Water Strategies with Limited Water Supplies

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Three main sources of water that sustain California:

- Mountain snowpack
- Water stored in reservoirs (including the Colorado River Water)
- Water pumped from underground aquifers

All three sources are connected, and when the California Governor declared a drought emergency on January 17, 2014, all three had been depleted by an extended dry period.

Los Angeles Times

CALIFORNIA

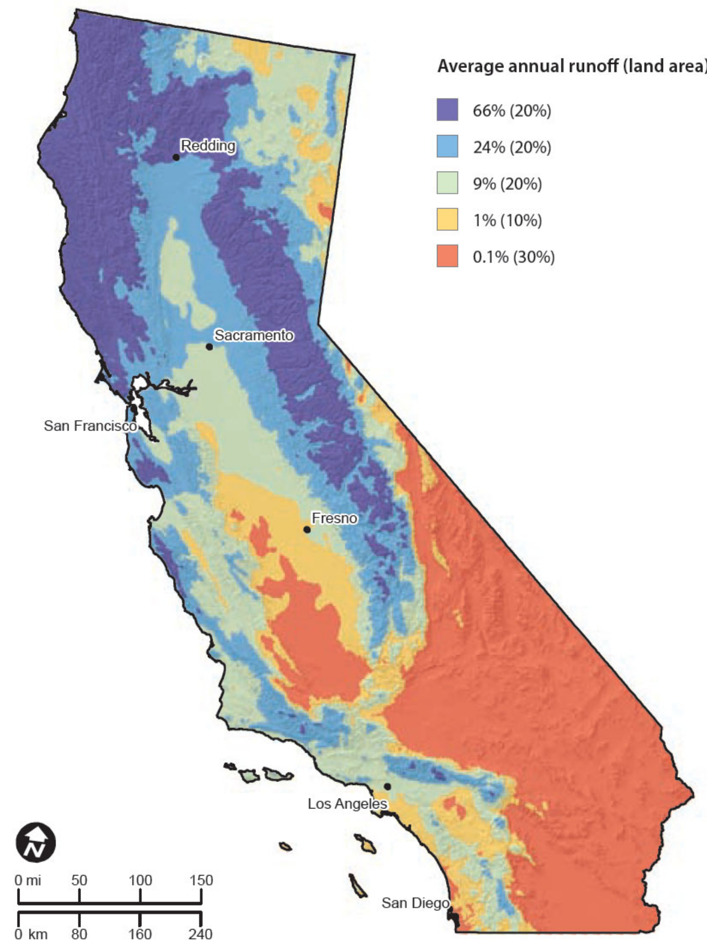
Satellite photos dramatically illustrate the effects of a dry winter on California's Sierra Nevada snowpack

What a difference a year makes

Satellite images released by the National Weather Service office in Sacramento on Monday. (Paul Duginski / Los Angeles Times)

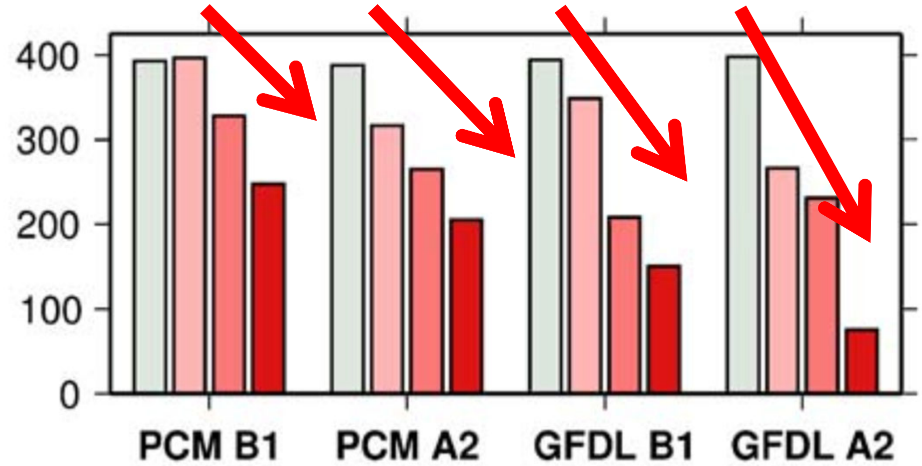
- **Water Supplies**
  - Mostly in North
  - Mostly during Wet Season

