WRRC 2022 Annual Conference:

Arizona's Agricultural Outlook:

Water, Climate, and Sustainability

12 July 2022

Jeffrey C. Silvertooth

Professor and Extension Specialist – Agronomy / Soil Science
Department of Environmental Science

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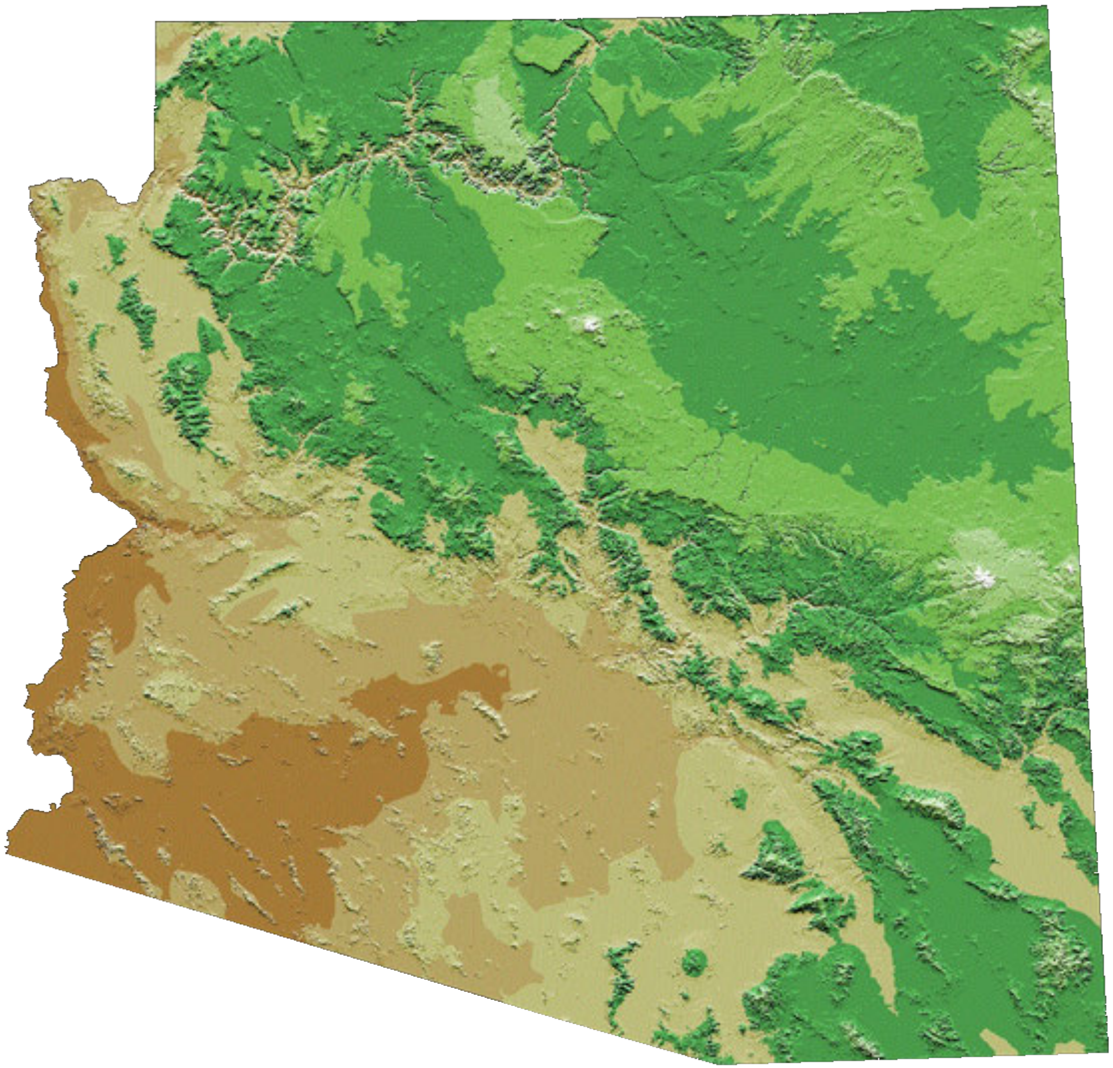
The Great State of Arizona



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Water is Life

Photo Credit: Jon Dinsmore

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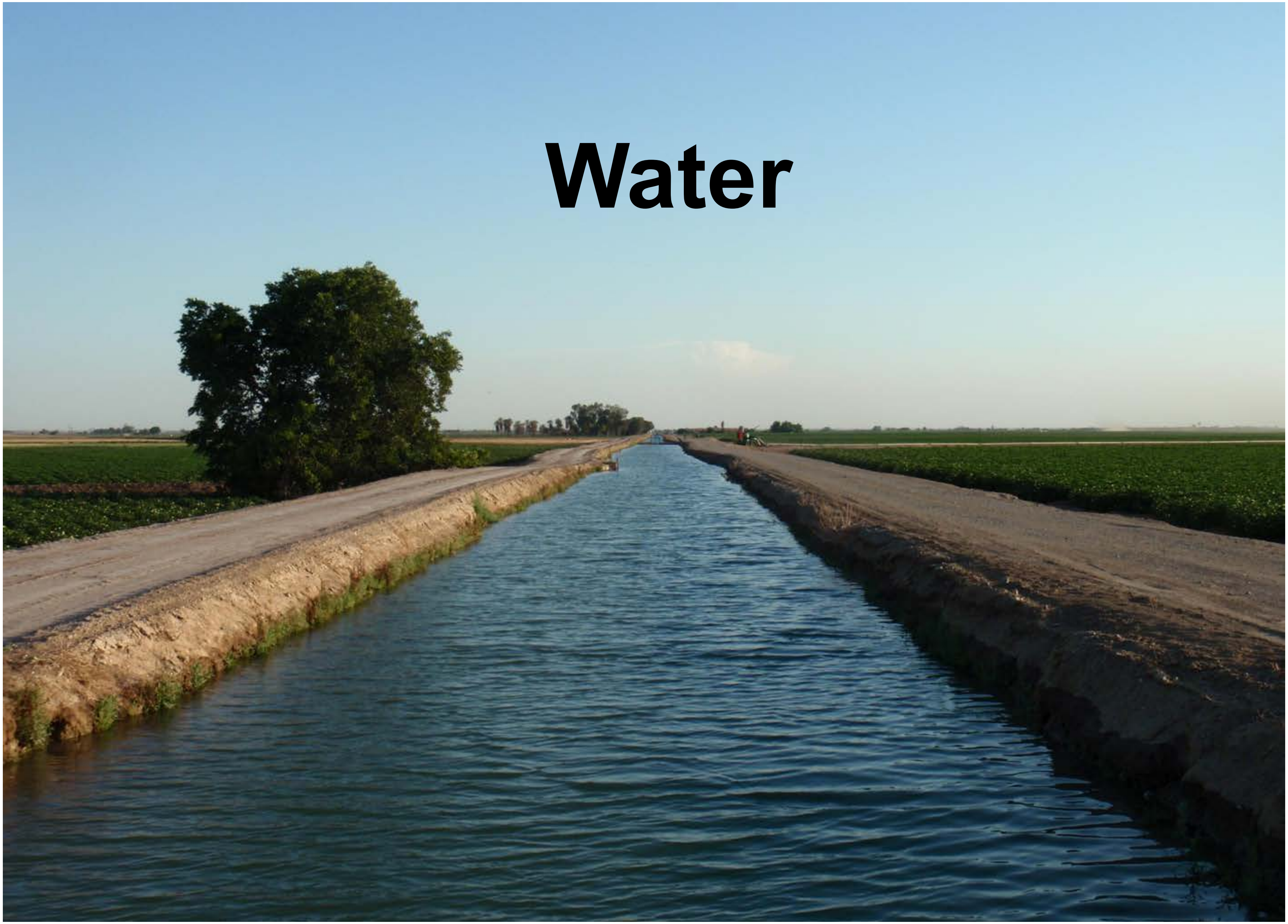
Water



