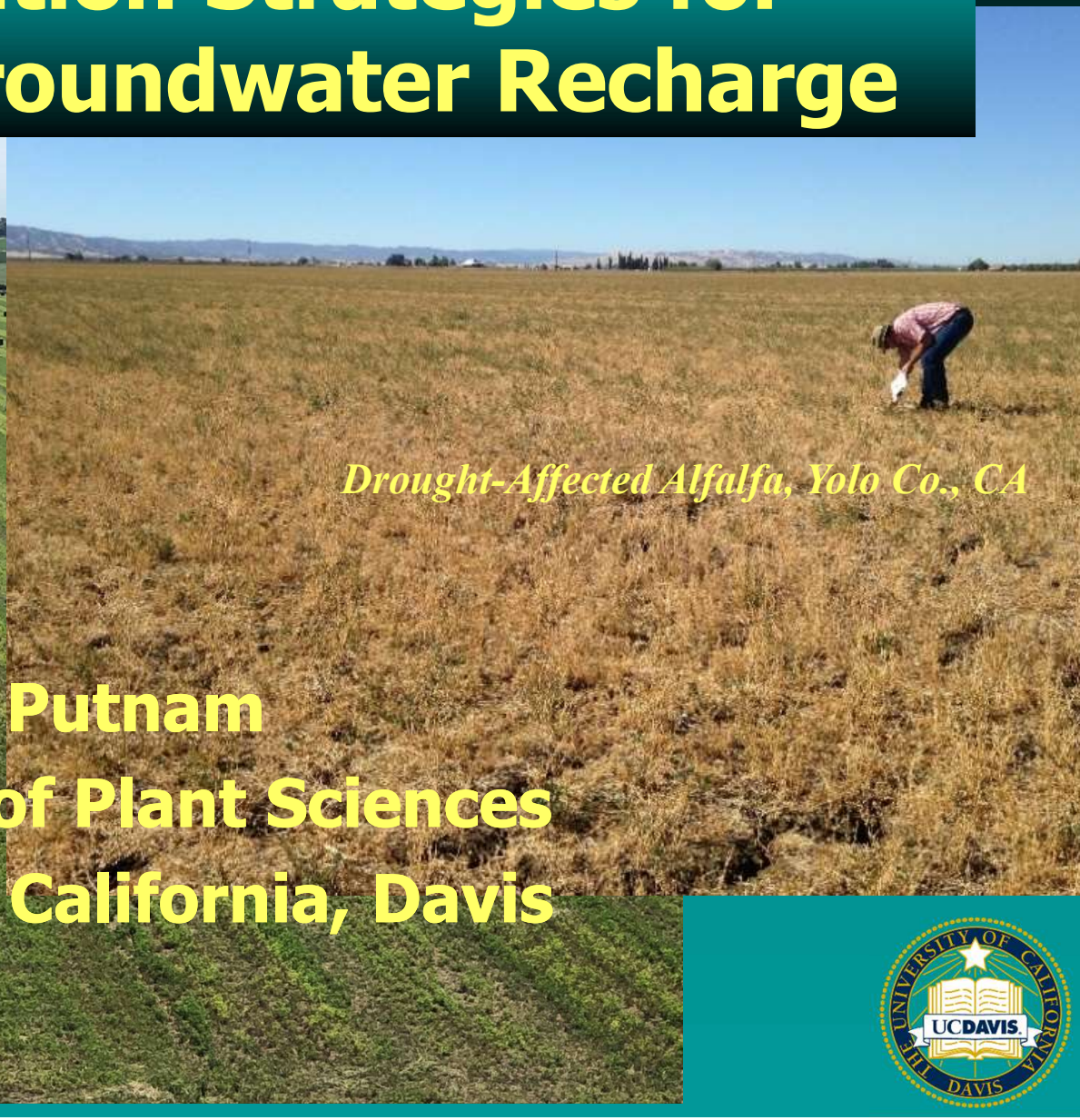
Alfalfa Irrigation Strategies for drought and Groundwater Recharge

Irrigated alfalfa, Woodland, CA



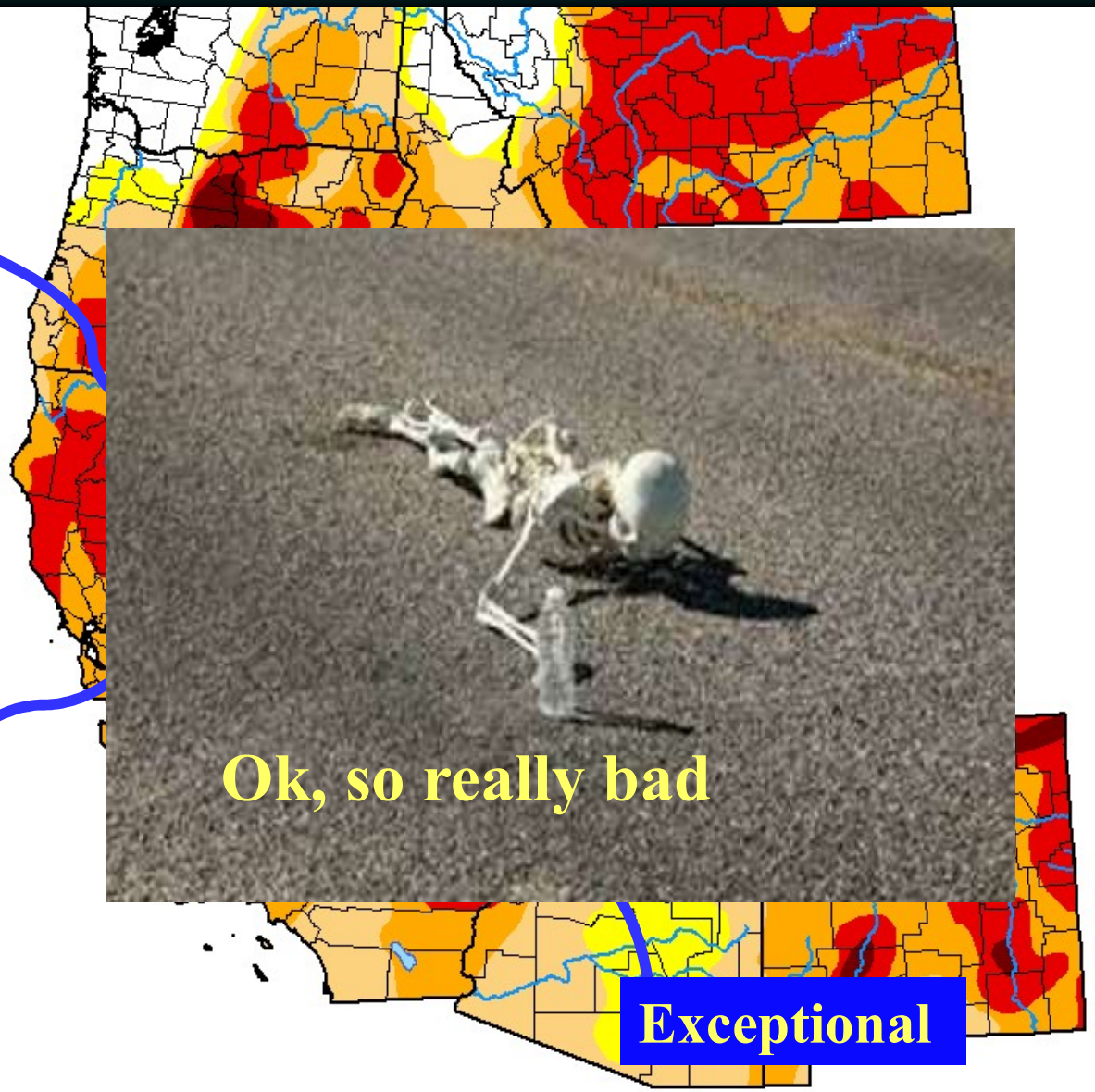
Drought-Affected Alfalfa, Yolo Co., CA

Dan Putnam
Department of Plant Sciences
University of California, Davis

World Alfalfa Congress

- San Diego (November 14-17, 2022)
- Irrigation/Pest Mgmt Training
- Field Tour Imperial Valley
- Talks from around the world
- https://worldalfalfacongress.ucdavis.edu/

Current Situation (March, 2022)



