Irrigation effects on nitrogen efficiency

Growers intuitively understand the link between irrigation management and N management, while accepting that their irrigation management may be less than perfect ...

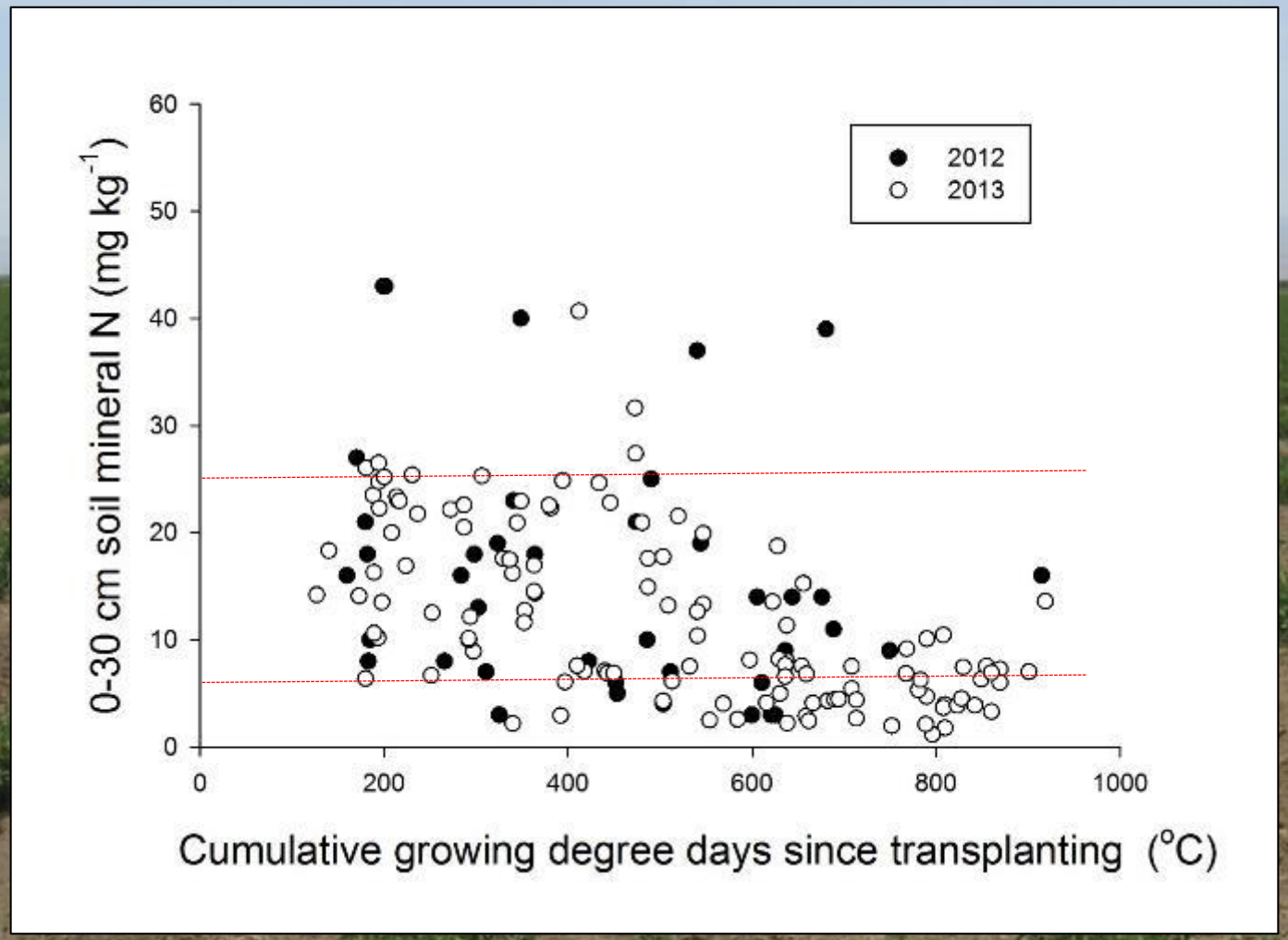
Current trends are pushing improvements:

- N regulation incentivizes more efficient N use ('A/R' metric will reward lower N application rates)
- The Sustainable Groundwater Management Act (SGMA) will incentivize irrigation efficiency (basin overdrafts will be limited)

What is the scale of potential NO_3-N leaching losses with inefficient irrigation ?