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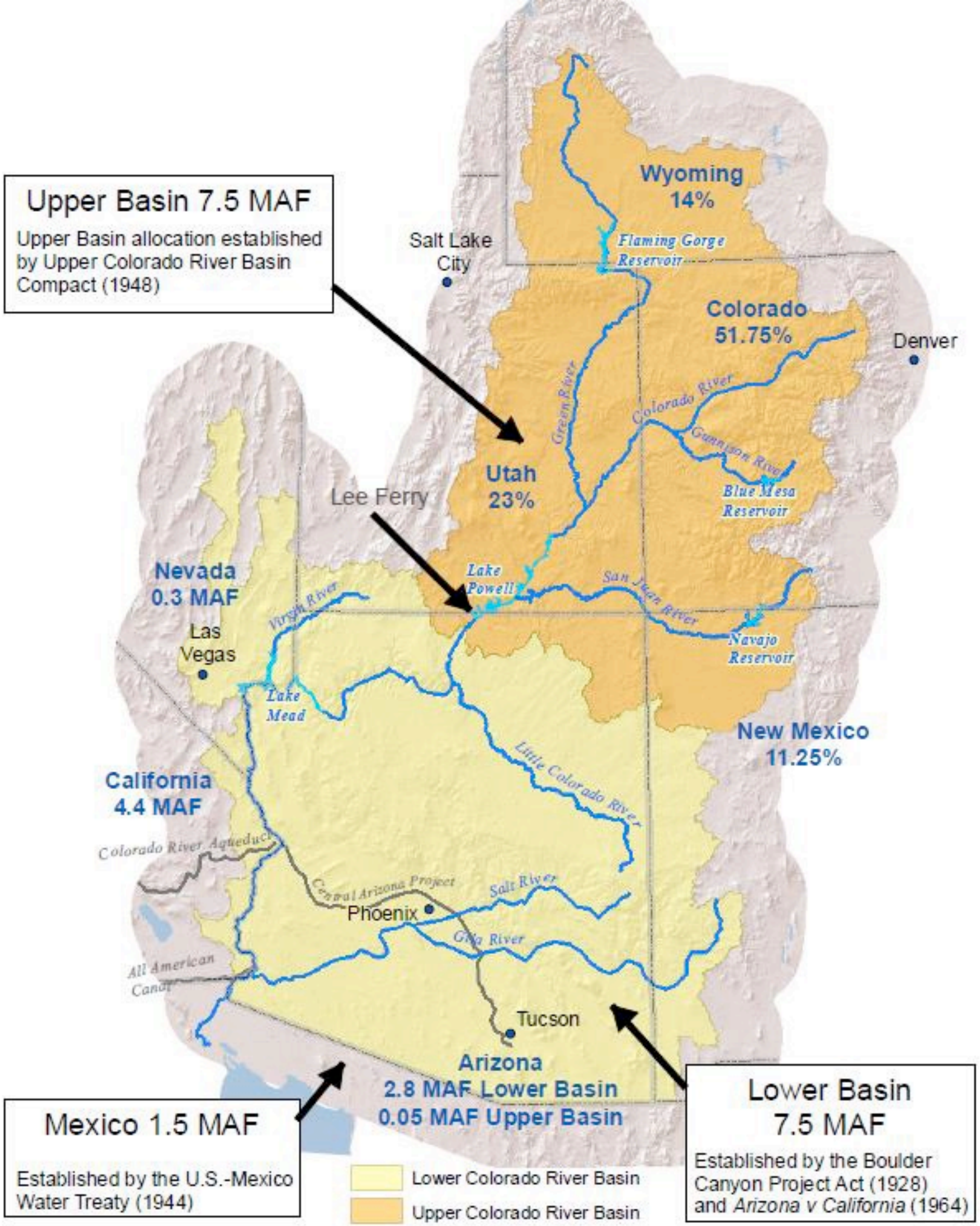
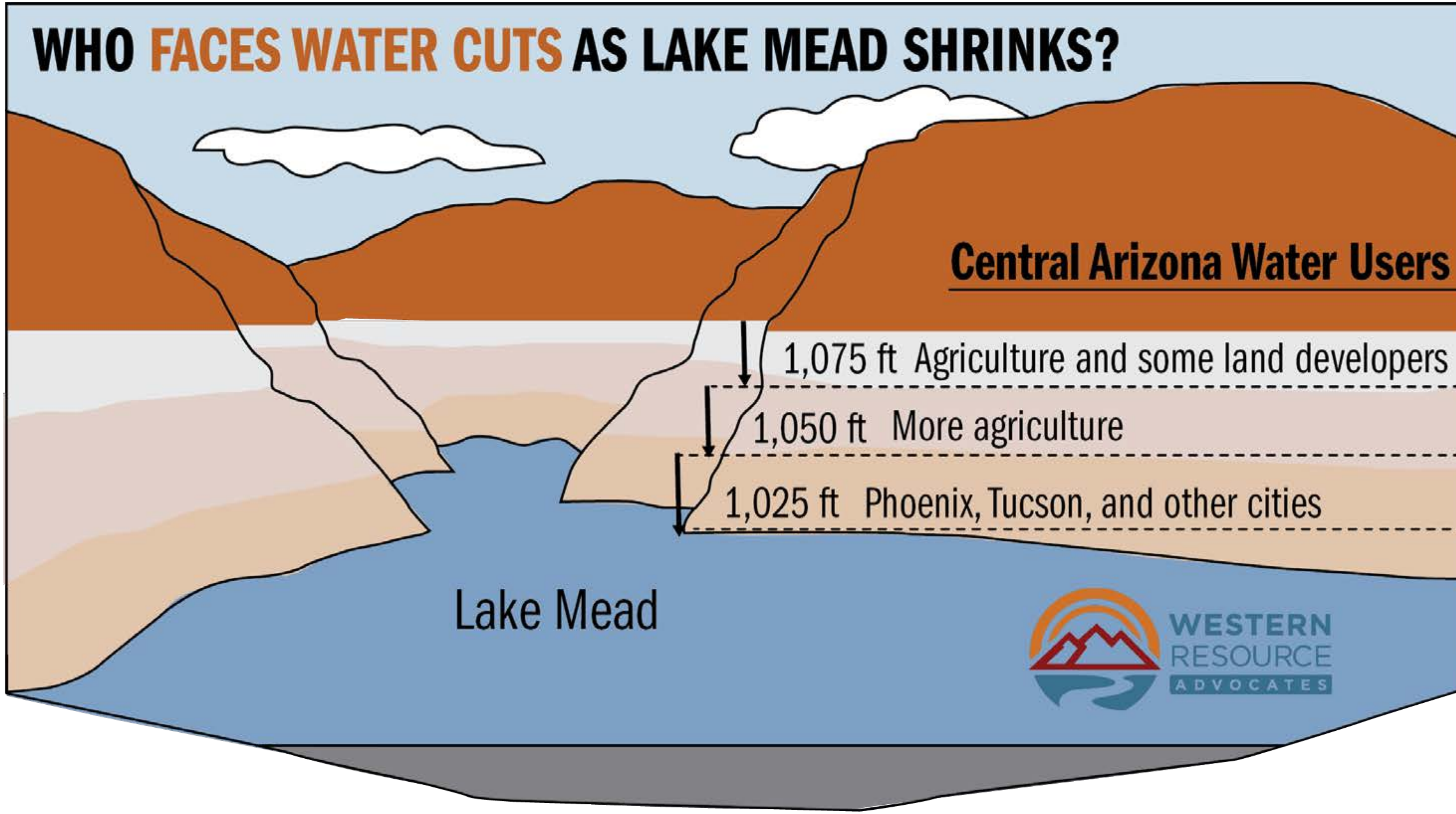
Colorado River Watershed

- 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)
Salt Lake City
Wyoming 14%
Flaming Gorge Reservoir
Colorado 51.75%
Denver
Green River
Colorado River
Gunnison River
Blue Mesa Reservoir
Utah 23%
Lee Ferry
Lake Powell
San Juan River
Navajo Reservoir
Nevada 0.3 MAF
Virgin River
Las Vegas
Lake Mead
New Mexico 11.25%
Little Colorado River
California 4.4 MAF
Colorado River Aqueduct
Central Arizona Project
Salt River
Phoenix
Gila River
All American Canal
Tucson
Arizona
2.8 MAF Lower Basin
0.05 MAF Upper Basin
Mexico 1.5 MAF
Established by the U.S.-Mexico Water Treaty (1944)
Lower Colorado River Basin
Upper Colorado River Basin
Lower Basin 7.5 MAF
Established by the Boulder Canyon Project Act (1928) and *Arizona v California* (1964)

Rio Colorado – Sonora/Baja California/Arizona



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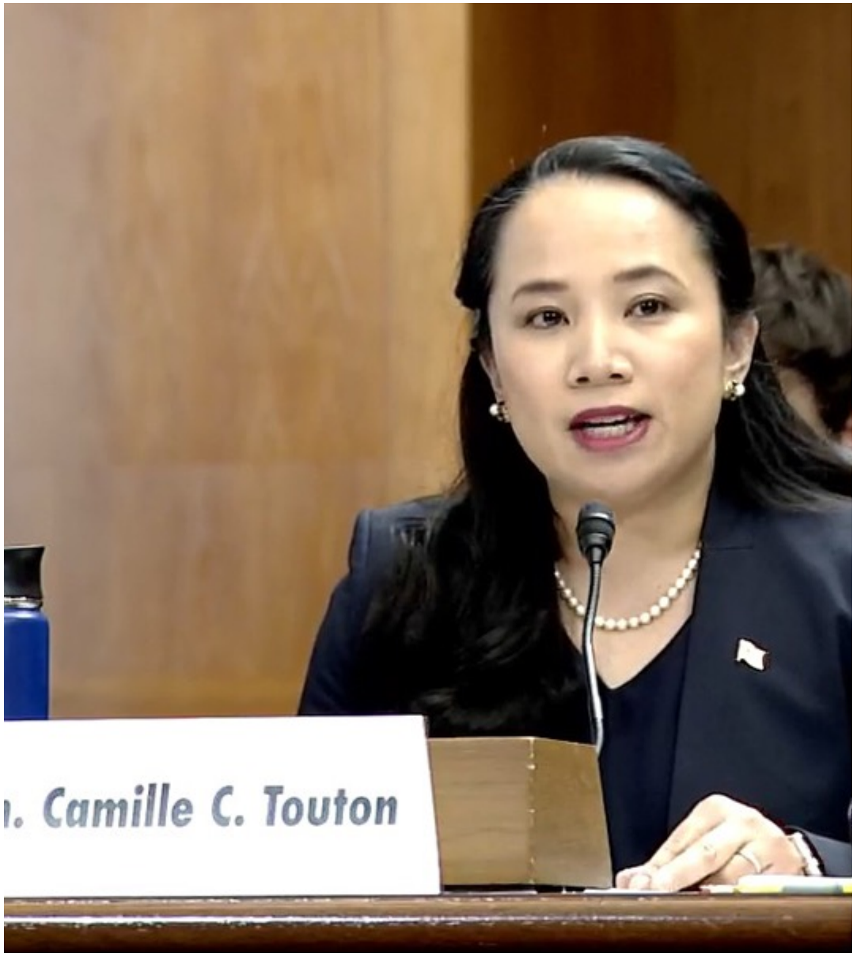
Bureau of Recalmation
14 June 2022



- 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."