- **Water Demands**
  - Mostly Central and South
  - Mostly during Dry Season



Water Resources and Climate Change

California statewide snowpack is projected to shrink drastically



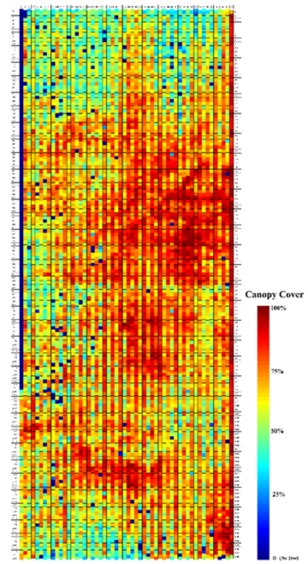
↓ 25% of Sierra snowpack will be lost by **2050**

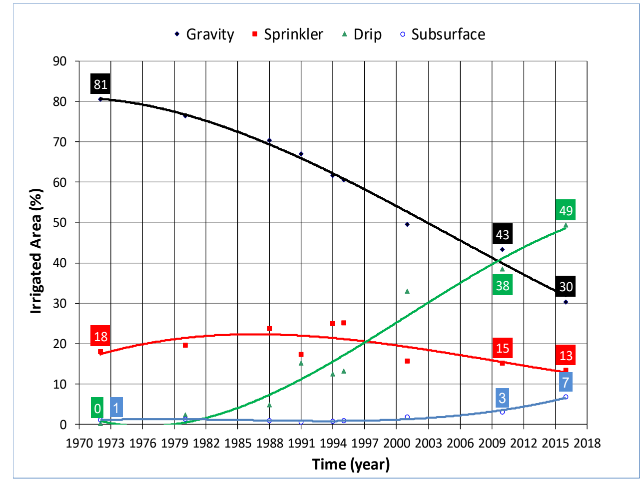
Department of Water Resources, State of California
Source: Tapan Pathak, Climate Adaptation in Agriculture - CE Specialist, University of California Merced

California agricultural is $50 billion industry
Under increasing pressure to conserve water and stretch the limited supplies

Strategies to cope with limited supplies:

- Careful management of limited water supplies (reduce waste)
- Climate-adaptive irrigation strategies to stretch the available water and minimizing the environmental issues associated with irrigated agriculture (irrigation scheduling, VRI, automation, canopy management, etc)
- Increase efficiency and minimize losses (DU etc)
- Groundwater recharge during wet years (??)
- Reuse of recycled water and new technologies to treat saline water
- State funded programs for water conservation and reduction of GHG emissions