- Depends on the soil NO_3-N concentration

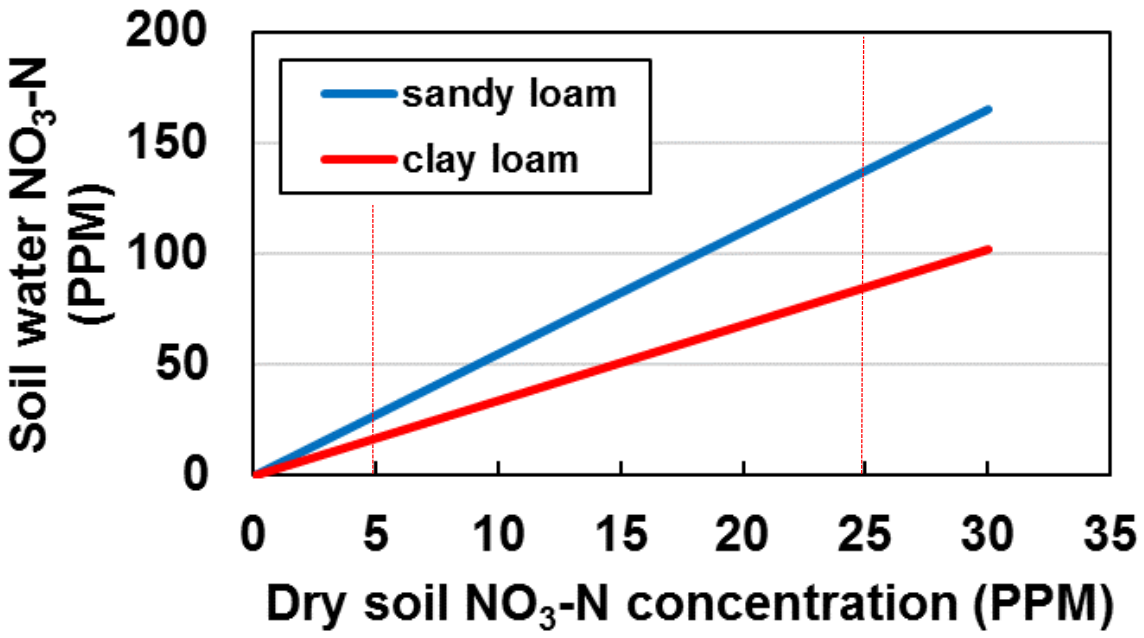
Dry soil NO_3-N concentration, 37 *organic* processing tomato fields