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Colorado River Water Budget

- **16.5 MAF** Currently budgeted total

  (7.5+7.5 MAF = 15 MAF + 1.5 MAF Mexico)

- Average annual flow 2000 - 2018

  ~ **12.4MAF**

  - 16 % lower than the 1906-2017 average of 14.8MAF/year

~ **4 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

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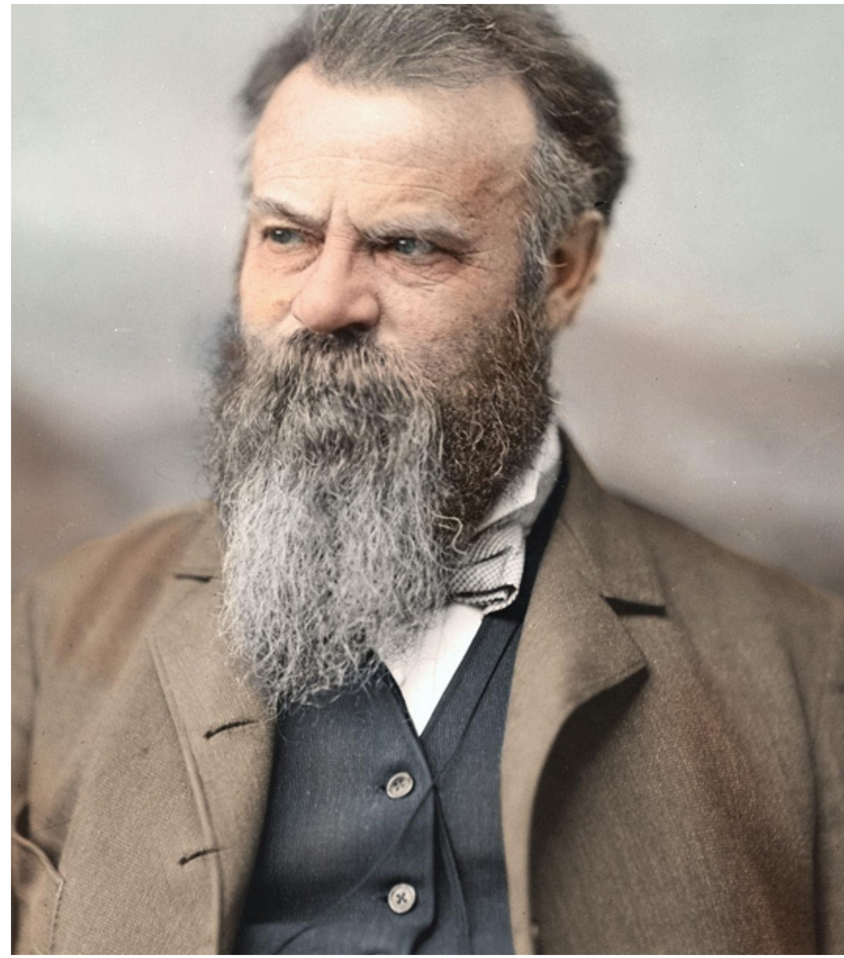
John Wesley Powell

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

John Wesley Powell, Montana Constitutional Convention, 1889.



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Limiting Factors in Desert Agriculture

1. **Water**
2. Bio-available Nitrogen
3. Plant Genetics

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Arizona Agriculture - Water

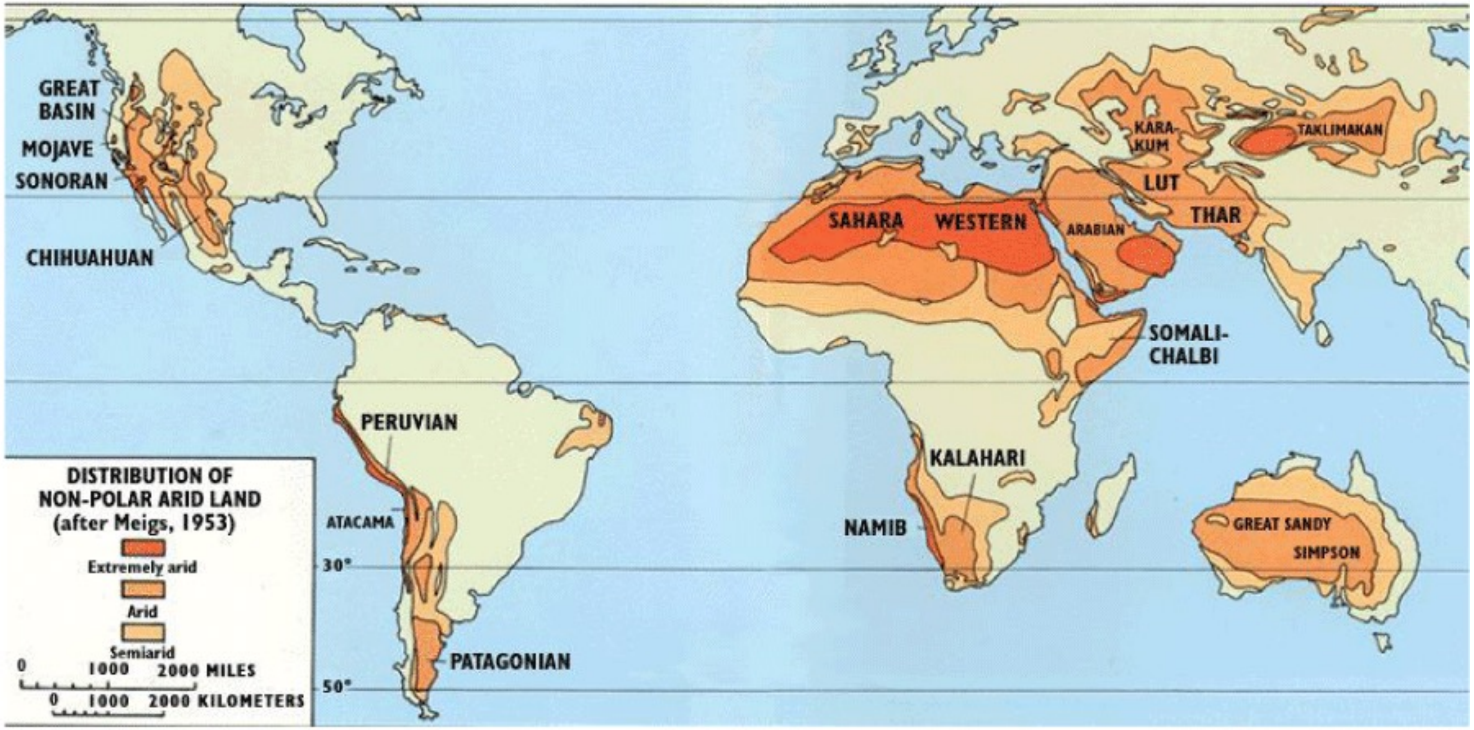
- Arizona Ag utilizes ~ 70% of freshwater, $23.3B value (AZ GDP of $334.03B)
  - ~ 7% of AZ GDP
  - ~ 70% of Arizona is *diverted* to agriculture

- 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

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Water & Arizona Agriculture

Good Stewards of Arizona Land & Water Resources

Irrigated Systems

Crop Production Systems – Basics

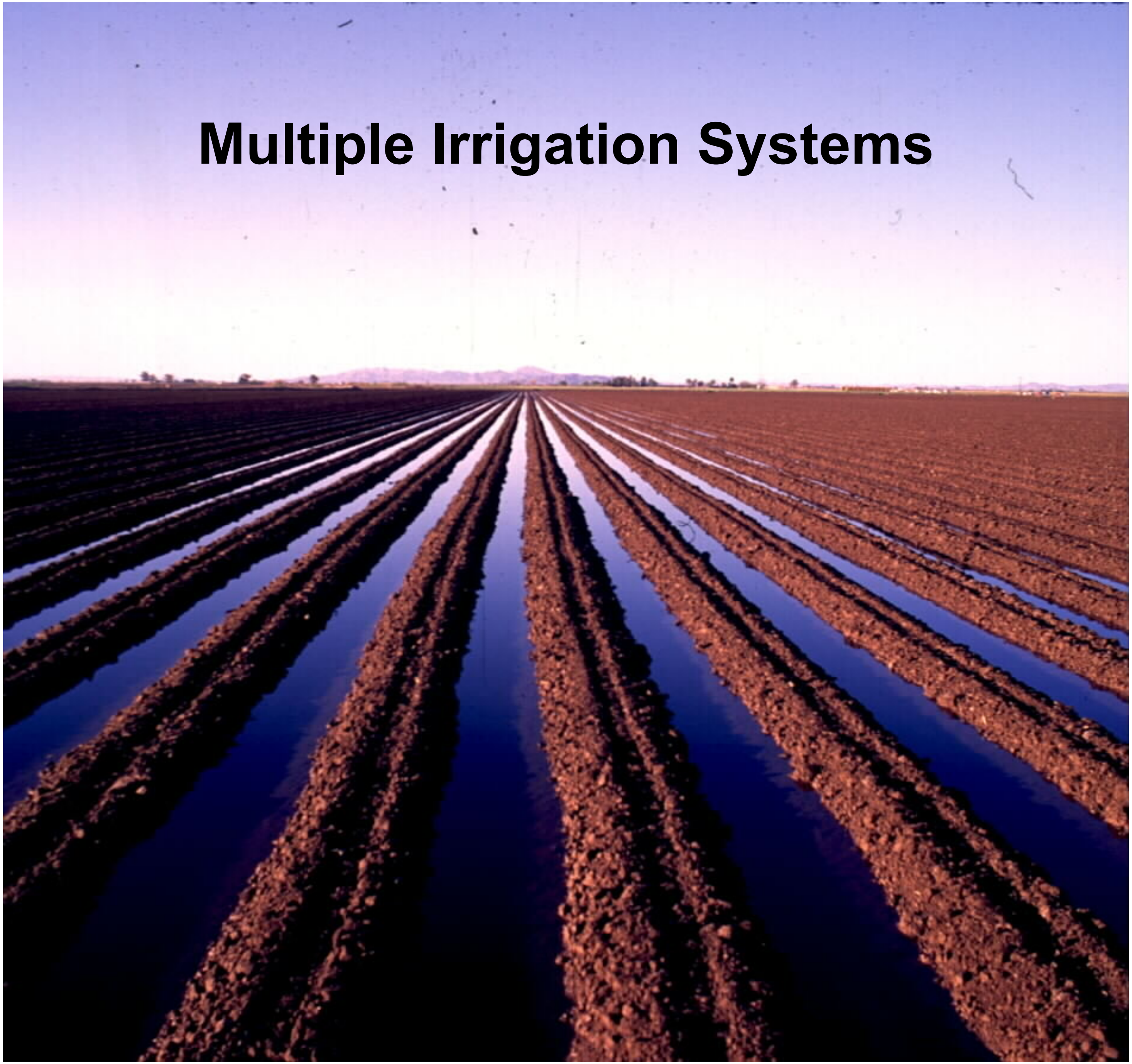
Primary Goal = Optimum production efficiency and use of natural resources.
- Water and Soils