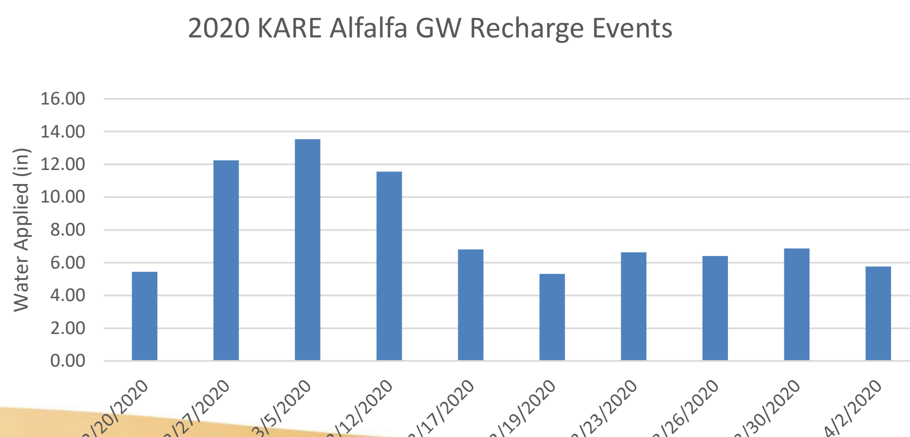


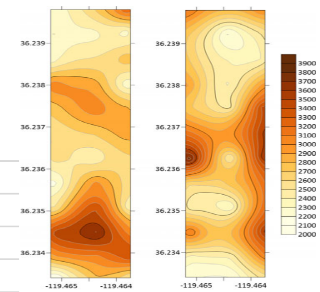
Water Conservation Practices and Groundwater Recharge

Examples:
- Drip irrigation on trees and vines
- Subsurface drip irrigation on alfalfa and field crops
- Variable rate irrigation practices on almond
- Groundwater recharge during wet years
- Utilization of technology for irrigation management




Consequences of improved on-farm efficiency:
Salinity buildup, less water for recharge, increased costs, GHG emissions, etc.



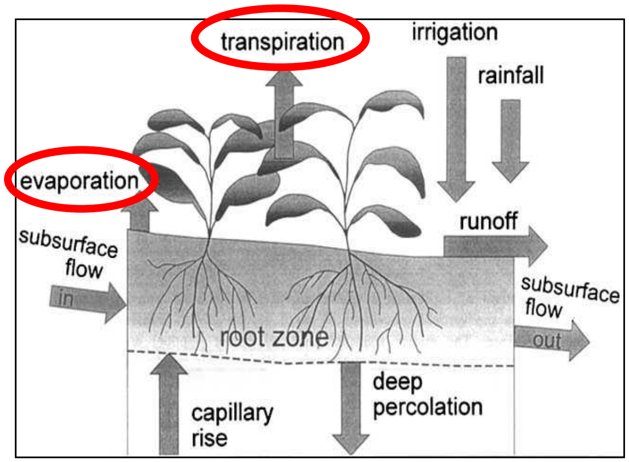


Why do we irrigae:

replenish the amount of water used by the crop (ET_C) since the last irrigation

Crop ET = Reference ET x Crop Coefficient

$$ET_C = ET_O \times k_C$$



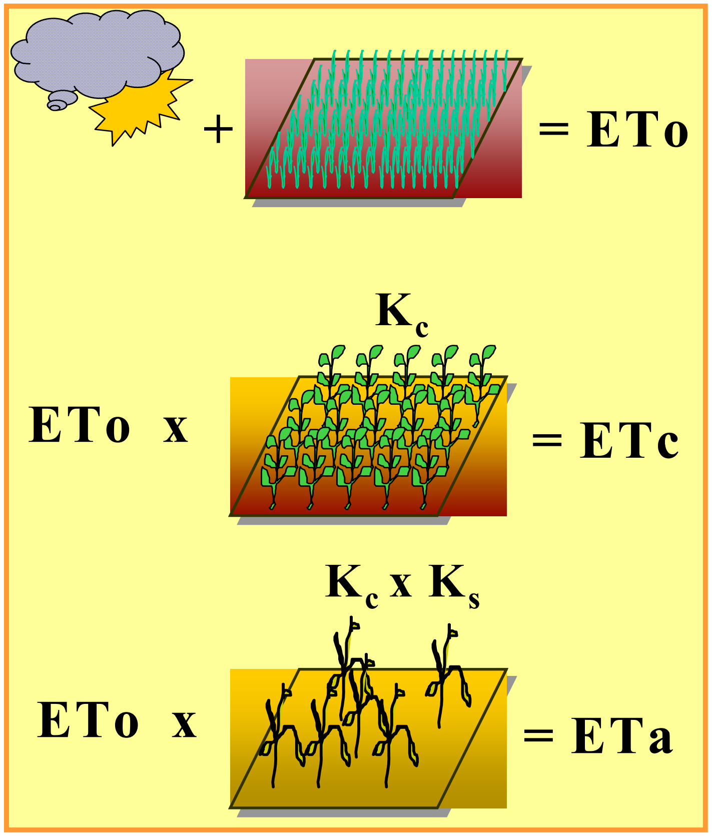
Applied Water (in)= ETc/DU

DU distribution Uniformity
Applied water=$$ water plus energy $$

Low DU= high $$$
High DU= efficient system, low cost

System	DU
Gravity	**70-85%**
Drip	**85-90%**
Micro-sprinkler	**80-90%**
Sprinkler	**70-90%**