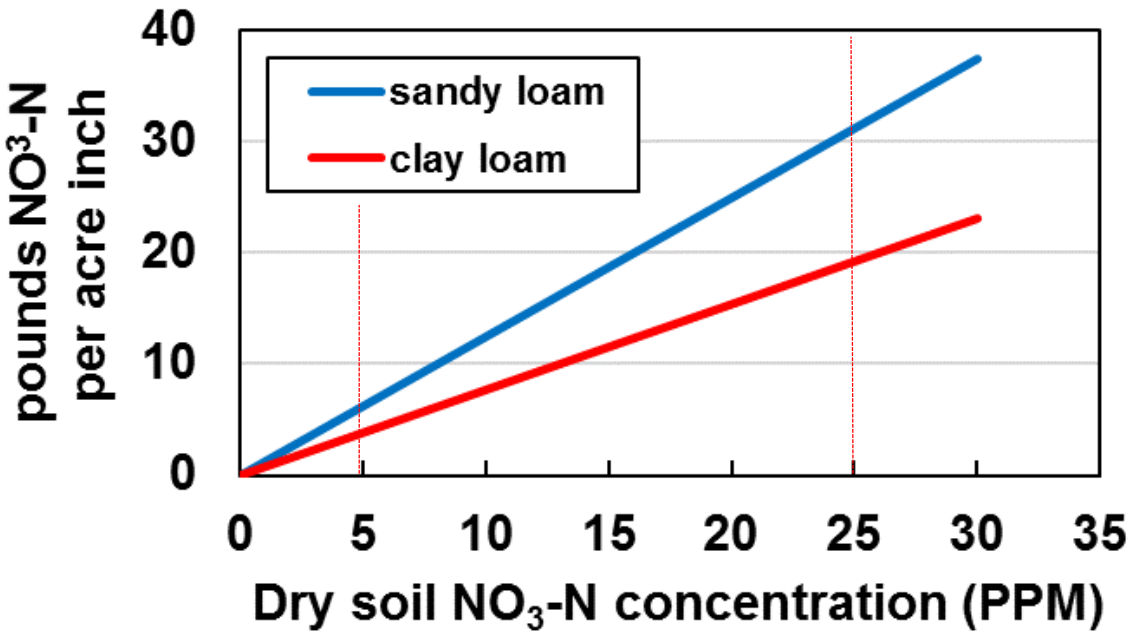


Source: Castro Bustamante and Hartz, 2015. HortScience 50:1055-1063.

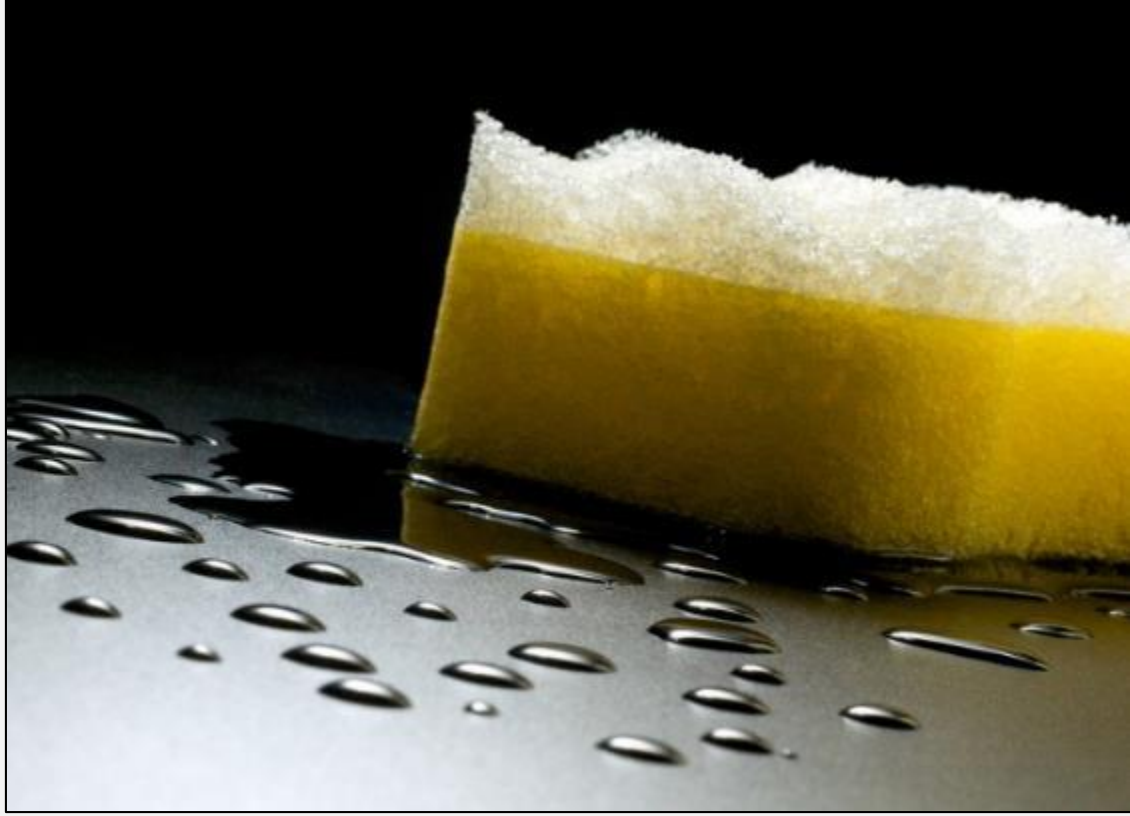
What is the scale of potential NO_3-N leaching losses with inefficient irrigation ?