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

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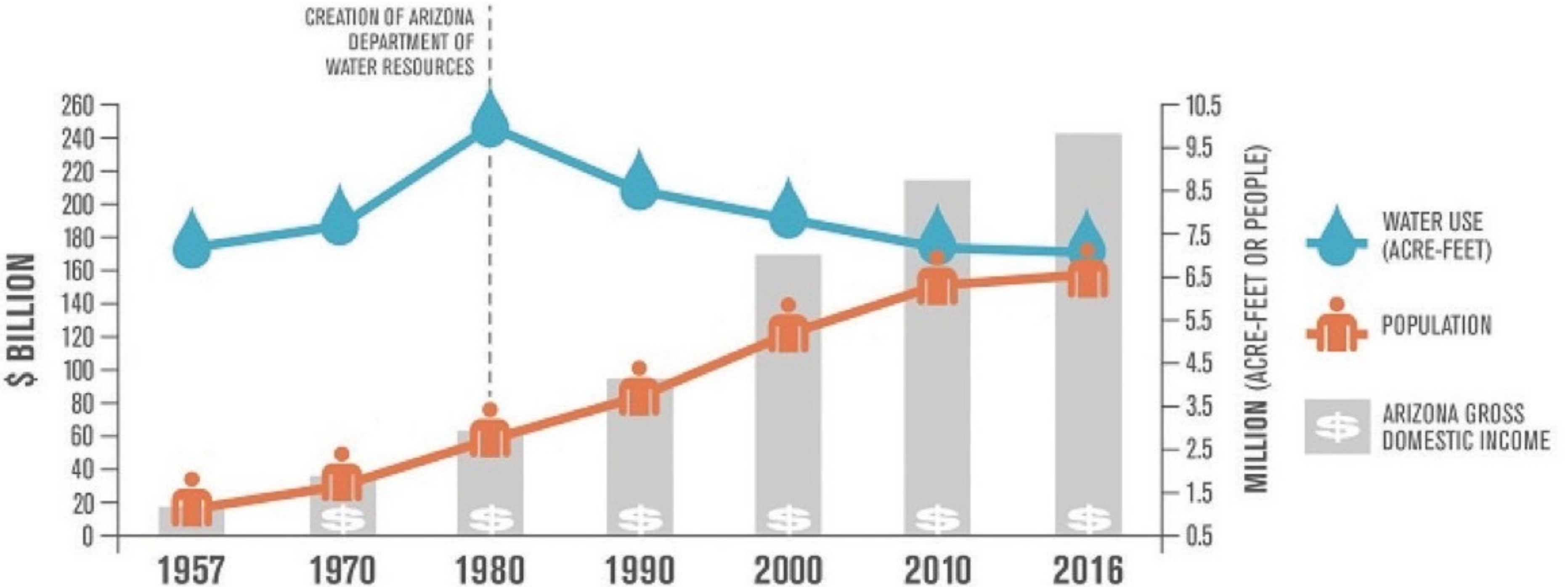
Irrigation Systems for Salinity Management

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

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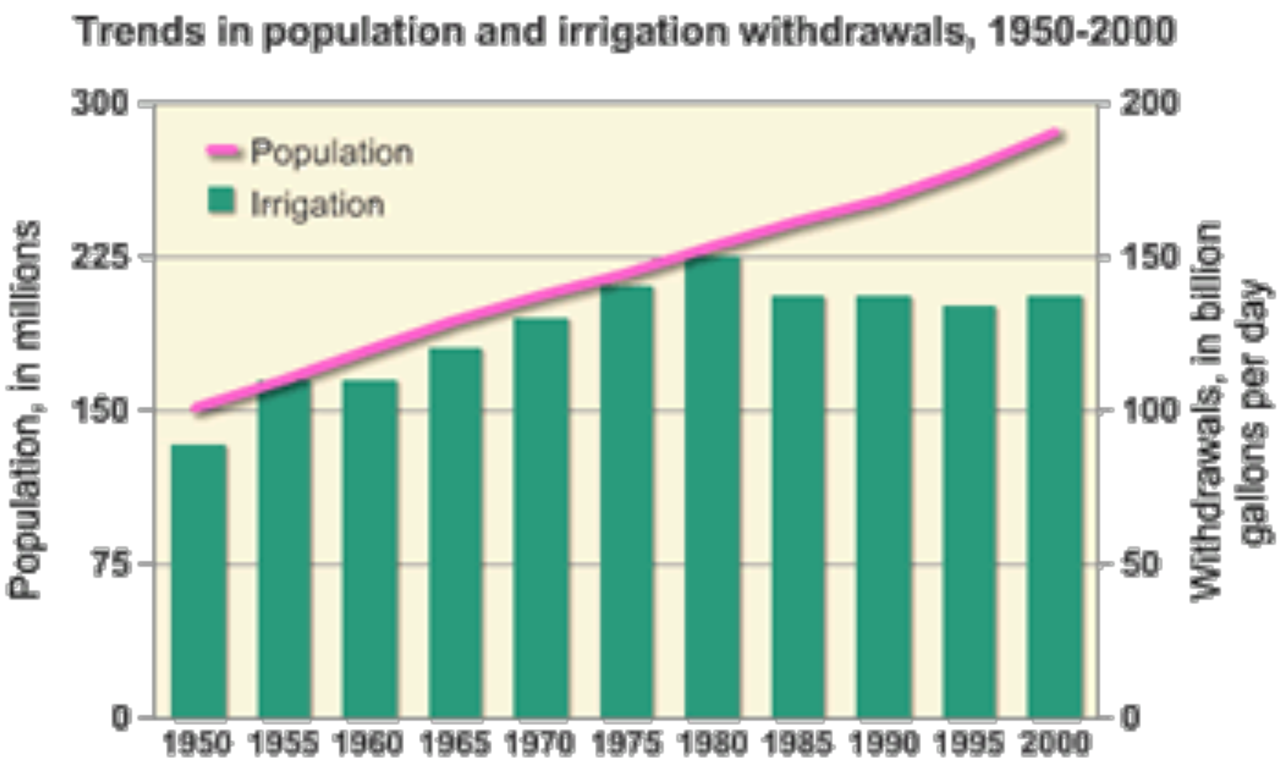
Ag Water Use – U.S. 1950-2000