ETc and ETa

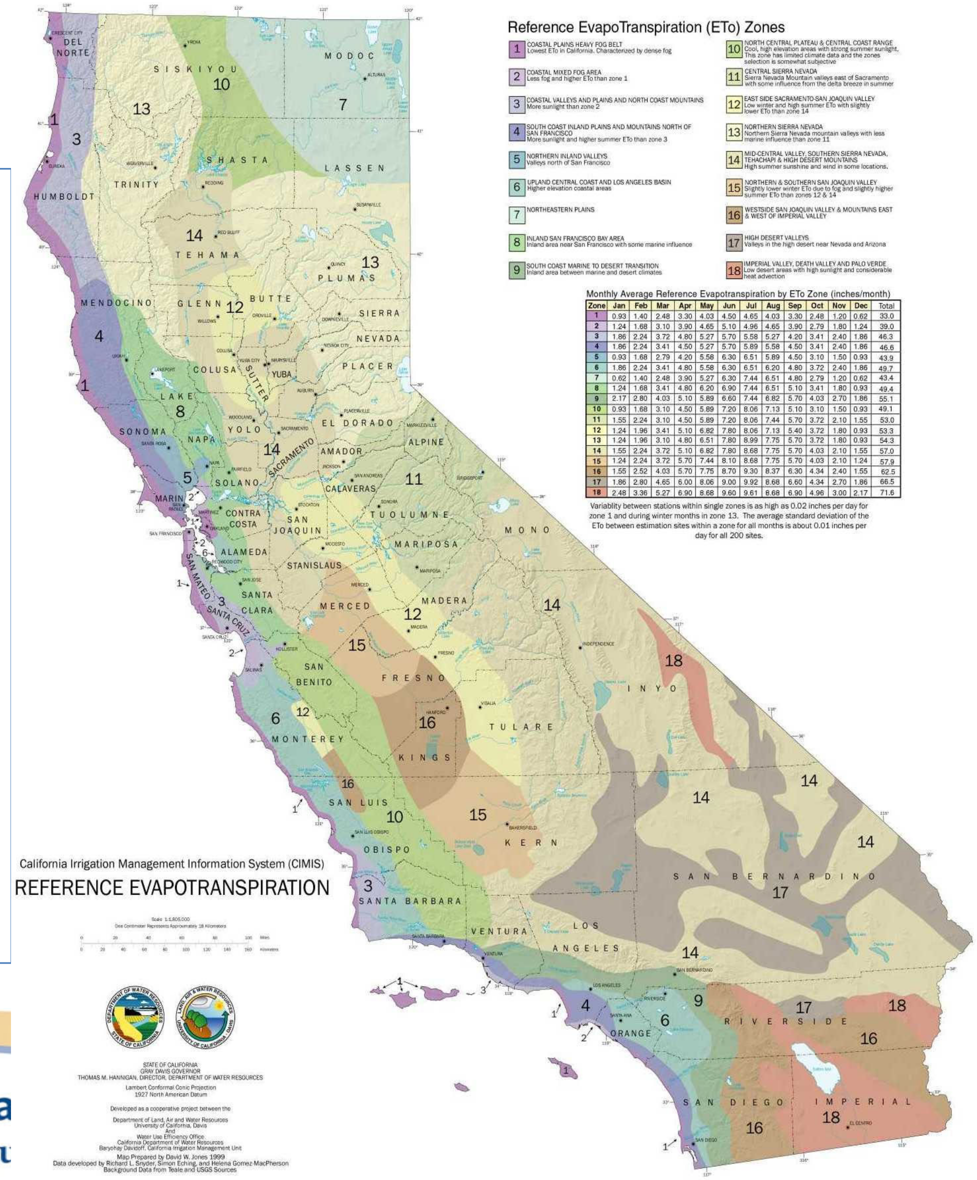


CIMIS (Map)