- All NO_3-N is in the soil solution, which weighs much less than the dry soil; this has a concentrating effect





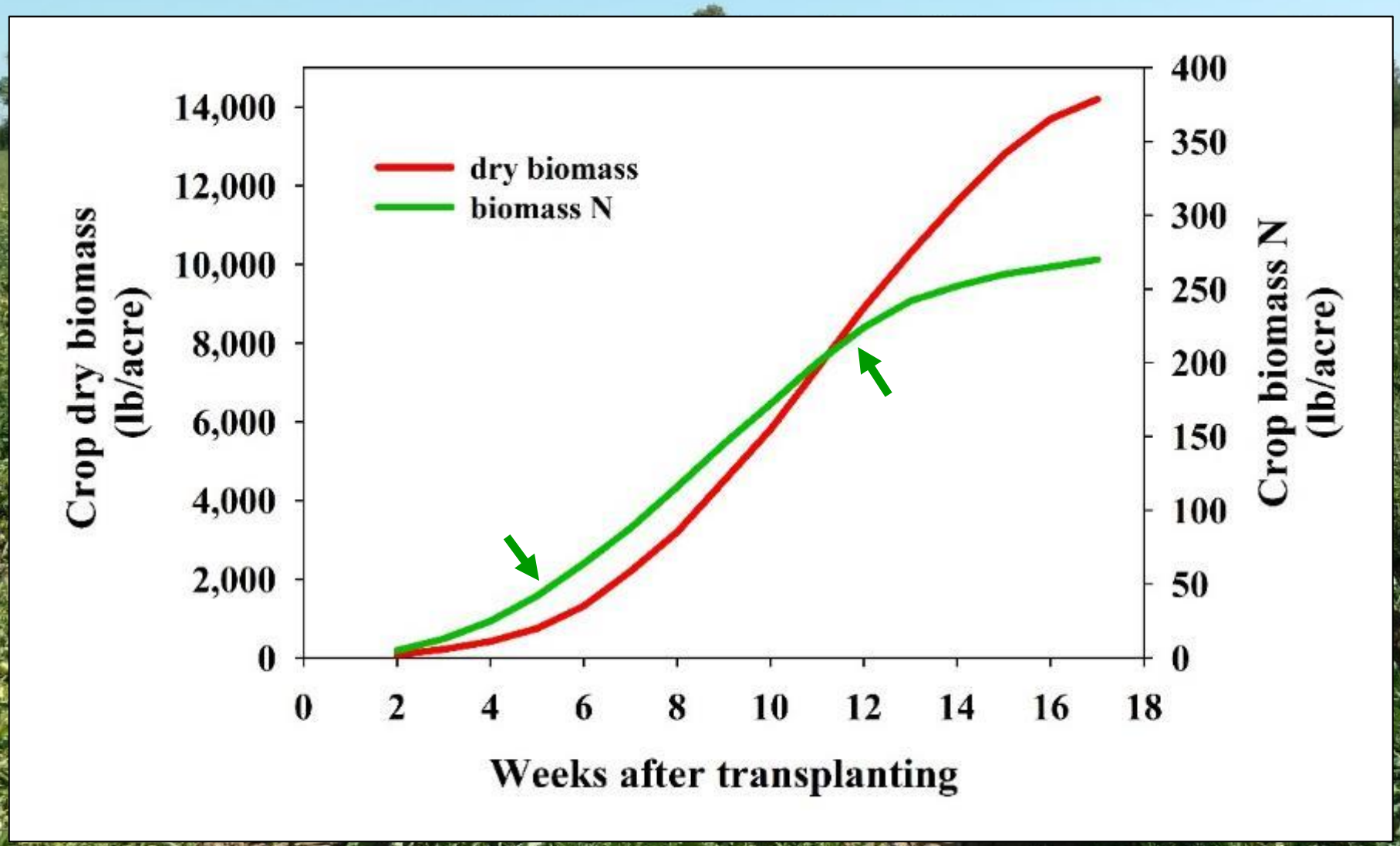
An inch of leaching can carry > 10 lb N/acre



Importance of N '*residence time*' in the root zone:

- **Plants do not soak up N like a sponge; rather, N is taken up selectively, *as needed*, to support new growth**
- **Therefore, applied N must remain in the active root zone for an extended period to be efficiently utilized**

Plant growth and N uptake are linked:



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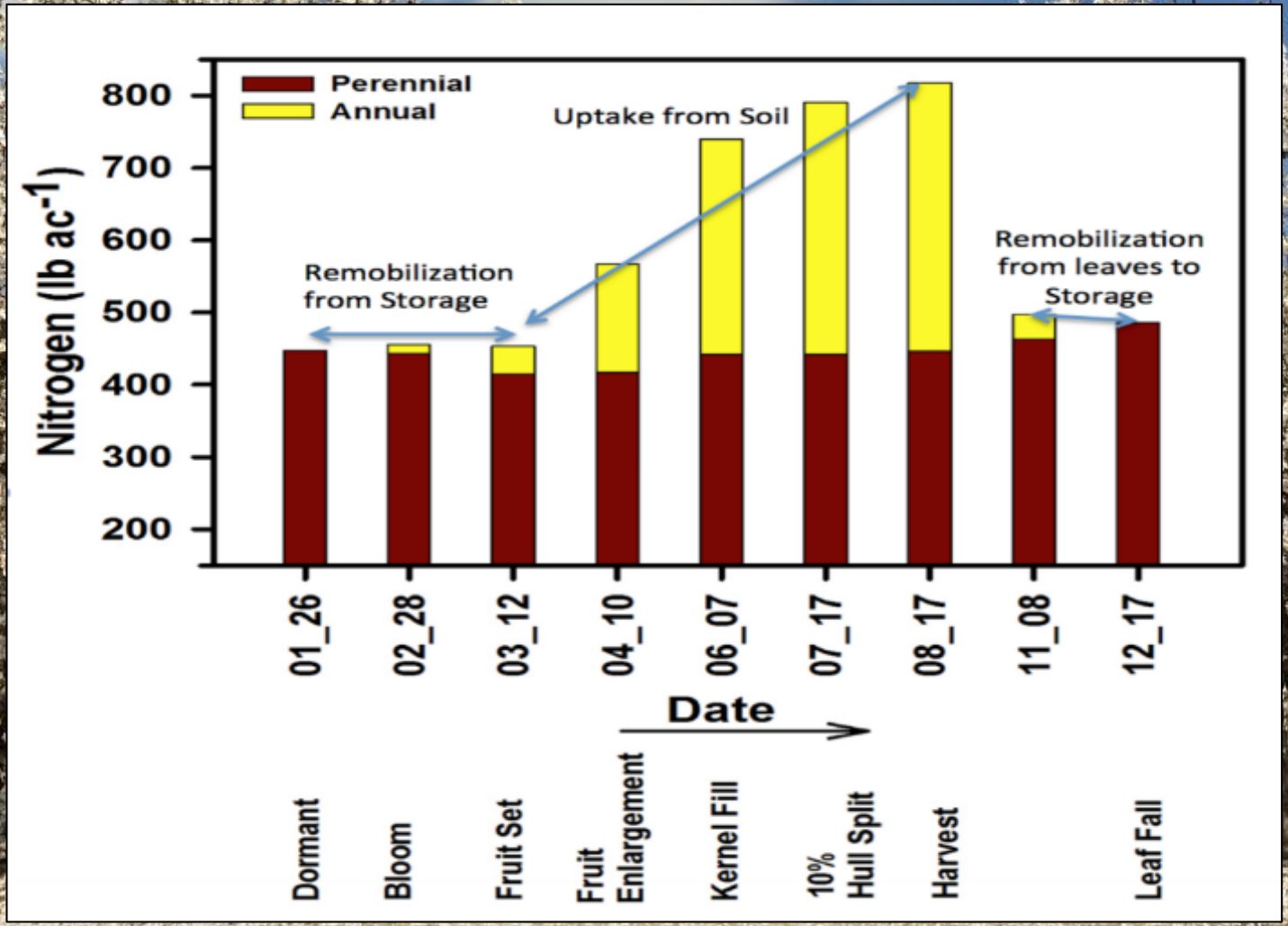