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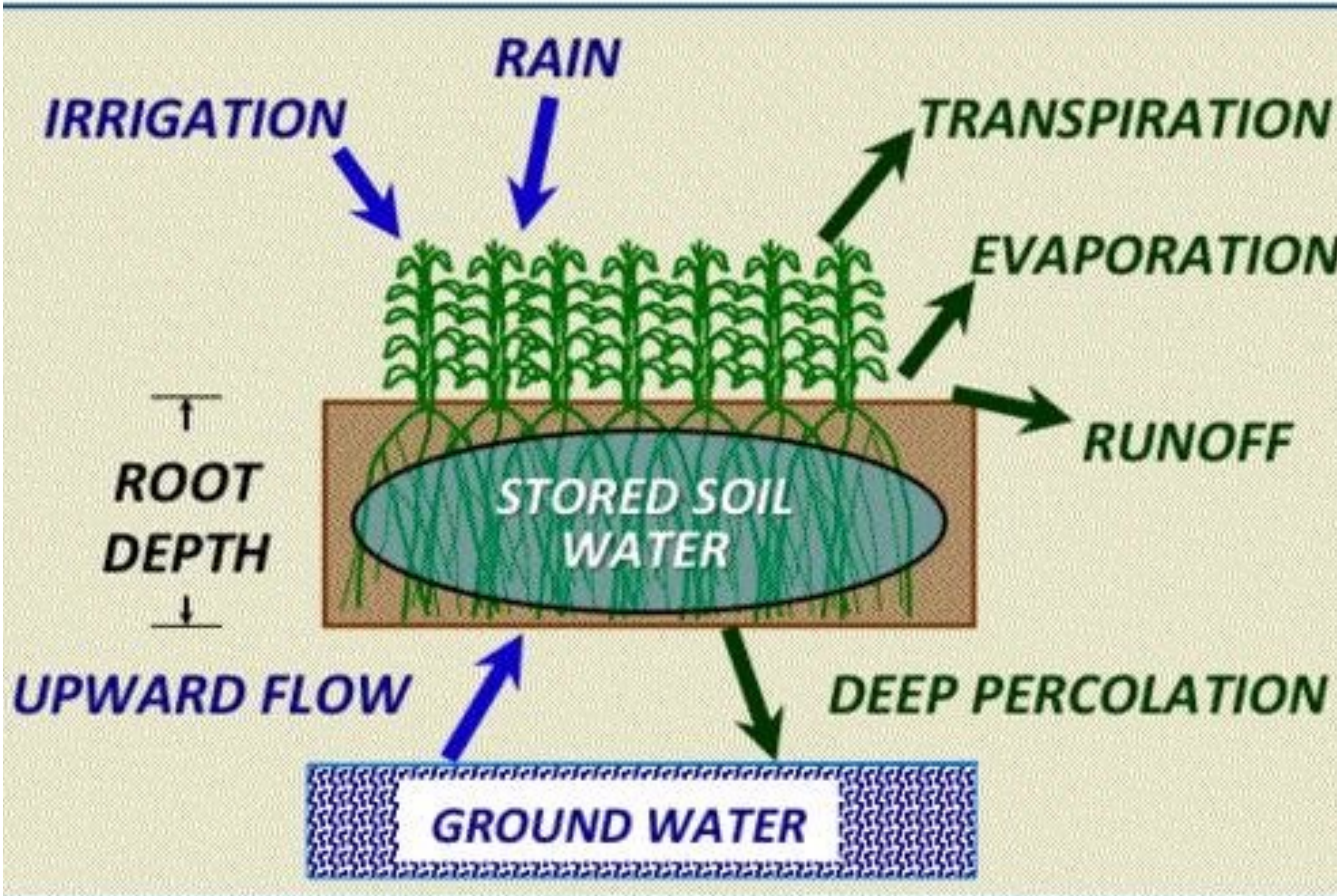
Crops & Water


Irrigation Management

Soil Water Balance



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 managment)
  - Irrigated crop production systems
  - Arid and semi-arid regions

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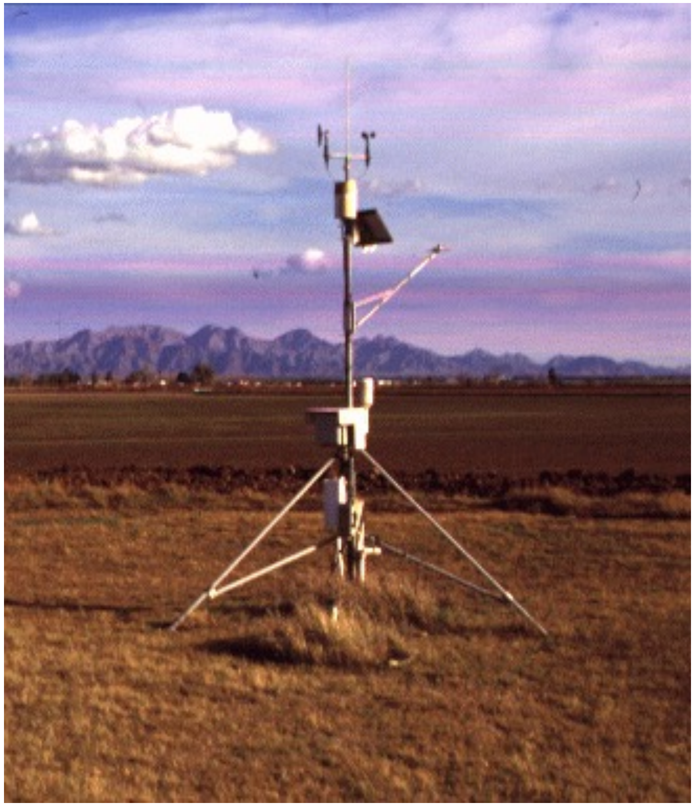
Arizona Meteorological Network (AZMET)

Reference ET (ETo) for Arizona (28 locations)



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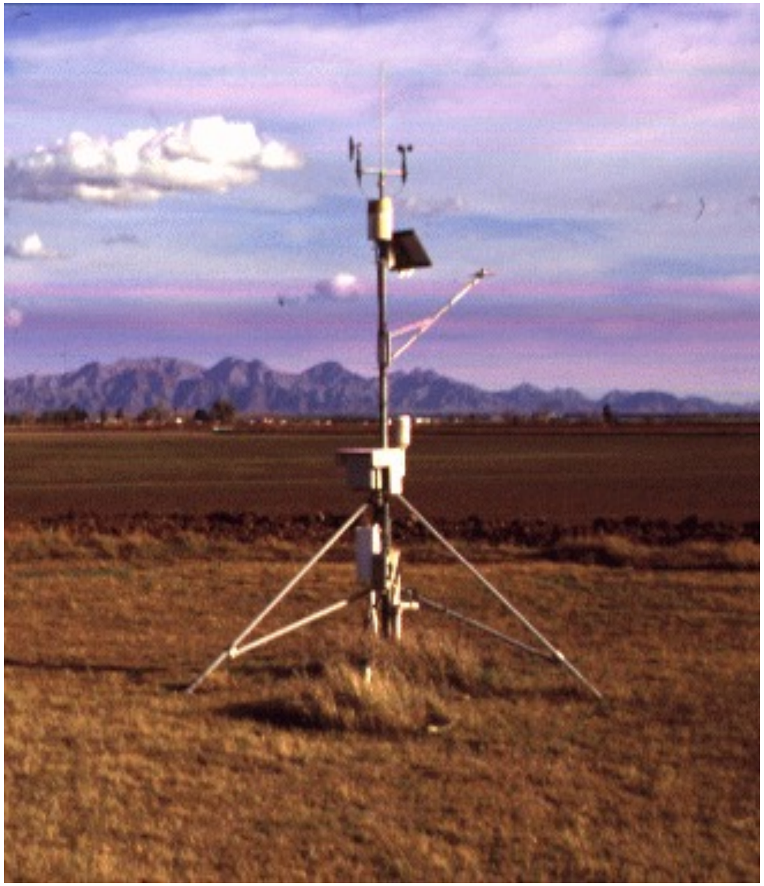
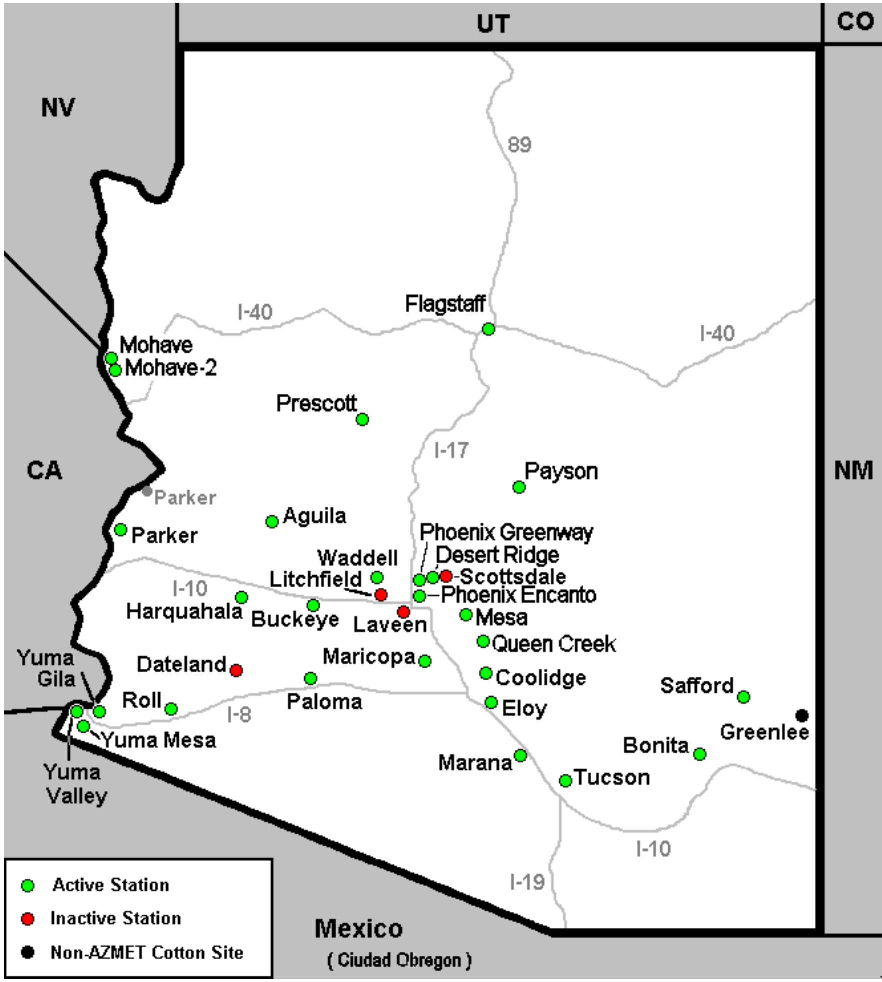
AZMET