- Simple table to estimate ETo based on historical data
- Data based on historical average ET
- Good estimates but doesn't account for climate variability
- Not location specific (zones)

CIMIS (website)
http://wwwcimis.water.ca.gov/

- Easy to access, provide historical and recent data.
- More accurate estimate from CIMIS stations close to the farm data



Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

HOME | STATIONS | DATA | SPATIAL | RESOURCES

Spatial Overview | Spatial Maps | Spatial Report | Schedule Spatial Report

Spatial Report

This report provides daily ETo and Solar Radiation data at a 2 km resolution. Spatial Report data covers from 2/20/2003 to yesterday's date. Reports are available in several data formats and in English or Metric units. You may specify date ranges and zip codes, map coordinate points, or data search by address. Bing Map tools to center the page on California, recall previously selected points, and clear selected points are also available at the bottom-right.

Create a [Web Report] in [English Units] from [8/18/2016] to [8/24/2016] using [Coordinate List]

Run Report

Address Search

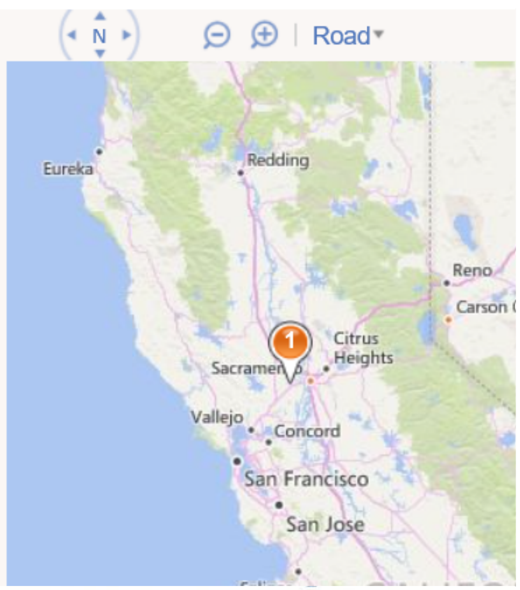
Search to add locations to the coordinate list or double-click the map interface. (ex: 1315 10th St, Sacramento, CA 95814)

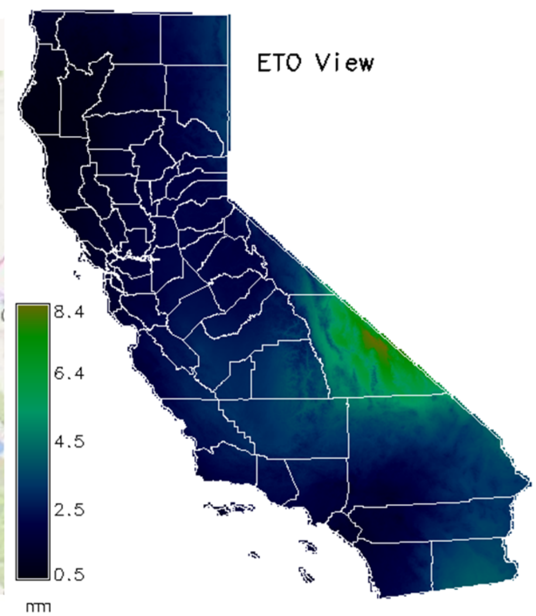
Search

Coordinate List

You must click the "Save Coordinates" button to keep your selection in your coordinate list.