Severe

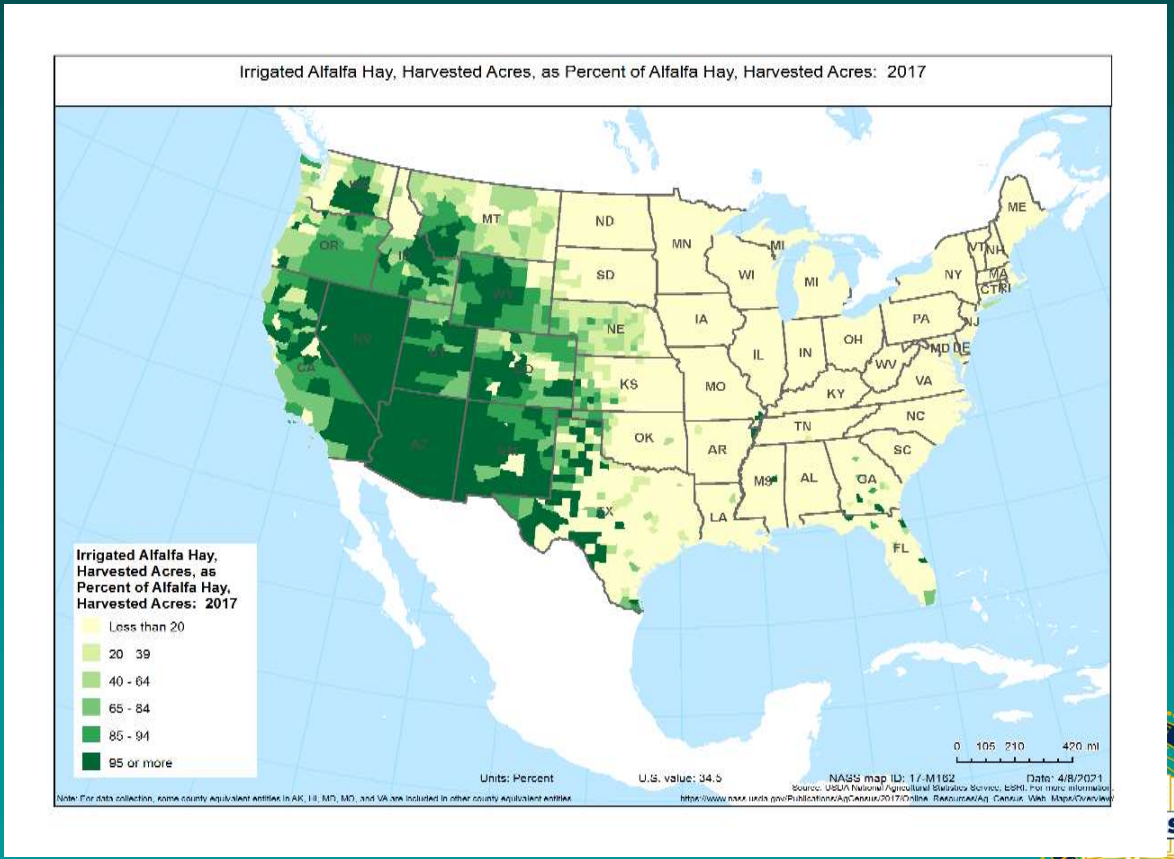
Extreme

Exceptional

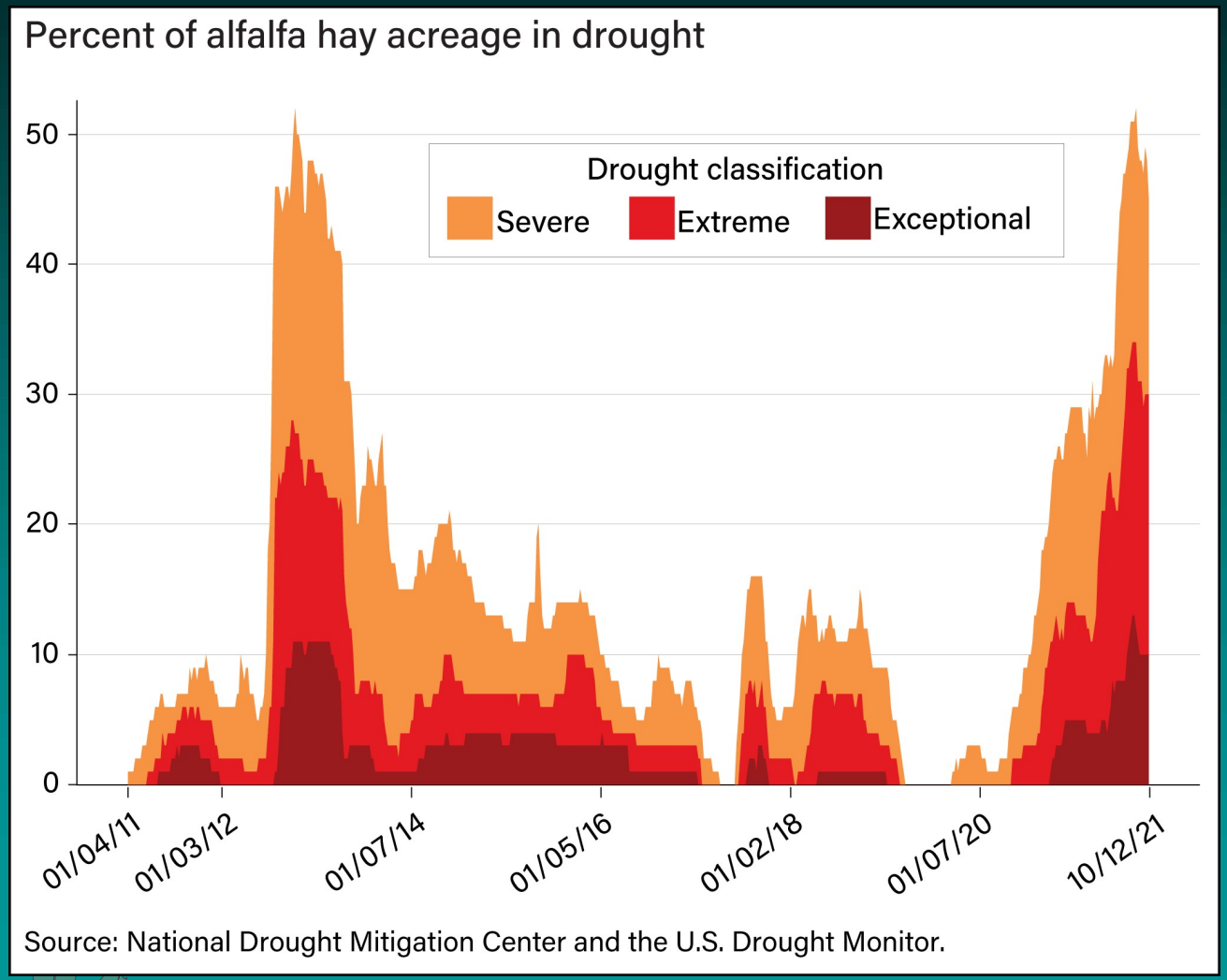
Source: USGS

Irrigated Alfalfa

- 45%-52% of US alfalfa is produced in irrigated regions
- Alfalfa is often the #1 water user in western states



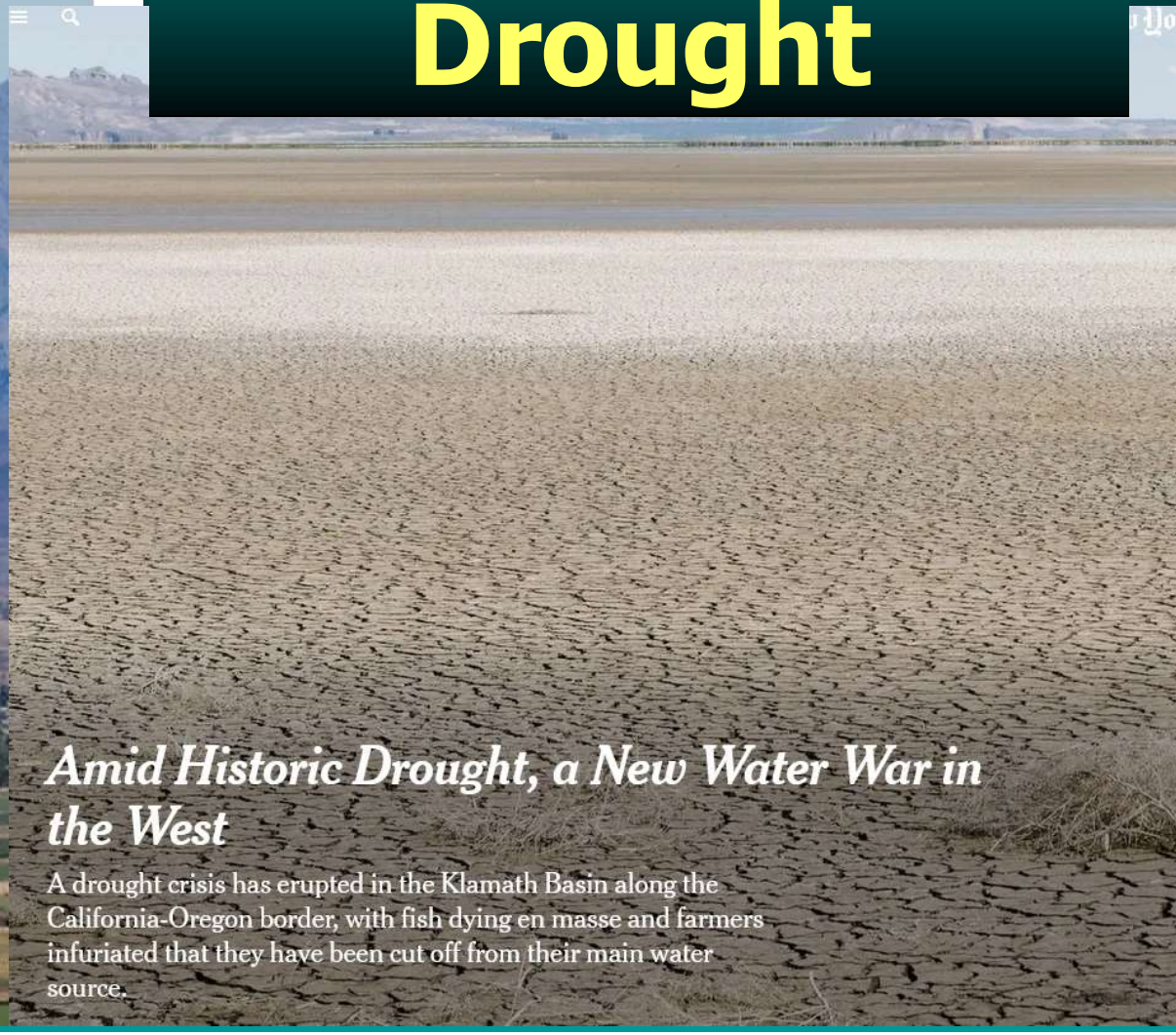
Percent Alfalfa impacted by drought



45% of Hay acres (US), summer of 2021 (NDMC, and ERS).

Drought, Drought, Drought

As drought worsens, California farmers are being paid not to grow crops



Amid Historic Drought, a New Water War in the West

A drought crisis has erupted in the Klamath Basin along the California-Oregon border, with fish dying en masse and farmers infuriated that they have been cut off from their main water source.

Followed by Deluge (Oct. 2021)

- Woodland, CA 7” in one day (highest ever)

Variation in Supplies more important than drought….

Winter, 2017 – Elk Grove, CA

Fall, 2021 – Folsom Lake, CA

Alfalfa..

- Uniquely Suited to Variations in Water Supply
- Deficits
  - Can provide partial yields when deficit irrigated (late dry-down)
  - Survives 1-2 month droughts
  - Generally recovers after dry-downs
- Excesses (Flood-MAR)
  - Groundwater Recharge possibility (soil type)
  - Winter irrigation may improve early yield

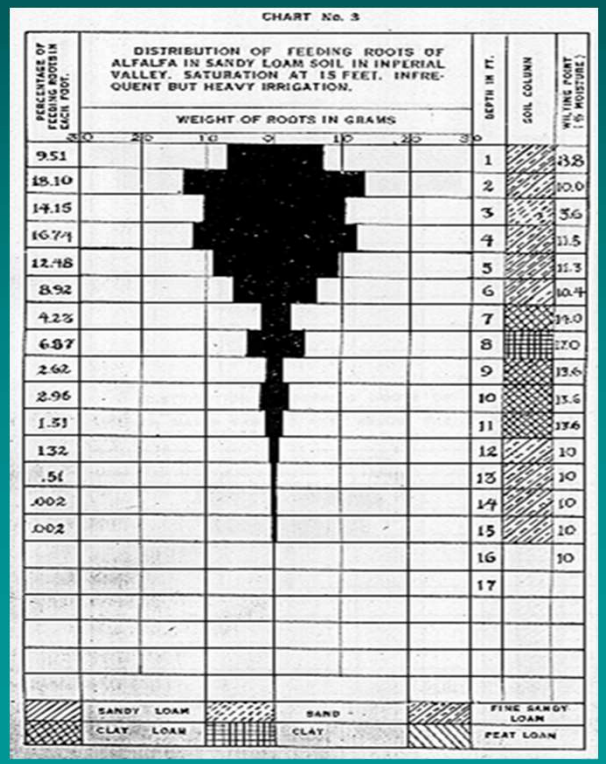
Our Challenge: More Crop Per Drop

Characteristics of Alfalfa for a Water Variable Future

- High Water Use Efficiency (DM yield/unit water)
- High Flexibility under variable supplies
  - Low Water – can be deficit irrigated
  - High Water – receipt of excess flows
- Highly saline tolerant
  - Accepting degraded waters
- Environmental Services: Wildlife and Soil health.

