 MAF
Established by the U.S.-Mexico Water Treaty (1944)

Lower Basin 7.5 MAF
Established by the Boulder Canyon Project Act (1928) and Arizona v California (1964)
WHO FACES WATER CUTS AS LAKE MEAD SHRINKS?

Central Arizona Water Users

- 1,075 ft  Agriculture and some land developers
- 1,050 ft  More agriculture
- 1,025 ft  Phoenix, Tucson, and other cities

Lake Mead

WESTERN RESOURCE ADVOCATES
Bureau of Recalmation  
14 June 2022

• Commissioner Camille C. Touton: **BoR needs 2-4 maf** in reductions of Colorado River use.
  – U.S. Senate Energy and Natural Resources Committee held hearings in Washington, D.C. to review the conditions and impacts of drought in the western U.S

• Basin states have **60 days (until mid-August)** to propose plans of action.

• BoR has the authority to “act unilaterally to protect the system, and we will protect the system.”
Colorado River Water Budget

• **16.5 MAF** Currently budgeted total
  
  \(7.5 + 7.5 \text{ MAF} = 15 \text{ MAF} + 1.5 \text{ MAF Mexico}\)

• Average annual flow 2000 - 2018
  
  \(~ 12.4 \text{ MAF}\)

  • 16 % lower than the 1906-2017 average of 
    \(14.8 \text{ MAF/year}\)

\(~4 \text{ MAF differential}\)

Restructure Budget @ 12 MAF ????
Colorado River Budget

12 MAF Budget: 27% less than 16.5 MAF

Proportionate reductions:

Arizona: 2.8 MAF → 2 MAF

California: 4.4 MAF → 3.2 MAF
John Wesley Powell

“All the great values of this territory have ultimately to be measured to you in acre feet”.

John Wesley Powell, Montana Constitutional Convention, 1889.
Limiting Factors in Desert Agriculture

1. Water
2. Bio-available Nitrogen
3. Plant Genetics
Arizona Agriculture - Water

• Arizona Ag utilizes ~ 70% of freshwater, $23.3B value (AZ GDP of $334.03B)
  ~ 7% of AZ GDP
  ~ 70% of Arizona is diverted to agriculture

• Arizona animal and crop production industries
  – Food and fiber products for Arizona, nation, and world.
Global Freshwater Use

70% - Agriculture

Primarily in arid & semi-arid regions
Arid/Semi-Arid Regions

~ 40% of total crop production
~ 60-65% of grain production
~ 40-45% of global population
Water & Arizona Agriculture
Good Stewards of Arizona Land & Water Resources
Irrigated Systems
Crop Production Systems – Basics

Primary Goal = Optimum production efficiency and use of natural resources.
- Water and Soils

Management of Photosynthesis (Ps)
Dry Matter Production (DM)
Efficiency Objectives

• **Agronomic**
  – Inputs and crop response

• **Economic**
  – Cost of production and net returns on the crop

• **Environmental**
  – Short-term impacts
  – Long-term impacts
Multiple Irrigation Systems
Irrigation Systems for Salinity Management
Decades of Improvements

• Yields and efficiencies of production have increased.
  – Higher yields
    • Highest yields and quality of crops in the world.
  – Less land utilized
  – Less irrigation water utilized per acre
  – Less crop inputs, e.g. pesticides & fertilizers
  – Increased diversification of crops and cropping systems.
    • Including extensive seed production
ARIZONA WATER USE, POPULATION, AND ECONOMIC GROWTH (1957-2016)

SOURCE: ADWR, 2017
Ag Water Use – U.S.
1950-2000

Trends in population and irrigation withdrawals, 1950-2000

Population, in millions

Withdrawals, in billion gallons per day

0 50 100 150

150 175 200


Population
Irrigation
Crops & Water
Irrigation Management
Soil Water Balance

IRRIGATION

RAIN

STORED SOIL WATER

UPWARD FLOW

GROUND WATER

TRANSPIRATION

EVAPORATION

RUNOFF

ROOT DEPTH

DEEP PERCOLATION
Crop Water Demand & Management

• Crop Consumptive Use (CU)
  – Germination & seedling development
  – ET (evapotranspiration)
    – Evaporation (soil) + Transpiration (crop)
    – Describes the demand for irrigation – how much to apply.

• Leaching requirement
  • Need to provide adequate soil leaching (salinity management)
  • Irrigated crop production systems
  • Arid and semi-arid regions
Arizona Meteorological Network (AZMET)

Reference ET (ET0) for Arizona (28 locations)
AZMET
Weather Information System That Serves Agricultural & Horticultural Producers
ESTIMATING CROP ET

\[ \text{ET}_c = K_c \times \text{ET}_o \]

Need: Source of \( \text{ET}_o \)
Irrigation Water Management

Irrigator’s Equation: \( Q \times t = d \times A \)

\( Q = \) flow (cfs)
\( A = \) Area (acres)
\( d = \) depth of irrigation (inches of water)

Solving for irrigation set time (\( t \)):

\[ t = \frac{d \times A}{Q} \]
Irrigation Management
6CO₂ + 6H₂O → C₆H₁₂O₆ + 6O₂

photosynthesis

carbon
dioxide

water

 glucose

oxygen
Photosynthesis

$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

carbon dioxide + water $\rightarrow$ glucose + oxygen
Salinity – Desert Agriculture
Salinity
A Desert Agriculture Challenge

“Successful irrigation schemes in arid regions carry seeds of their own demise”
(Gardner, 1985)

Example: ppm X 2.7 = lbs./AF-water
700 ppm X 2.7 = 1,890 lbs. salt/AF
X 5 AF-water = 9,450 lbs. salt/acre
(4.7 T salt/acre)
Water Sucking Crops?
Water Sucking Crops?

Photo Credit: Jon Dinsmore
Desert Cropping Systems

• Well adapted to desert environment
• Heat tolerant
• Salt tolerant
• Highly productive
• Important crop rotation component
• Marketability
Crop & Dairy Production
Production Links

[Diagram showing] Water → Crop Production → Cattle → Milk → Dairy Products → Consumer Health & Happiness
Arizona Dairy Production

Arizonaans have a direct benefit from the Arizona dairy industry for milk and related products.

Fresh milk often originates from dairy farms within 300 miles to point of final delivery. Consumer delivery within 48 hours.

Most Arizona dairy farms are family-owned and operated.

Arizona dairy and milk direct sales value: ~ $77B
Crop Production = Art + Science
Manage irrigation systems for efficiency & sustainability
Contributions From Academia

• Need: Scientifically sound and practical ideas
• Field experimentation and testing
• Refinement
• Demonstration
• Collaboration with growers - demonstration
• Application
Sustainable Systems for the Next Generation
Water is Life

Photo Credit: Jon Dinsmore
Strategic Narcissism*

• The corresponding tendency to artificially separate interconnected problem sets.
  – Encourages short term and simplistic solutions to complex problems

The War for Kindness: Building Empathy in a Fractured World*

• Both time and distance diminish empathy because humans “caring instincts are short sighted”.

• “Our ability to feel empathy about future development is limited because we tend not to feel for our future selves. It goes against our instincts to tackle problems that we have not yet been forced to confront.”

*Jamil Zaki, Professor of Psychology, Stanford University
The War for Kindness: Building Empathy in a Fractured World*

“If the consequences of action or inaction are far off and afflict strangers yet to be born, we are less likely to sacrifice or invest today.”

This is clearly evident across the globe with issues such as food and water security.

*Jamil Zaki, Professor of Psychology, Stanford University
You can't always get what you want
But if you try sometimes, well, you just might find
You get what you need

M. Jagger