1. 95616, CA(38.5359, -121.7765)
2. (empty)





ET_o - accounts for weather

Solar radiation, humidity, temperature, wind

K_c - accounts for crop

- **light absorption**
- **canopy roughness**
- **physiology**
- **age**
- **surface wetness** (irrigation system)

Crop Coefficients for Avocados

Using CIMIS or an E-pan, you end up with a number that's called Reference evapotranspiration or ETo for short. This number approximates the evapotranspiration of a field of 4 to 6 inch tall, cool-season grass that is not water stressed. To use this number to calculate water use for avocados you must multiply the ETo by a crop coefficient (Kc) that accounts for the ET difference between the avocado and the cool-season grass. Below are the crop coefficients for avocado based on research done in Corona, Ca (1988-92) and Covey Lane, North San Diego County, Ca (1992-97).

Months	Kc's
Jan	0.40
Feb	0.50
Mar	0.55
Apr	0.55
May	0.60
Jun	0.65
Jul	0.65
Aug	0.65
Sep	0.60
Oct	0.55
Nov	0.55
Dec	0.50

For Further Information

Irrigation Scheduling, a guide for efficient on-farm water management. University of California Division of Agriculture and Natural Resources Publication #21454. 1989.

Comments about crop coefficients for Hass Avocado on Mexican Seedling Rootstocks.
January 10, 2007
J.D. Oster and M.L. Arpaia
University of California
Riverside, CA.
James.oster@ucr.edu
The comments begin with the cover page and abstract of a paper
accepted on January 9, 2007 for publication by the J. Amer. Soc. Hort. Sci.

Kc~0.86* fraction of shaded area

Table 1 Recommended irrigation crop coefficients (Kc) for avocado production in the South-West and northern Perth in Western Australia based on month and growth stage

Approximate grwoth stage	Crop coefficient South-West	Crop coefficient northern Perth
Fruit Growth	0.4 (Jul)	0.5 (Jun)
Fruit Growth	0.4 (Aug)	0.5 (Jul)
Flower development	0.7 (Sep)	0.7 (Aug)
Flowering, vegetative flush	0.8 (Oct)	0.9 (Sep)
Flowering, vegetative flush	0.8 (Nov)	0.9 (Oct)
Initial fruit drop, vegetative flush	0.7 (Dec)	0.8 (Nov)
Vegetative flush, root flush	0.7 (Jan)	0.8 (Dec)
Vegetative flush, root flush, summer fruit drop	0.8 (Feb)	1.0 (Jan)
Root flush, fruit growth	0.8 (Mar)	1.0 (Feb)
Root flush, fruit growth	0.7 (Apr)	0.9 (Mar)
Root flush, fruit growth	0.4 (May)	0.9 (Apr)
Root flush, fruit growth	0.4 (Jun)	0.7 (May)

Table 1. source: Growing avocados – annual water requirements
Department of Primary Industries and Regional Development (DPIRD)
Government of Western Australia
https://www.agric.wa.gov.au/water-management/growing-avocados-%E2%80%93-annual-water-requirements

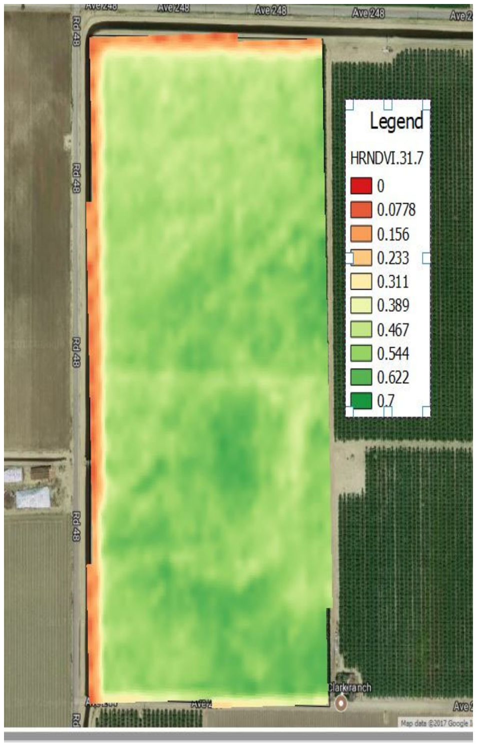
Strategies for Avocado Under Limited Water Supplies