Biological Advantages of Alfalfa With regards to water

- Deep Roots
- Perennial plant

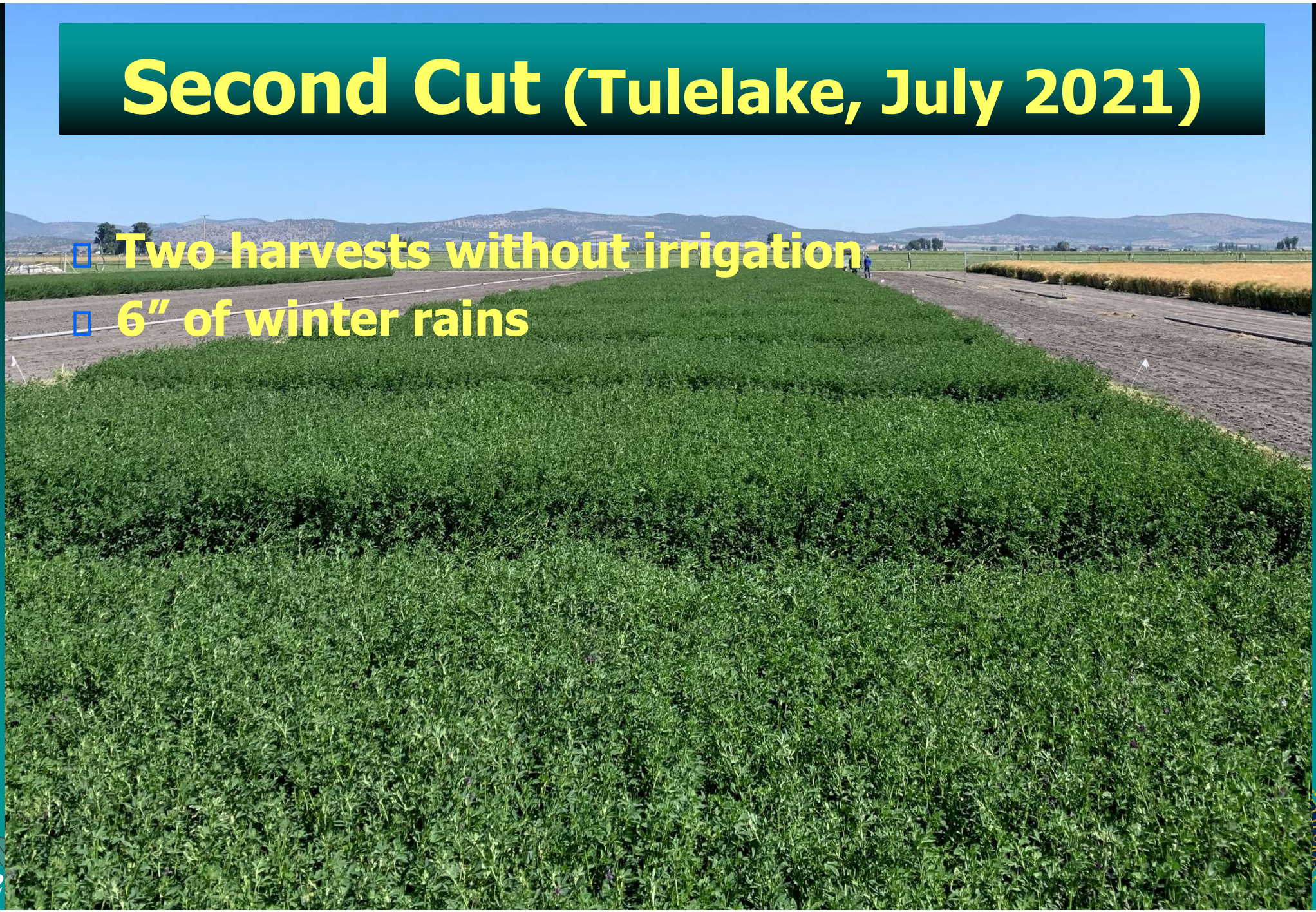


Imperial Valley

Deep Roots/Perennial: Why is this important?

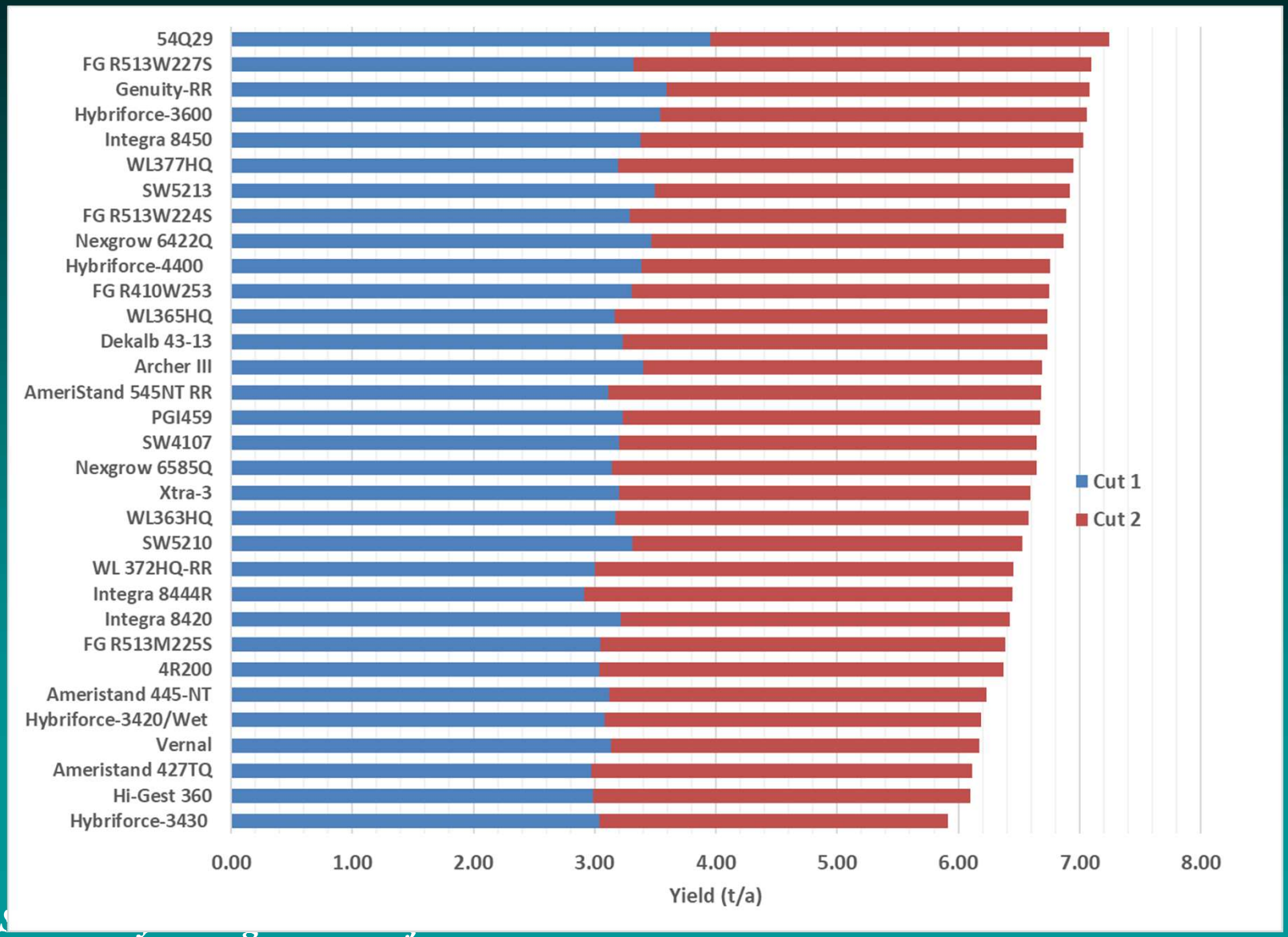
- Starts right away in the spring
- Utilization of residual moisture from rain/early irrigations
- Difficult to water below the root zone
- Survives droughts
- Uptake of nitrates from depth
- Soil health (sequestration of carbon, soil biology)

Second Cut (Tulelake, July 2021)



- Two harvests without irrigation
- 6” of winter rains

Tulalake Yields (2 cuts, 2021) non-irrigated

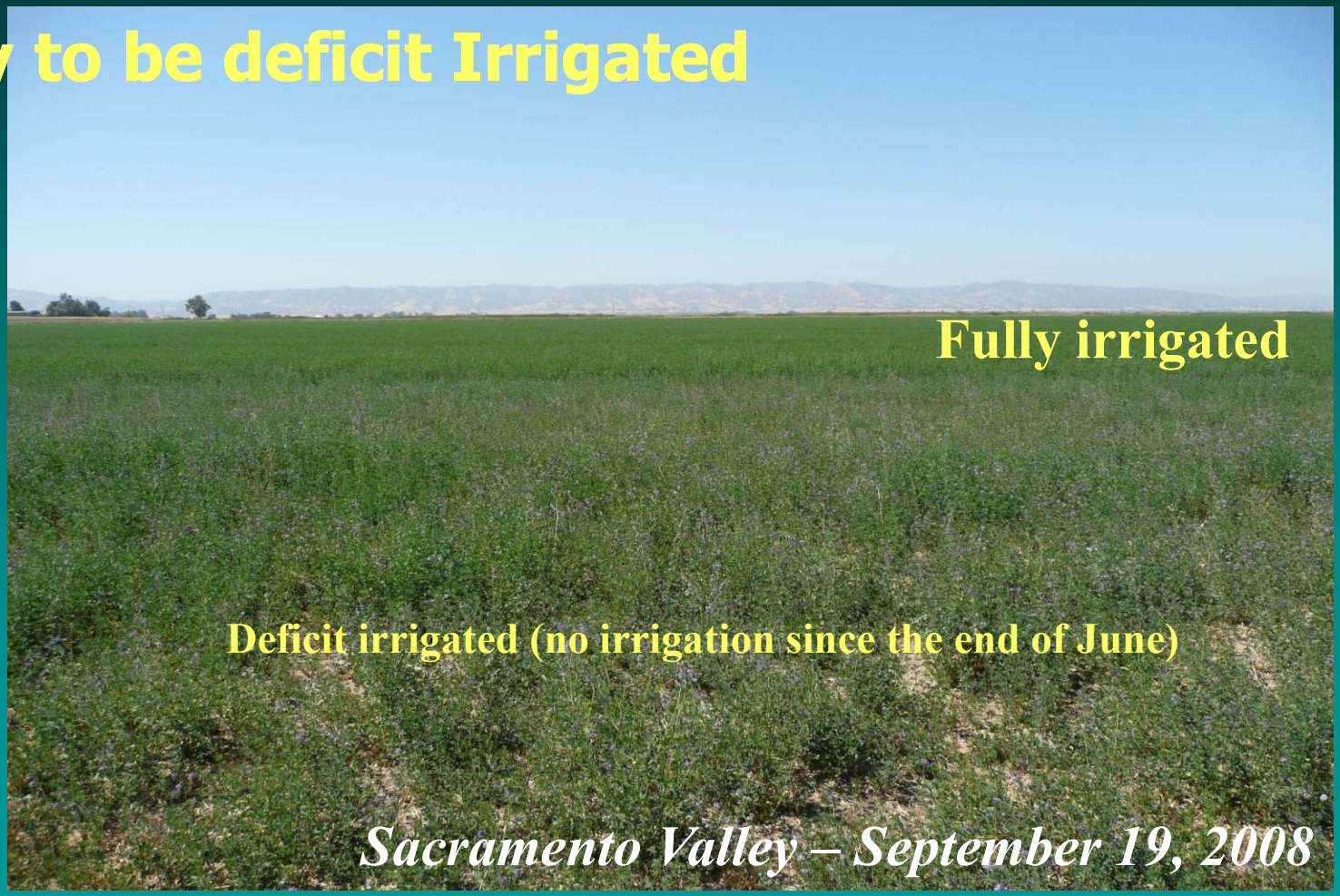


What is happening below ground?