Weather Information System That Serves Agricultural & Horticultural Producers





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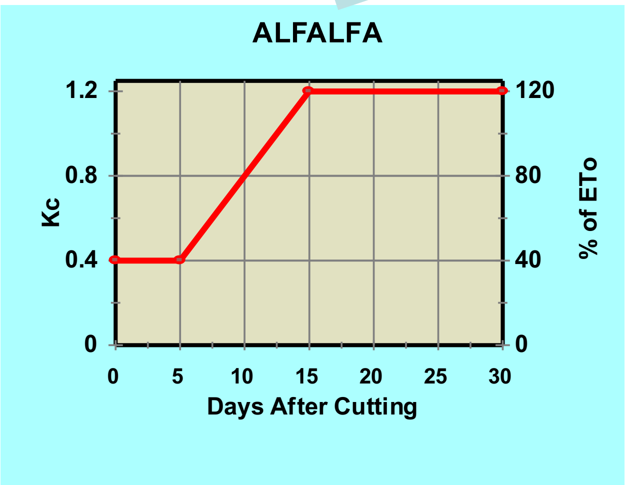
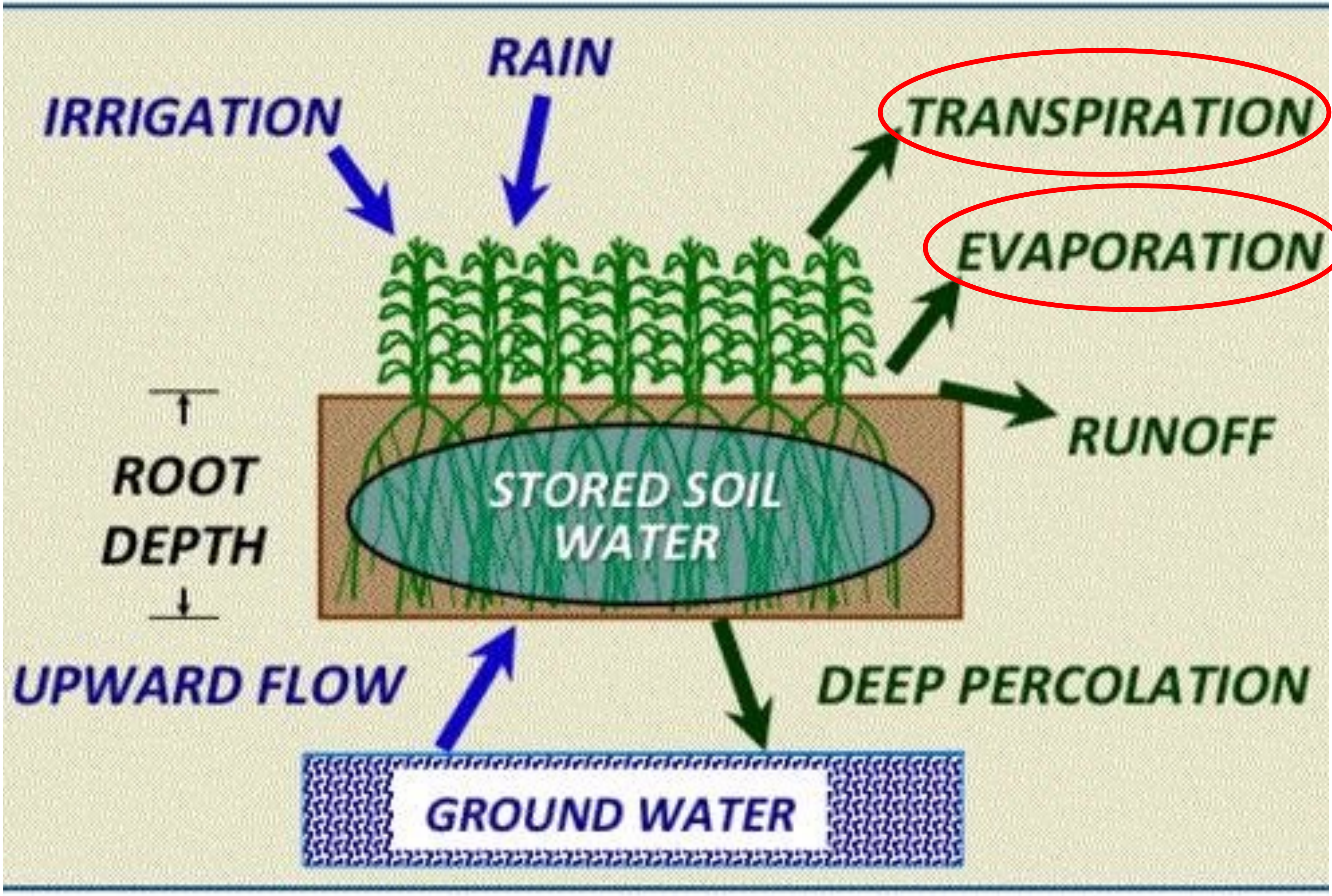
ESTIMATING CROP ET
(ET_c)

$$ET_c = K_c \times ET_o$$



Need: Source of ET_o

Soil Water Balance



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Irrigation Water <u>Management</u>

Irrigator's Equation: $\mathbf{Q \times t = d \times A}$

Q = flow (cfs)

A = Area (acres)

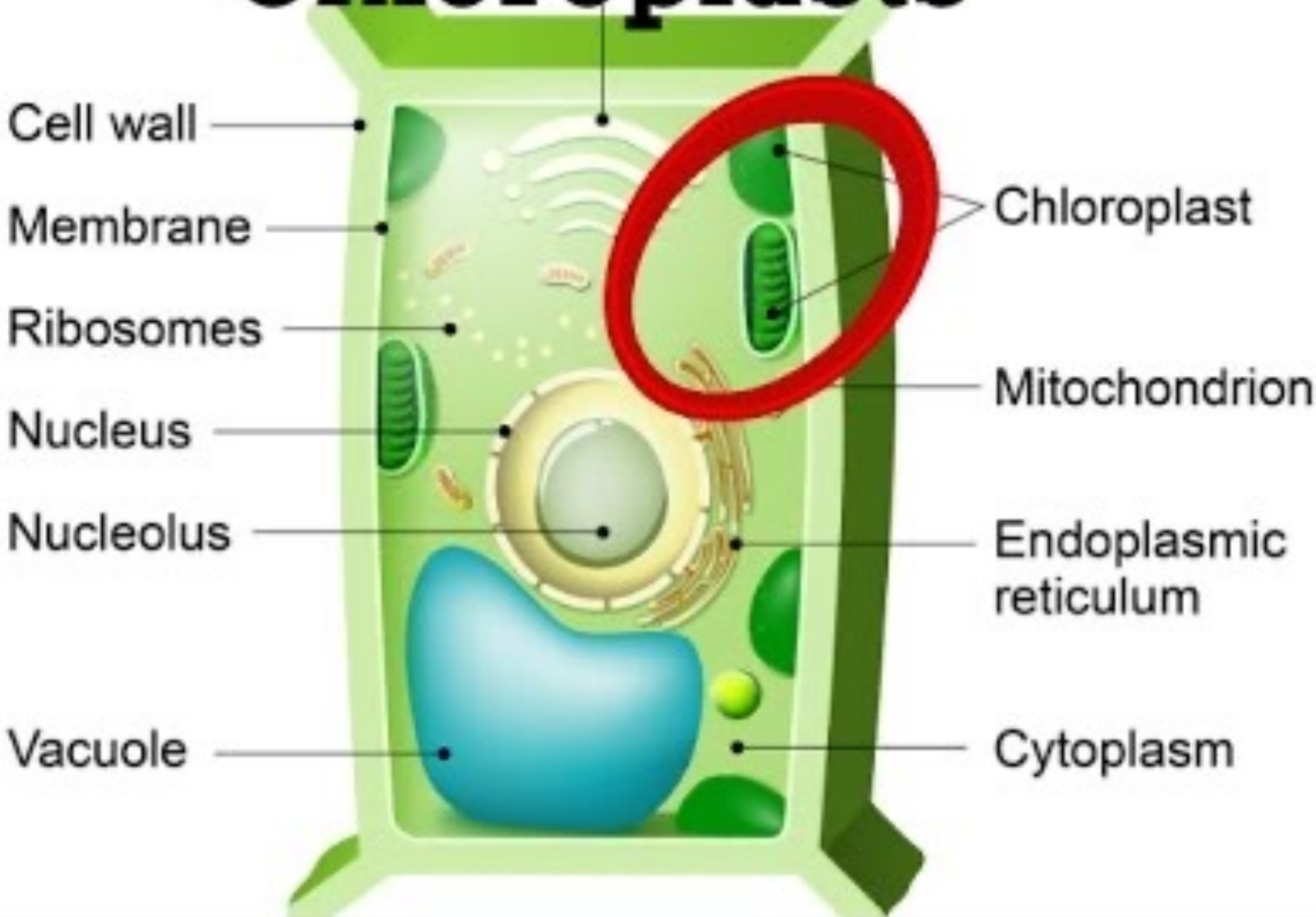
d = depth of irrigation (inches of water)

Solving for irrigation set time (t):