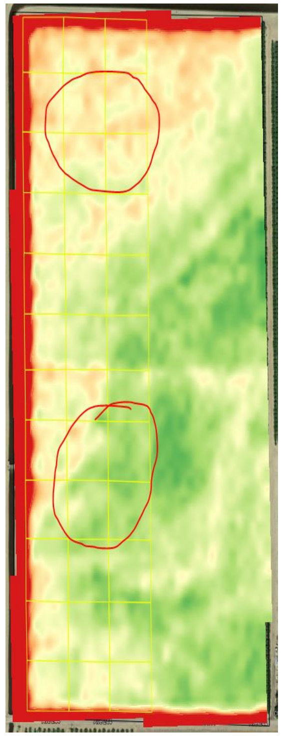
- Efficient irrigation system; high DU (Distribution Uniformity)
- Energy cost and irrigation scheduling (time of use)
- Canopy management (reduce canopy size to reduce ET)
- Canopy management (irrigate healthy trees, reduce water on small trees)
- Protectants (reflectants) Materials to reduce ETc

Prune

- Removing half the foliage doesn't reduce water use by half
- Estimates would be 20-30% reduction
  - Increased light within canopy
  - Increased air flow

Strategies
Tulare County- Almond Variable Rate Irrigation (VRI)- NDVI





Historically peak hours were defined as the hours between 12pm-6pm (PG&E, 2016). Proliferation of solar generation in California is forcing those peak hours to shift to later hours in the day (4pm-9pm) with Some over generation during the day

VRI- 1 acre zone

System design: irrigate 1 zone (1/36 of the field) or irrigate up to 36 zones all at once

System design to meet peak energy demand/pricing (irrigate when cost of energy is low)

Impacts of Drought

- Avocado Not adapted to hot, dry climates
- Shallow root system
  - 80% roots in top 45 cm
- Low salt tolerance

So what to do in a drought?

Analyze the Grove

- Poor production areas:
  - Cold temperatures?
  - Excessive salinity?
  - High soil pH?
  - Low bee visitation?
  - High wind areas?

- Irrigate the areas with good production record

Drought Strategies

- Set priorities
- Irrigate productive blocks
- Fix and Maintain the irrigation system

Read more about heat and avocados:

- Avocados and Cover Crops
- Why and How to Cool Avocado Trees
- What's Happening to Climate?
- Mitigating Heat in the Orchard
- Connecting to the Changes Around Us
- Made in the Shade
- With Climate Change Will We Grow Cactus?
- Heat, Wind, Freeze, Wind, Repeat
- Optimizing Salt Leaching
- Changing Temperatures Affecting Herbicide Efficacy?
- Heat Stress Advice
- Avocado Heat Damage
- Heat and Trees

https://ucanr.edu/blogs/Topics/

frequent blogs on tree issues

http://ceventura.ucanr.edu/news/Topics_in_Subtropics/

quarterly newsletter on trees

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Summary and next steps

- First examine general strategies to cope with limited supplies, then explore crop (avocado) specific strategies
- Improving efficiency is a key for avocado (DU is the low hanging fruit, most effective/least expensive)
- General strategies like deficit irrigation may not work for avocado (good for alfalfa or sunflower) but for avocado canopy management, reflecting materials on leaves to reduce avocado ET are effective tools to conserve water
- Reduce irrigation labor cost through automation ($15/hr plus 40% overhead)
- Utilization of technology for irrigation scheduling and precision irrigation
- Improving irrigation district system efficiency and flexibility (on-demand, demand/response, pressurized irrigation water, etc)
- Assessing the water, energy, pollution and GHG footprints of these different production systems
- Not specific for avocado, potential for utilizing existing surface irrigation infrastructure for groundwater recharge (SIGMA)

Thank You