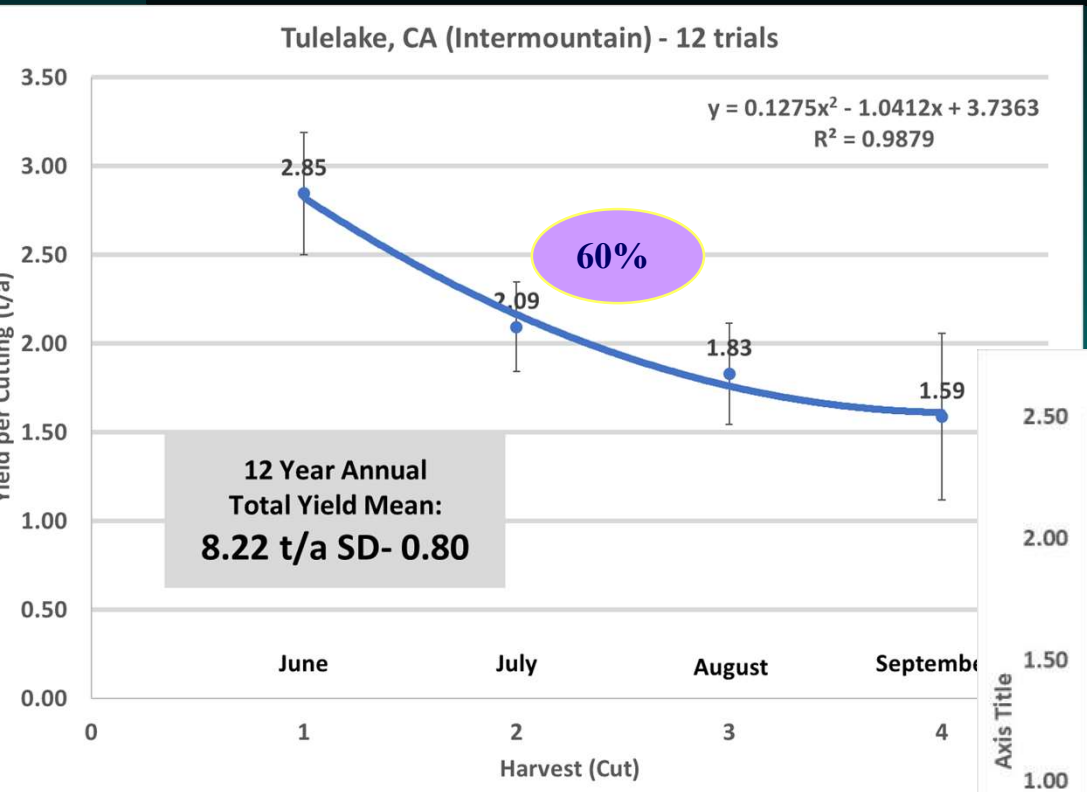
Organic Loam Soils, no impediments

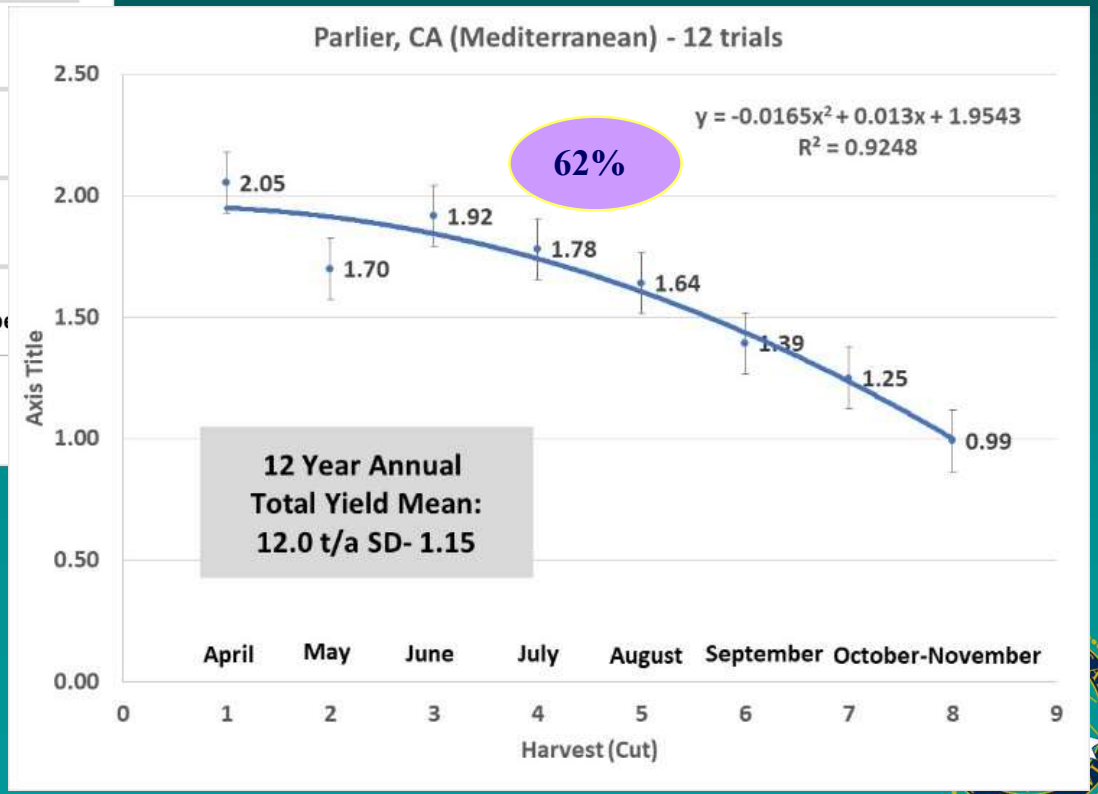
Biological Advantages of Alfalfa
vis-à-vis water

Ability to be deficit Irrigated



Biological Advantage:
Alfalfa Yield Patterns



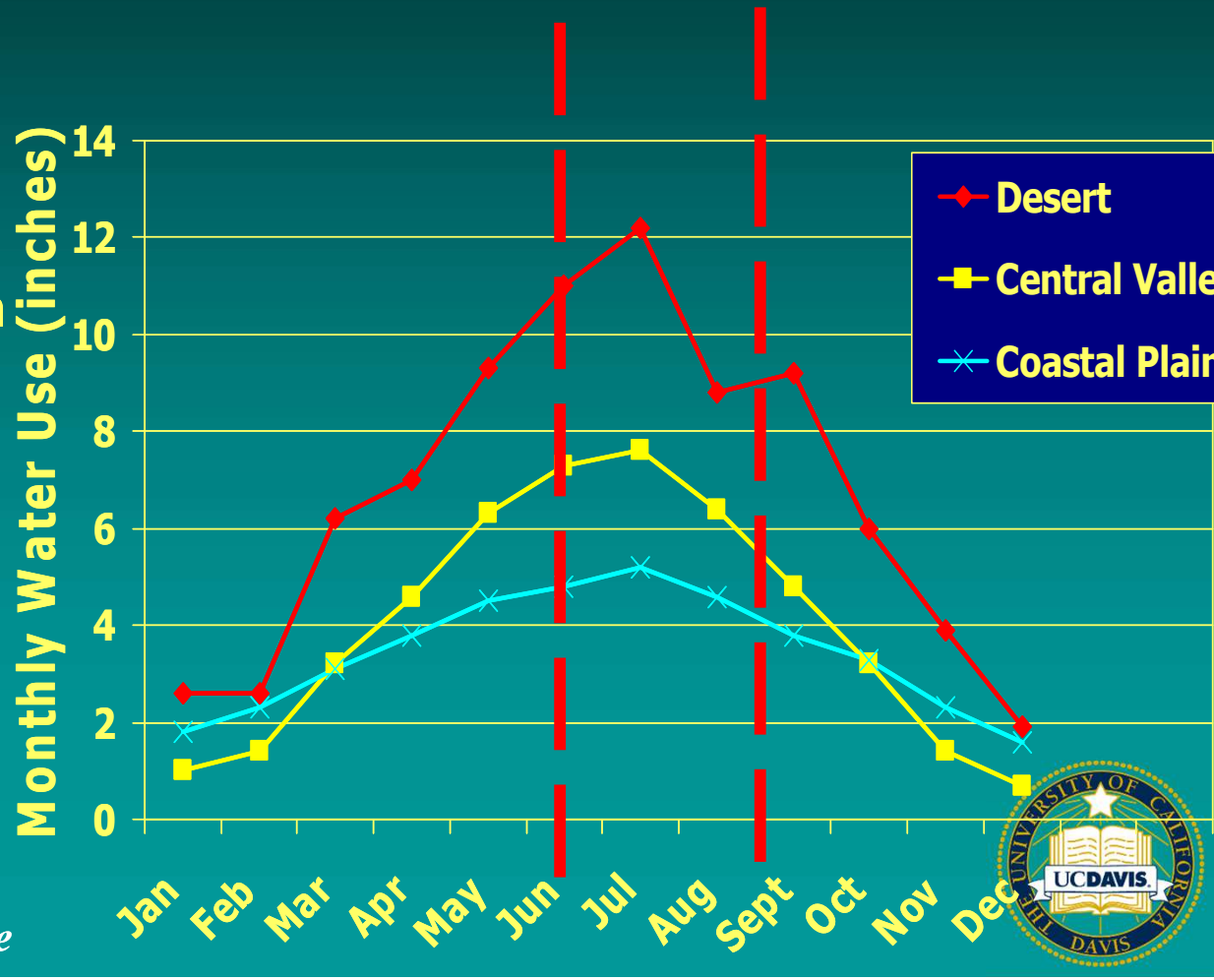


Opportunities to Save Water with Alfalfa:

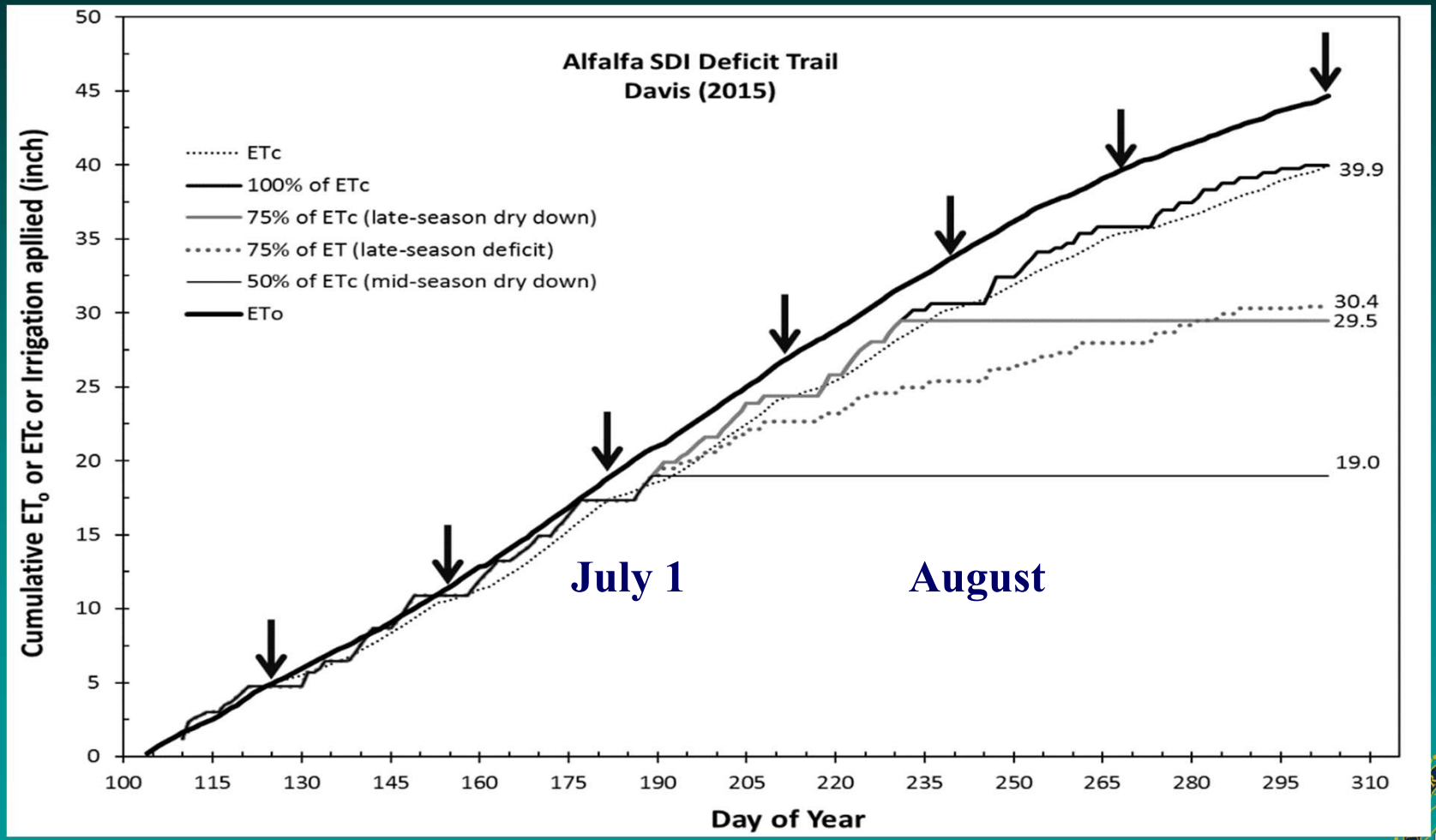
Regulated Deficit Irrigation

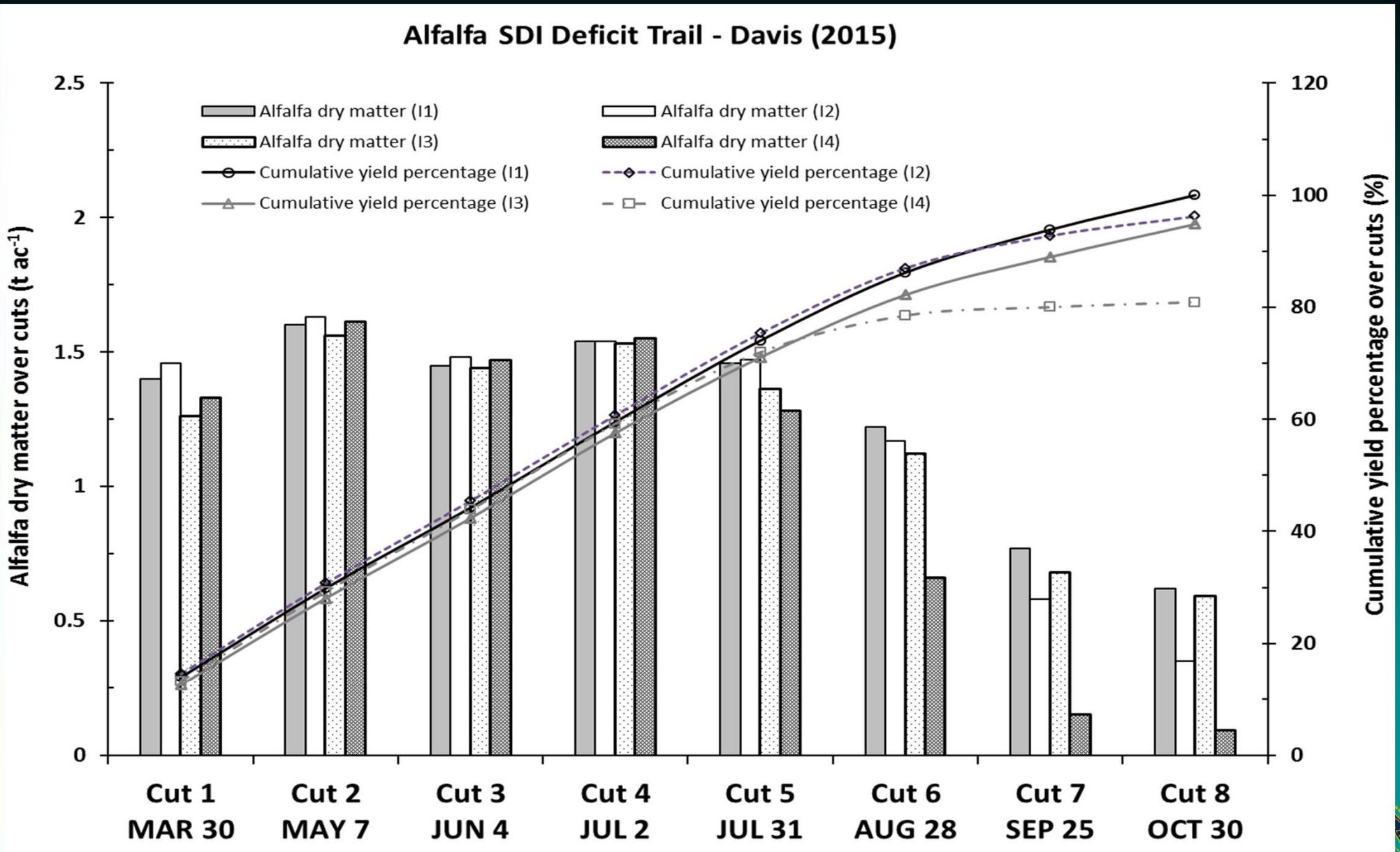
LOGIC:

- ET is highest in summer
- Yields decline late summer
- WUE is lowest mid summer-fall
- Produce a full crop early, then dry down?



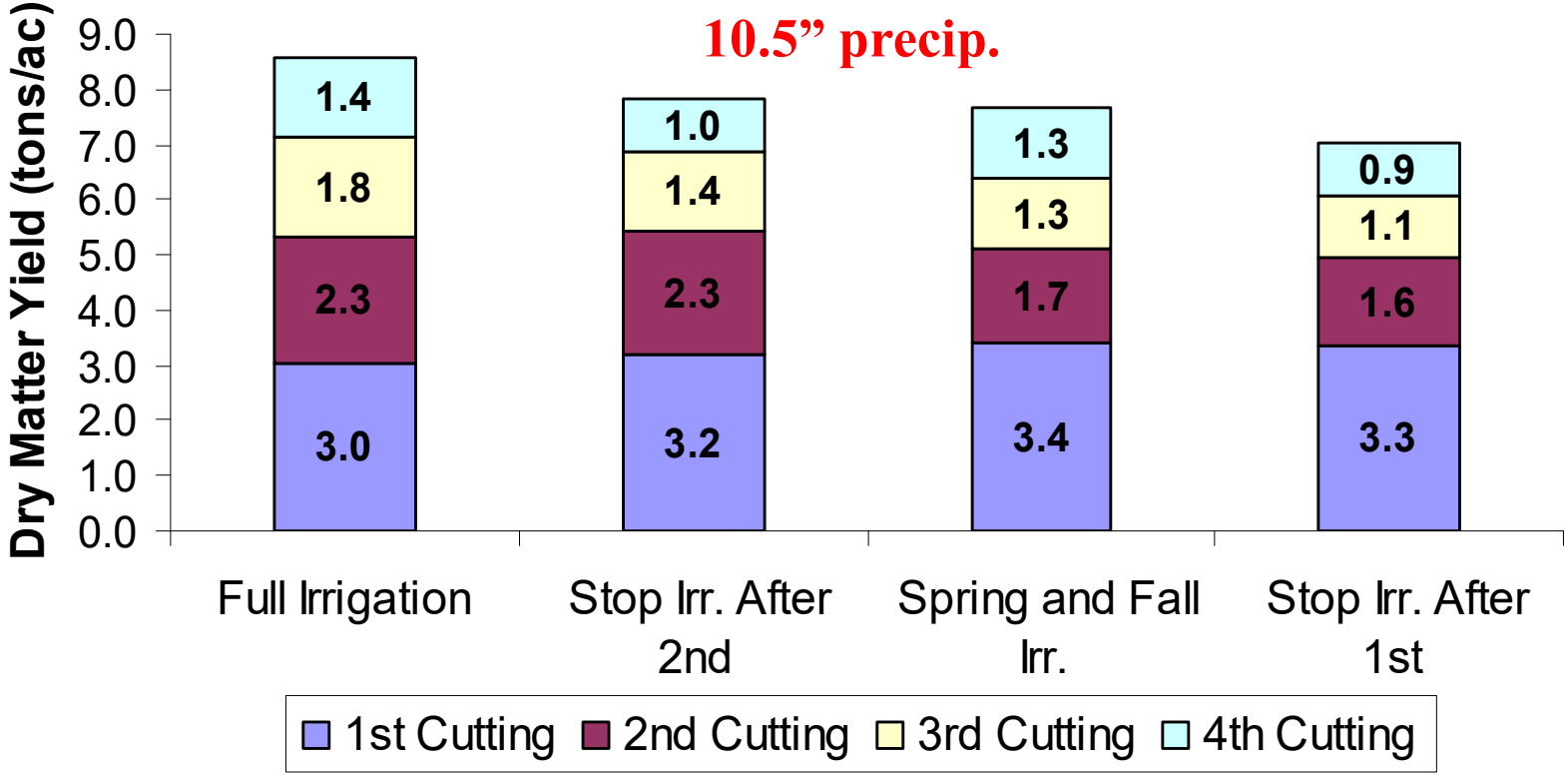
Deficit Study, Davis (2015-2018




Alfalfa SDI Deficit Trail - Davis (2015)
Alfalfa dry matter (I1)
Alfalfa dry matter (I2)
Alfalfa dry matter (I3)
Alfalfa dry matter (I4)
Cumulative yield percentage (I1)
Cumulative yield percentage (I2)
Cumulative yield percentage (I3)
Cumulative yield percentage (I4)
Alfalfa dry matter over cuts (t ac-1)
Cumulative yield percentage over cuts (%)
2.5
2
1.5
1
0.5
0
120
100
80
60
40
20
0
Cut 1 MAR 30
Cut 2 MAY 7
Cut 3 JUN 4
Cut 4 JUL 2
Cut 5 JUL 31
Cut 6 AUG 28
Cut 7 SEP 25
Cut 8 OCT 30

2007Alfalfa Yields Berthoud, CO

Irrigation	21.3”	9.5”	10.4”	2.7”
Total Yield	8.5 tons/ac	7.9 tons/ac	7.7 tons/ac	6.9 tons/ac