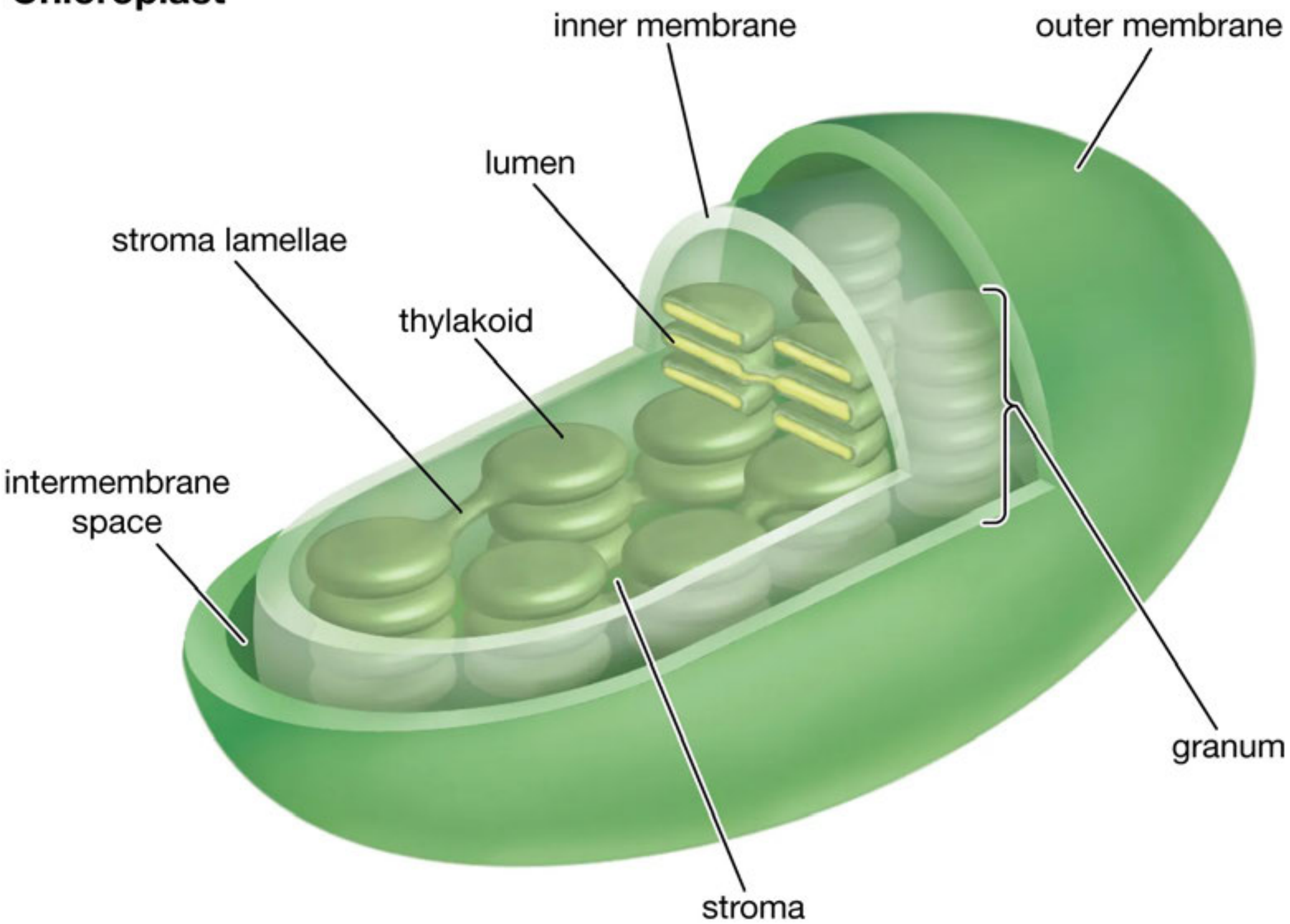
$$t = d \times A / Q$$


Irrigation Management

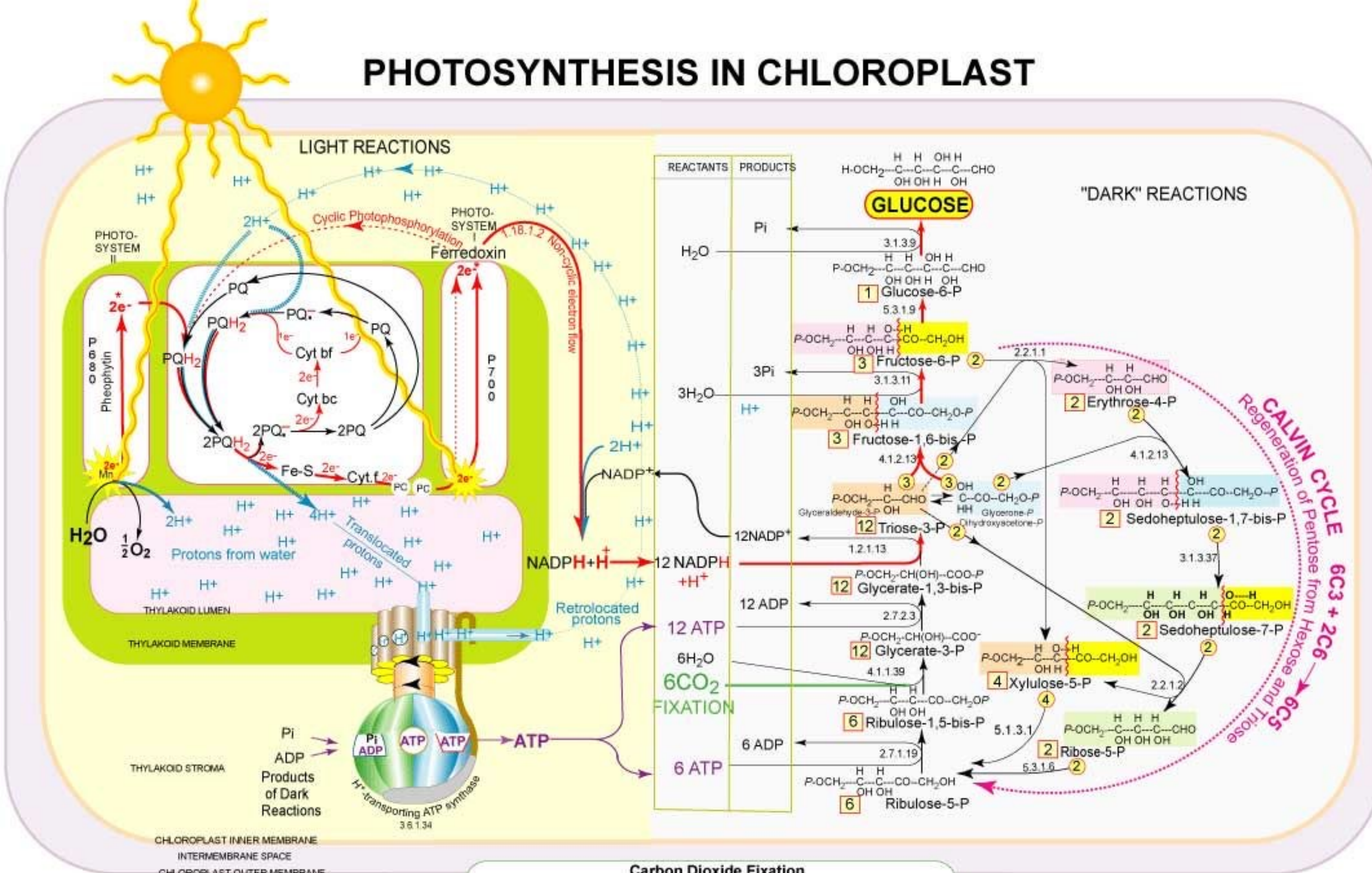
Chloroplasts



Chloroplast



PHOTOSYNTHESIS IN CHLOROPLAST



Carbon Dioxide Fixation

$$6CO_2 + 12NADPH + 12H^+ + 18ATP + 12H_2O \longrightarrow C_6H_{12}O_6 + 12NADP^+ + 18ATP + 18Pi$$

→ LIGHT-DRIVEN ELECTRON FLOW (electric current) from H_2O to $NADP^+$ and thence to Glucose (and starch)

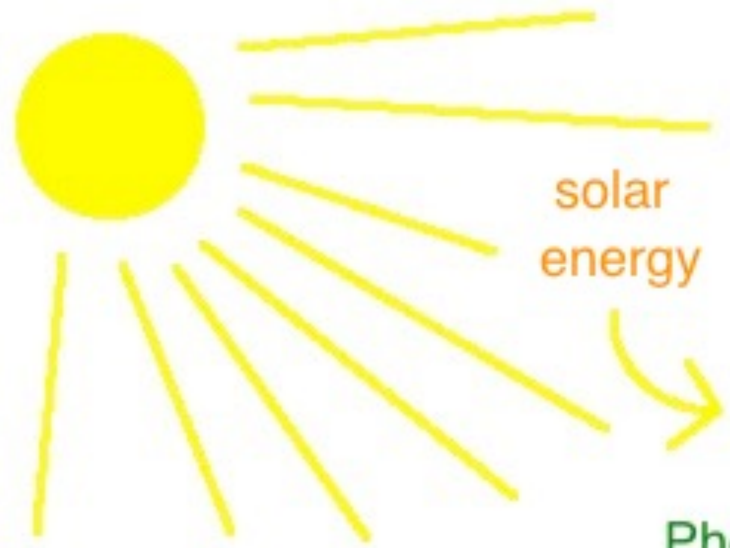
Reduced NADP inhibits Ferredoxin- NADPH reductase (1.18.1.2) and thus initiates

⋯→ CYCLIC PHOTOPHOSPHORYLATION - a light-driven electron flow that drives

→ PROTON TRANSLOCATION from stroma to lumen. These protons, together with those from water produce a pH gradient that drives ATP synthase to form ATP