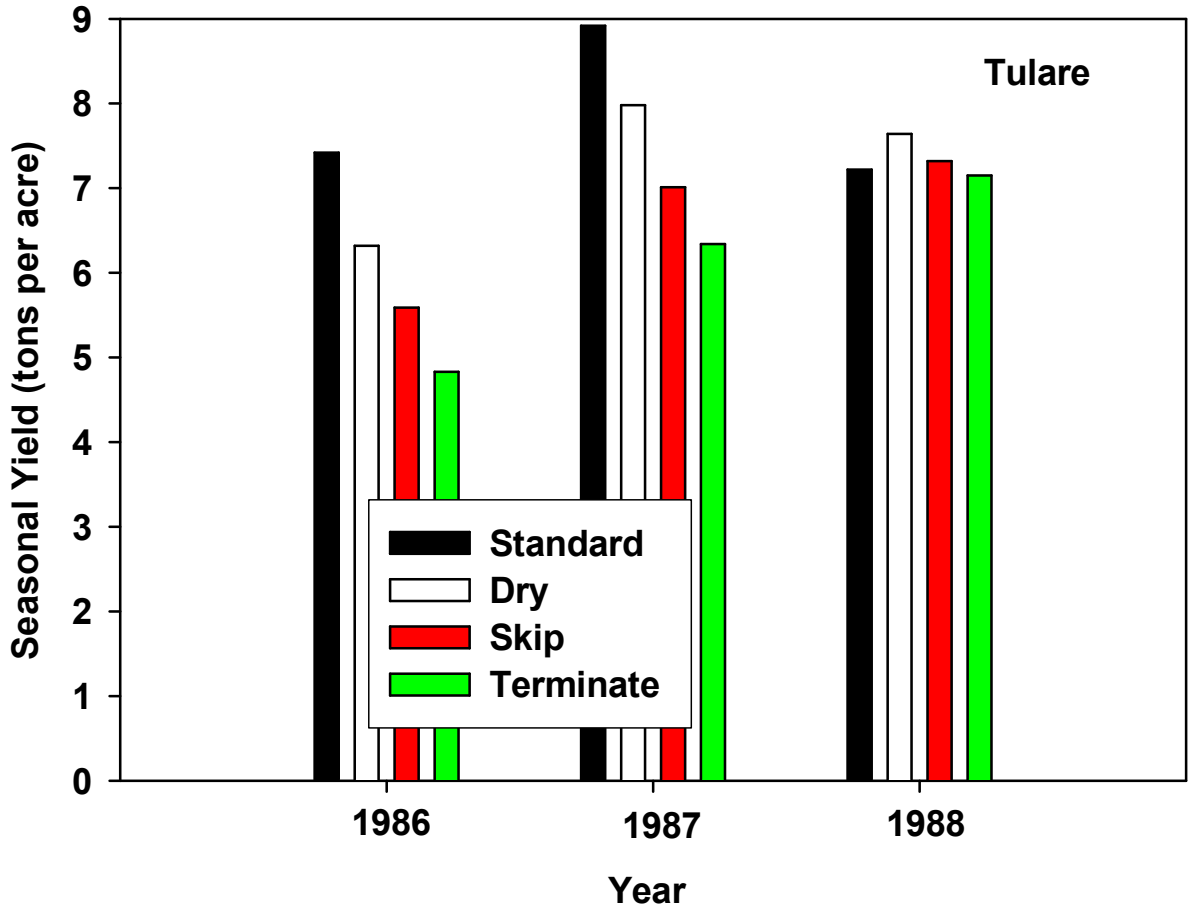


J. Brummer et al., 2017

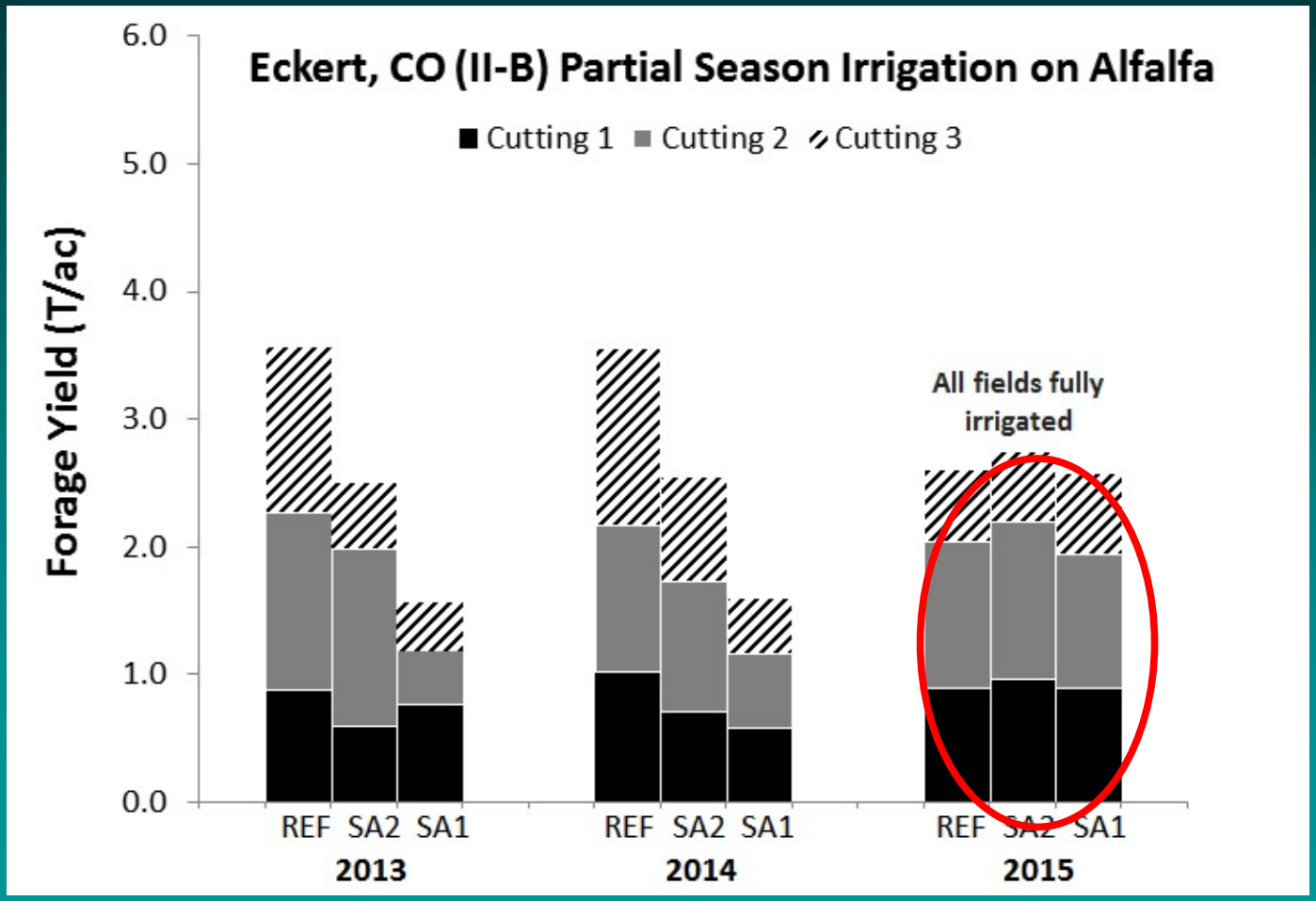
Does Alfalfa Recover after Deficits?

- Yes, generally
- Depends upon soil type
- Early irrigation patterns
- Cracking clay soils more challenging

Fresno Co., CA


Tulare
Seasonal Yield (tons per acre)
0
1
2
3
4
5
6
7
8
9
1986
1987
1988
Year
Standard
Dry
Skip
Terminate

Impact of 2 Years of Treatment and 1 Year of Recovery on Alfalfa Yield – Eckert, CO



J. Brummer, 2017

How important is early irrigation during drought?

- **VERY!!**

ALFALFA & FORAGE NEWS

UC ANR

News and information from UC Cooperative Extension about alfalfa and forage production.

UCANR: Building climate-resilient communities and ecosystems

SHARE | PRINT

Drought coming? Start irrigation early! – For alfalfa, you need to fill that soil profile!

Author: Umair Gull
Author: Rachael Long
Author: Isaya Kisekka
Author: Khaled Bali
View More...

Published on: March 19, 2021

Looking a little dry out there?

January and February of 2021 were some of the driest months on record, with near Zero (1.7") precipitation in Northern California. Things don't look good for summer. What can alfalfa growers do under these conditions?

Drought Coming. Currently much of the Southwest US is under 'extreme' to 'exceptional drought', depending upon the region (Figure 1). A key issue for many regions is snow pack – which currently is at about 60% of normal. Although we've had some recent precipitation, the trend is for relatively low rainfall for the rest of the month of March. Allocations of surface water to the large irrigation districts are scheduled to be a fraction of normal in 2021.

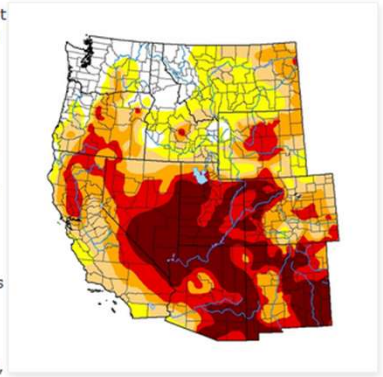


Figure 1. Drought Conditions in SW US (USDA, NOAA, Nat'l Drought monitoring Center, Lincoln, NB. March 16, 2021.

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- Yes indeed.

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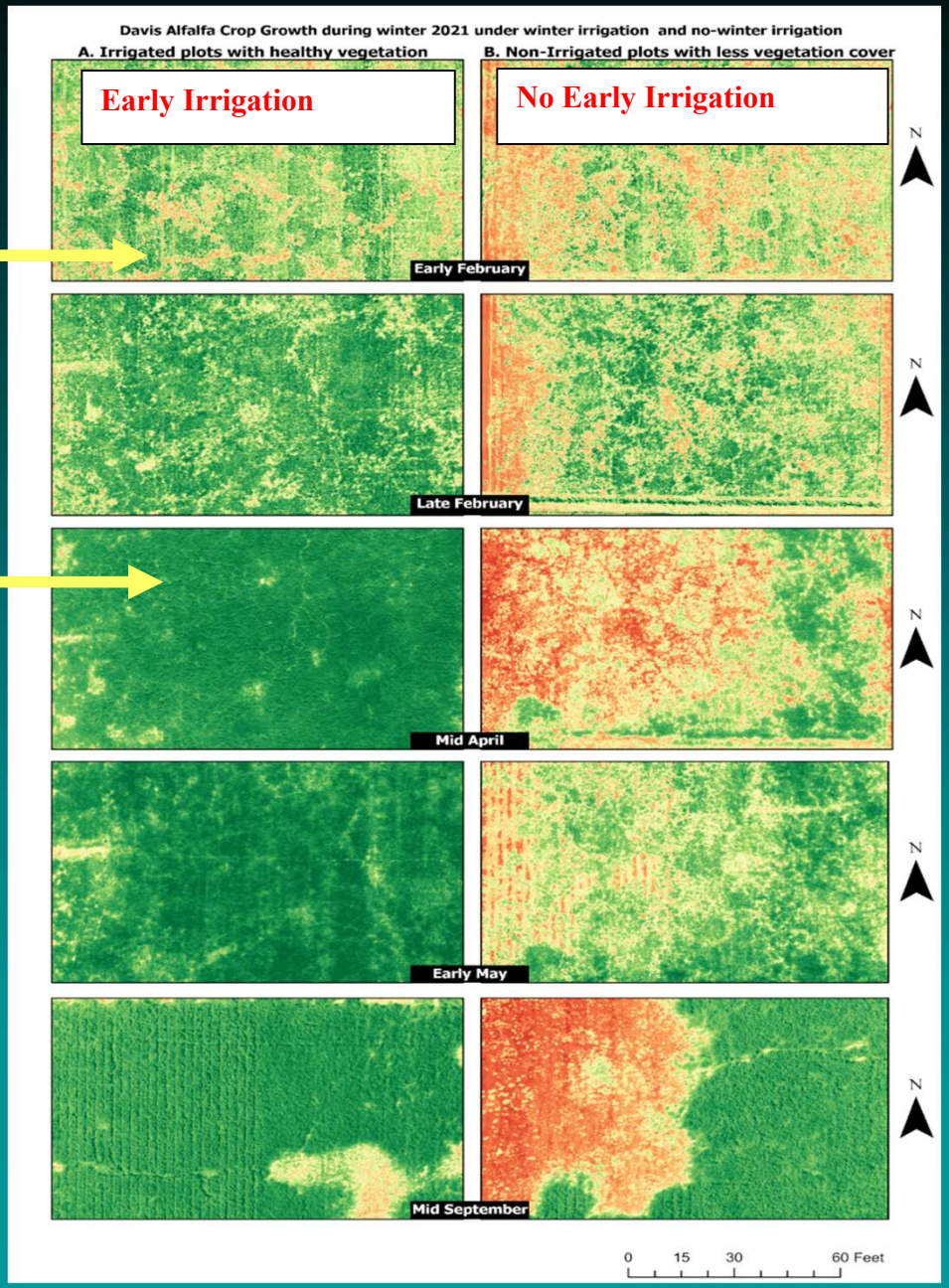
- January 2022
- October 2021

Irrigation:

Irrigation:



Deficit Irrigation Strategies

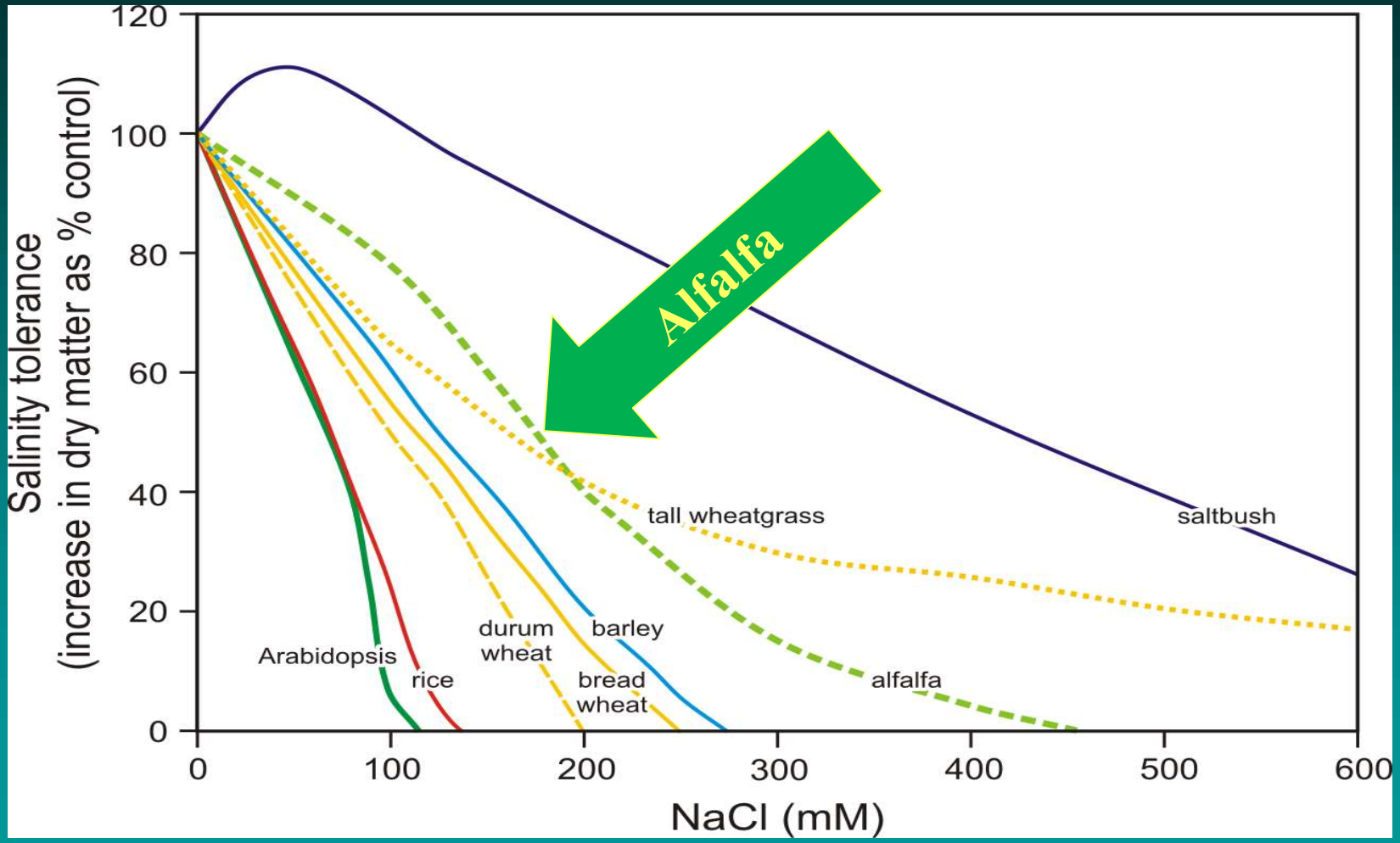
- Partial season irrigations are viable to sustain alfalfa production during drought periods, or for water transfers
- Yields are reduced, but generally the crop recovers for the following year.
- How to manage?
  - Full irrigation followed by 'cold turkey' cutoffs recommended

Biological Advantages of Alfalfa (Salinity Tolerance)

- Five-year old alfalfa variety trial after two years of season-long drought conditions under high salinity, 2013 and 2014 (Western Fresno County, CA).

Photo taken Nov. 2014 after a single irrigation – plants mostly recovered

Advantages of Alfalfa: Salinity tolerance
(Australian work)



Munns & Tester, Ann Rev Plant Biol, 2008

Salinity Effects on Alfalfa over 4 Years (Fresno County)

Table 1. Effect of salinity on yield, average of 35 alfalfa varieties, over four years, Five Points, CA, 2017-2020 (planted 3/29/17). Water with ECw of 8 to 11 dS/m was applied to saline plots, and 1-2 dS/m to low saline plots. Soil salinity at the completion of the trial ranged from 12-16 dS/m EC depending upon depth. Unpublished data (D.H. Putnam, UC Davis).

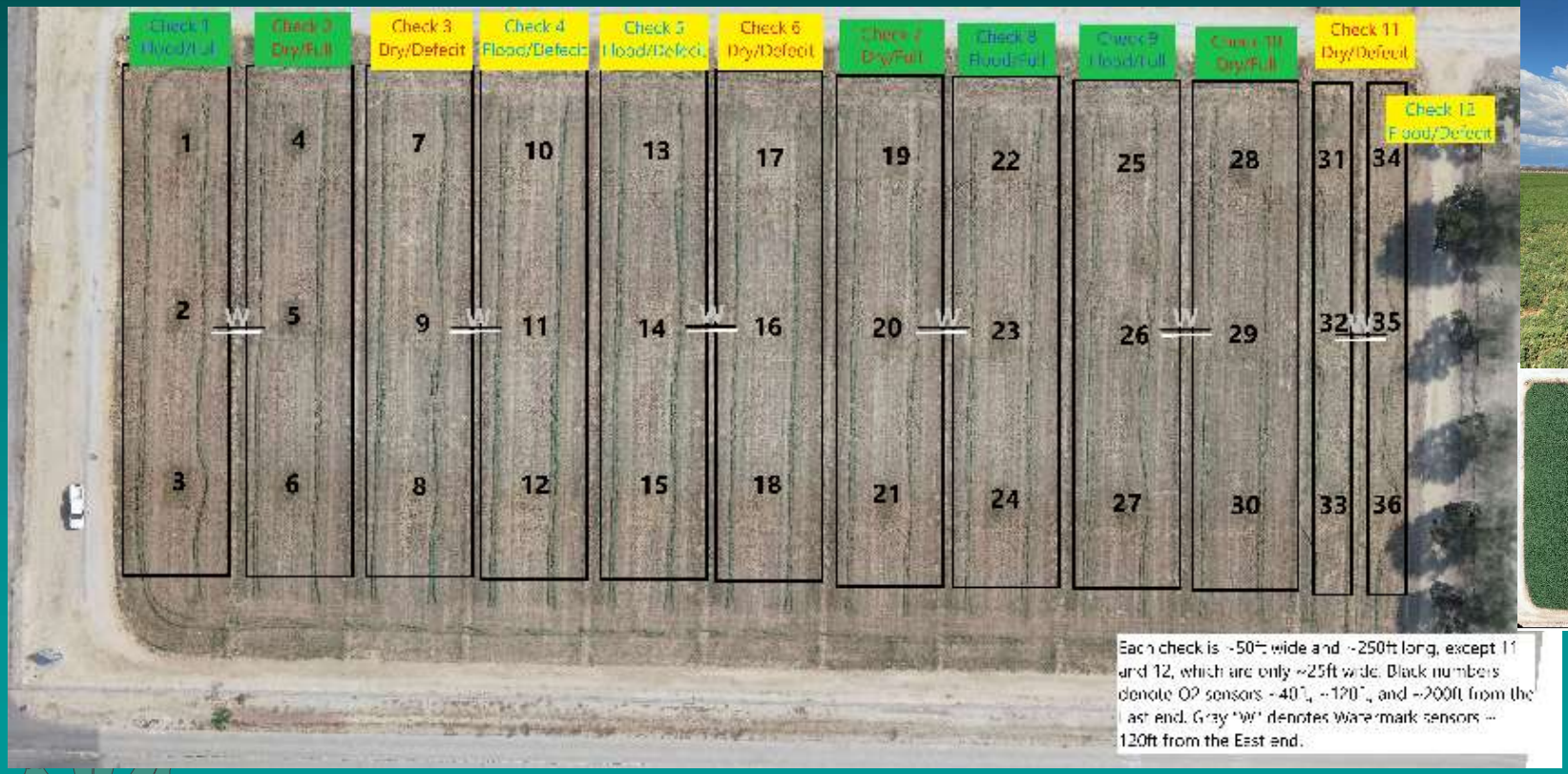
	2017 Season Yield - 4 cuts		2018 Season Yield 7 cuts		2019 Season Yield 8 cuts		2020 Season Yield 7 cuts		Cumulative Average (t/A)	
	Salinity Level									
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
	tons/acre									
Minimum	3.5	3.6	10.2	7.9	11.4	9.9	12.0	7.7	39.0	30.5
Maximum	6.0	5.5	14.6	11.3	16.2	13.3	17.3	13.0	52.7	42.7
Average	4.8	**4.6**	12.3	**9.6**	14.4	**11.5**	**14.7**	**10.2**	**46.1**	**36.1**
Yield loss	**4%**		**22%**		**20%**		**31%**		**22%**	
Treatment Mean	4.7		11.0		13.0		13.0		41.1	
CV%	16.3		16.5		12.8		20.5		10.0	
LSD (p=0.05)	0.2		1.8		1.6		0.6		1.0	

Winter Flood Capture (Flood-MAR)

- Excess flows are often a problem for water managers (releases under floods)
- Capture on soils where deep percolation is possible?
- What system is ideal? (orchards, fallow, forages?) – flood systems needed
- Considerations: damage to crop, nitrate or pesticide impacts, conduit to groundwater

Surface Irrigation and Groundwater Recharge on alfalfa (2020, 2021 and 2022)) (Bali Et al.)