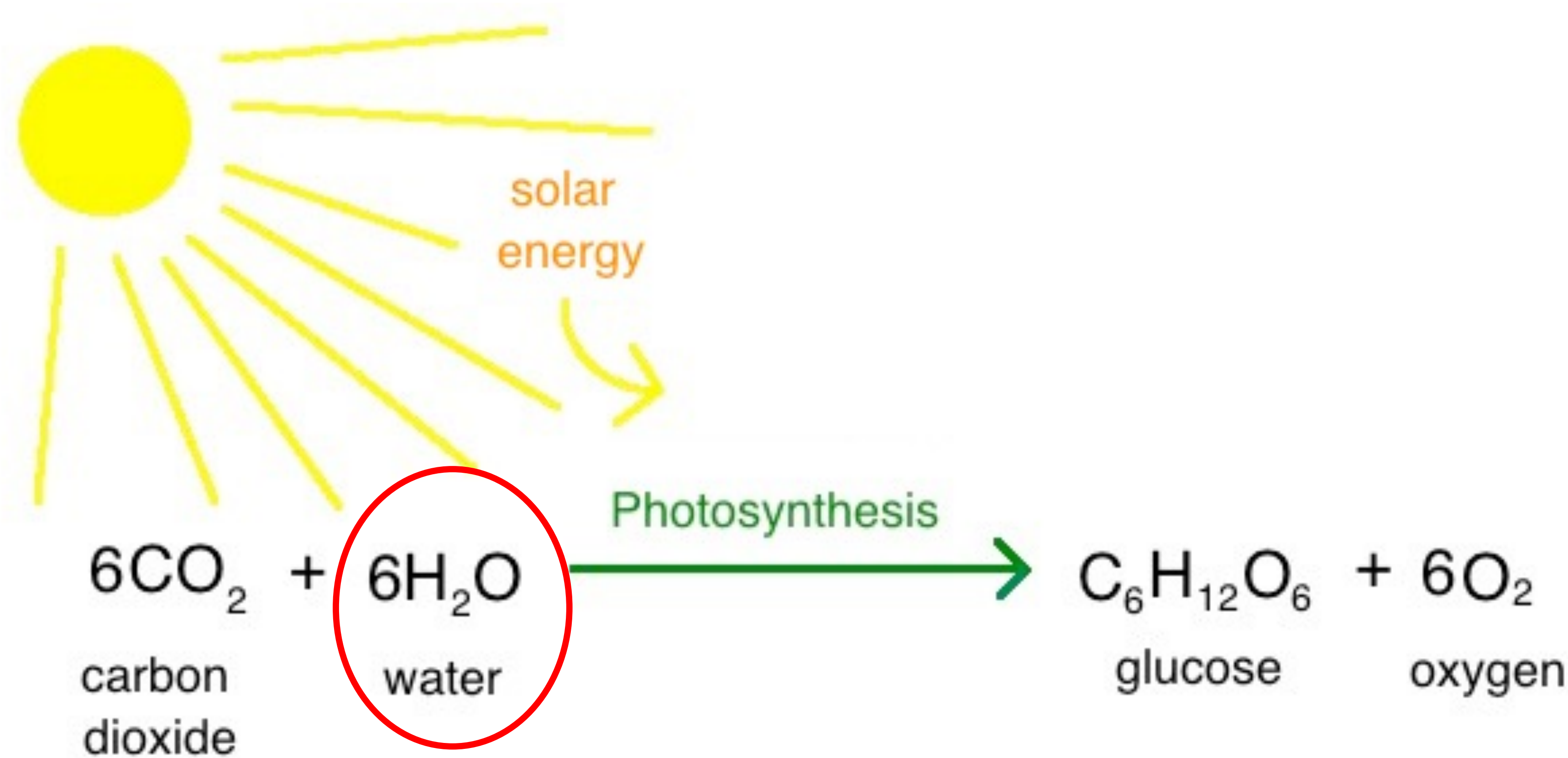
ENZYMES

1.2.1.13	Glyceraldehyde-3-P dehydrogenase	2.7.1.19	Phosphoribulokinase	4.1.1.39	Ribulose-bis-P carboxylase
1.18.1.2	Ferredoxin-NADPH+ reductase	2.7.2.3	Phosphoglycerate kinase	4.1.2.-	Aldolase
2.2.1.1	Glycolaldehydetransferase (Transketolase)	3.1.3.9	Glucose-6-phosphatase	4.1.2.13	Fructose-bis-P aldolase
		3.1.3.11	Fructose-bis-phosphatase	5.1.3.1	Ribulose-P epimerase
2.2.1.2	Dihydroxyacetonetransferase (Transaldolase)	3.1.3.37	Sedoheptulose-bis-phosphatase	5.3.1.1	Triosephosphate isomerase
		3.6.1.34	ATP synthase	5.3.1.6	Ribose-5-P isomerase
				5.3.1.9	Hexose-P isomerase



$$6CO_2 + 6H_2O \xrightarrow{\text{Photosynthesis}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide	water		glucose	oxygen


solar energy
Photosynthesis
6CO2 + 6H2O → C6H12O6 + 6O2
carbon dioxide
water
glucose
oxygen

Salinity – Desert Agriculture

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Salinity
A Desert Agriculture Challenge

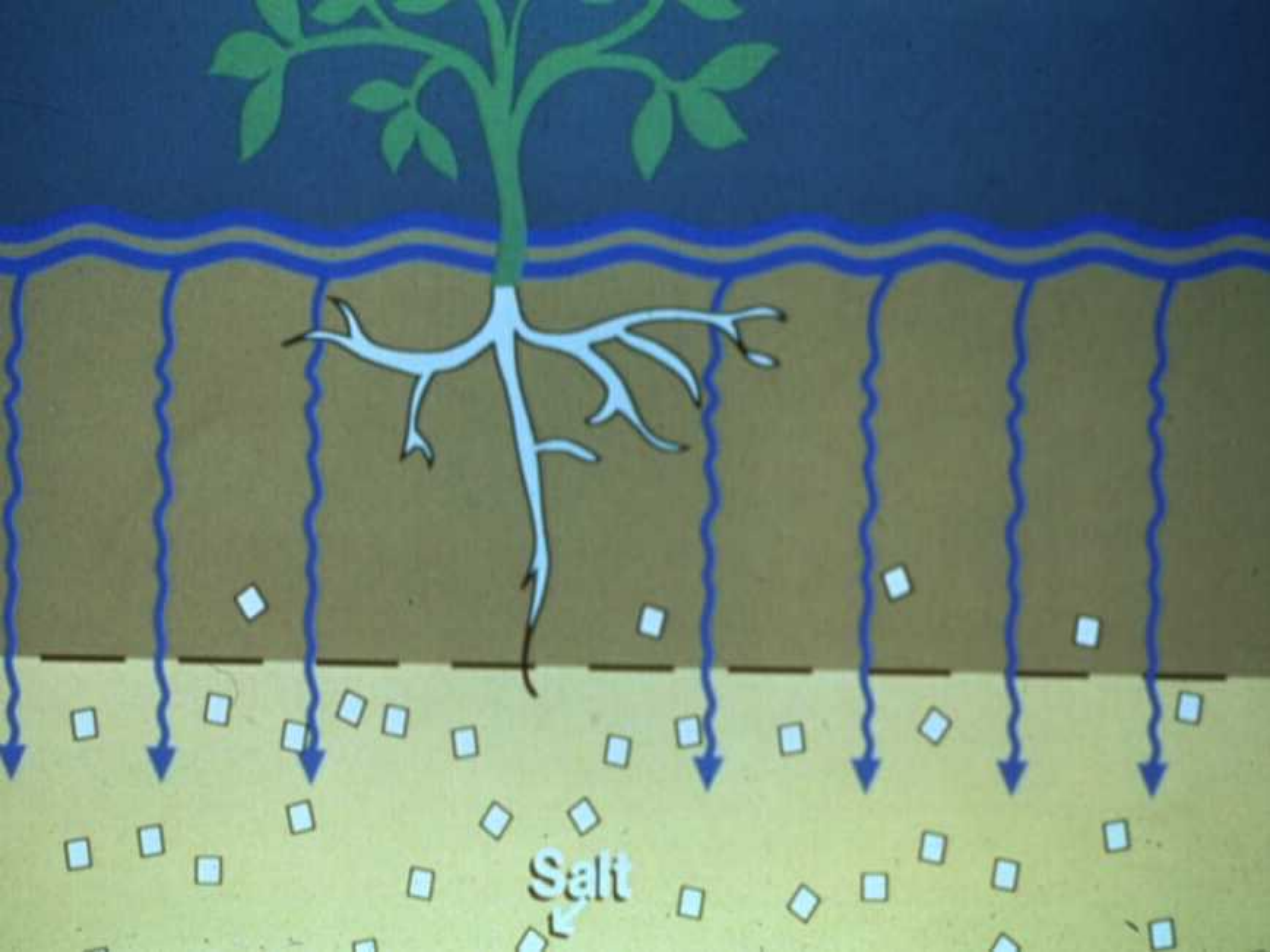
"Successful irrigation schemes in arid regions carry seeds of their own demise" (Gardner, 1985)

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)


Salt


Water Sucking Crops?

Water Sucking Crops?

Photo Credit: Jon Dinsmore

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Desert Cropping Systems

- Well adapted to desert environment
- Heat tolerant
- Salt tolerant
- Highly productive
- Important crop rotation component
- Marketability

Crop & Dairy Production

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Production Links

Water

↓

Crop Production

↓

Cattle

↓

Milk

↓

Dairy Products

↓

<u>Consumer Health & Happiness</u>

Arizona Dairy Production

Arizonans 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

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Water is Life

Photo Credit: Jon Dinsmore

Photo Credit: Jon Dinsmore

Strategic Narcissism*

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

*Hans J. Morgenthau, "*Politics Among Nations*", 1948.
H.R. McMaster, "*Battlegrounds*", 2020.

*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

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