- Irrigation treatments during the growing season (April-November, 2019, 2020, and 2021):
  - Full irrigation and Deficit irrigation after August cutting
- GW recharge treatment: Intermittent winter flooding (1 day/week 2019 and 2020 and 2 days/week in 2021) and no flooding
- Replicated three times (yield, O_2 level in soil, moisture content, ETa, etc)

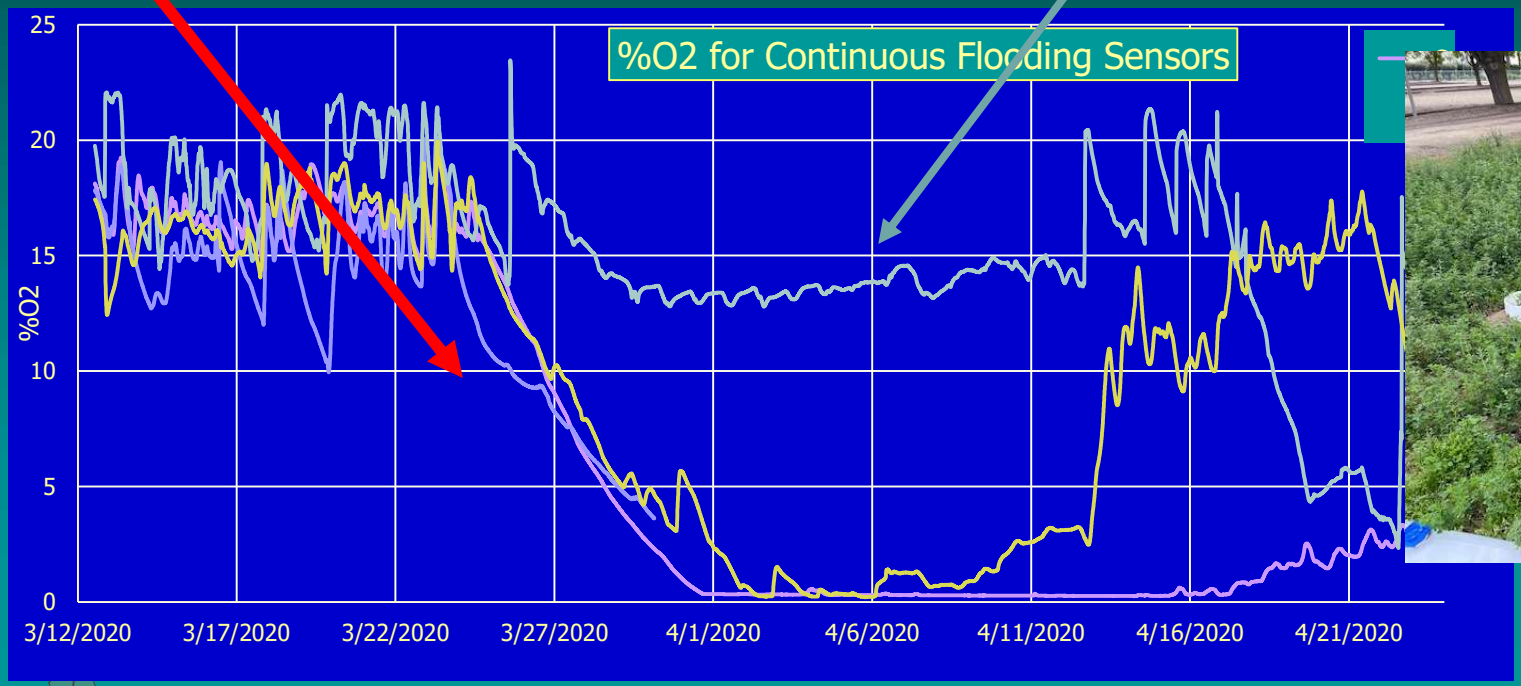


Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand) (Bali et al.)

- Continuous flooding: reached 5% O_2 level in 5-7 days

$\%O_2$ level continuous flooding

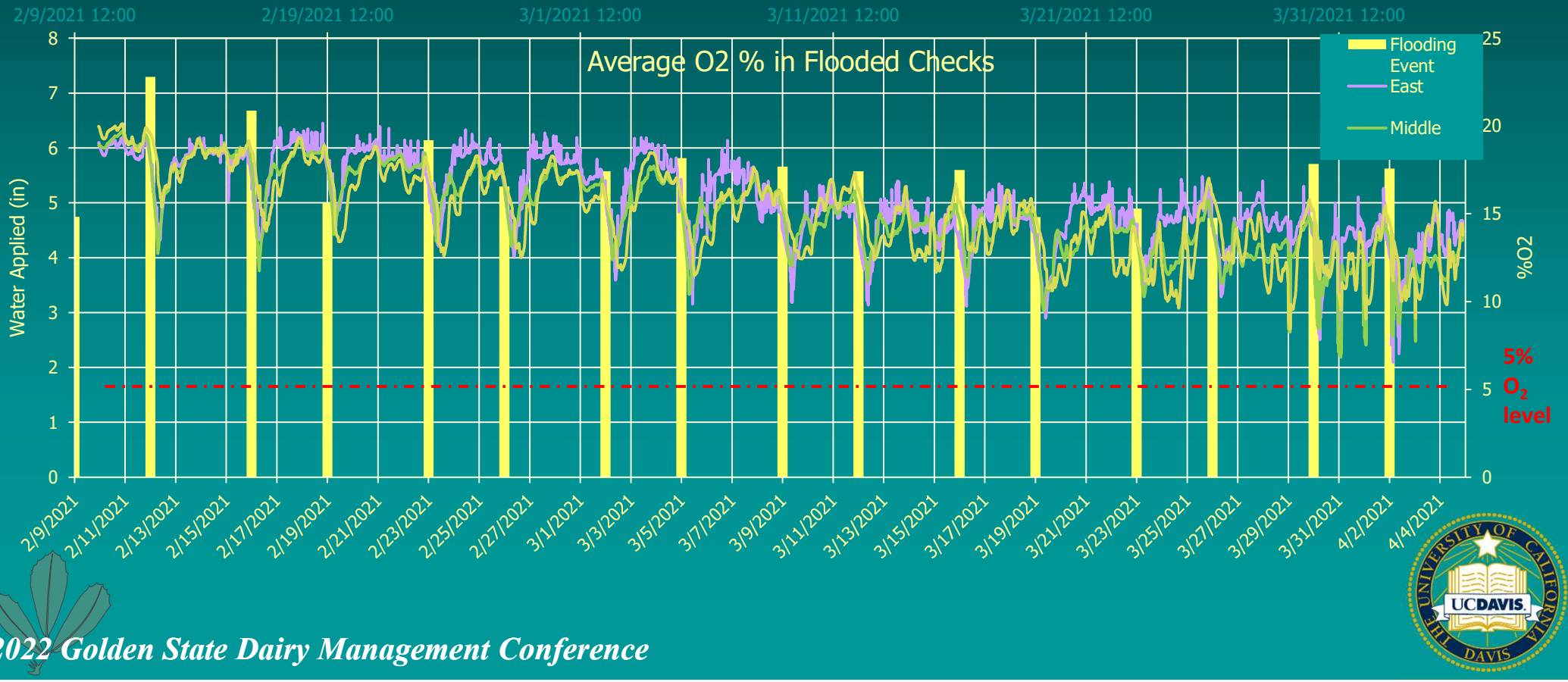
$\%O_2$ level control (no flooding)



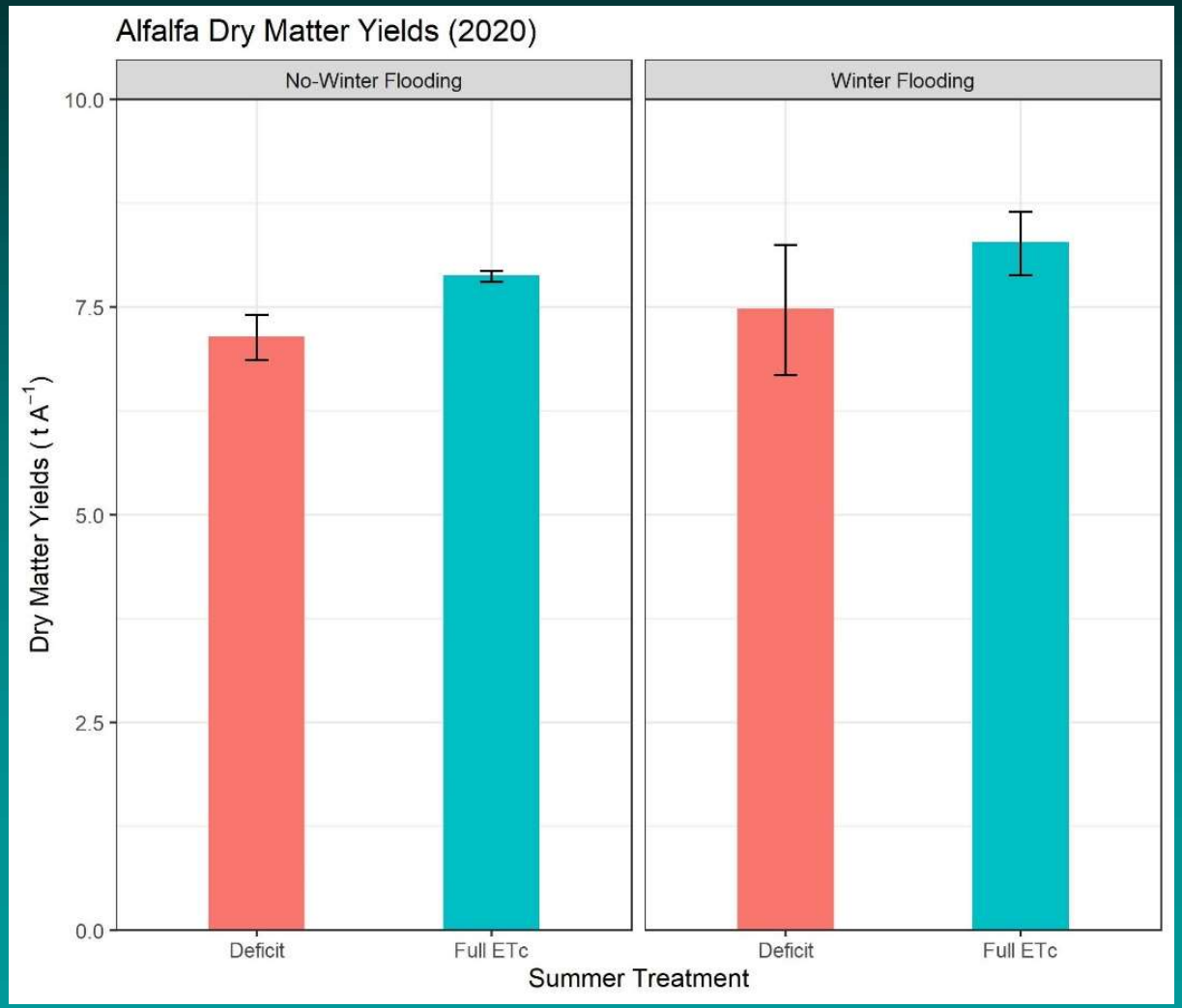
Surface Irrigation and Groundwater Recharge on alfalfa (2021)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 7”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- Data from UC Kearney Research and Extension Center:

2021; **~89 inches** of recharge in 16 irrigation events over a 7.5 week period (~12”/week)



Early Watering Advantages of Alfalfa: Flood-MAR (managed aquifer recharge)



Excess Water (Ohio, 2019, 52” rain)

Tile drains

Drainage, Drainage, Drainage

Photo: Sam Custer, OSU Extension
and Jacob Wuebker of Wuebker Farms

Photo: Jeff Stachler
OSU Extension

Winter Flooding Take-home

- Winter Flooding (Flood-MAR) highly feasible with alfalfa on high infiltration soils
- 6-12 AF/A, depending
- 'Pulsed' not continuous applications
- Biggest risk is O_2 deprivation, timing (7"/week OK, December-April).
- Filling early profile may benefit early yields
- Alfalfa: protection from nitrate leaching
- Linkage with SGMA

Summary

- Alfalfa has some unique biological values to provide resilience with variations in Water supply
  - Ability to be ‘dried down’ but produce some yield, saving many AF of water in late season
  - Can be flooded in the winter (carefully) to recharge aquifers and soil profile
  - Salinity tolerance

Thank you

Snow Geese in Alfalfa

http:alfalfa.ucdavis.edu