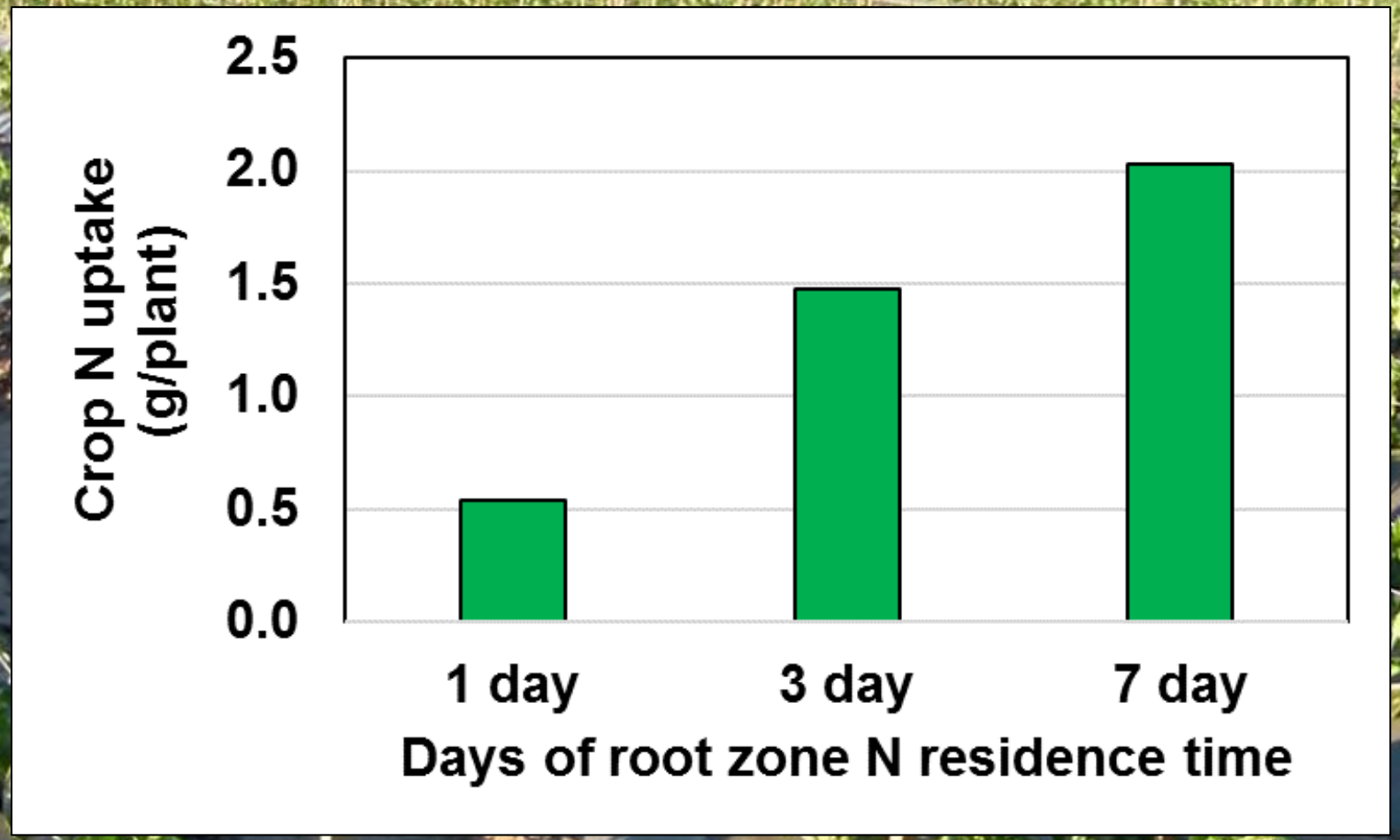
Crops vary in peak N uptake rate:

- Pounds of N per day per acre during rapid growth

Low (< 3 lb/A/d)	Medium (3-5 lb/A/d)	High (> 5 lb/A/d)
Almond	Cotton	Corn
Citrus	Lettuce	Cole crops
Grape	Melon	High-density leafy greens
Pistachio	Tomato	
Walnut		

The typical N fertigation takes many days (and multiple irrigations) to be taken up by the crop

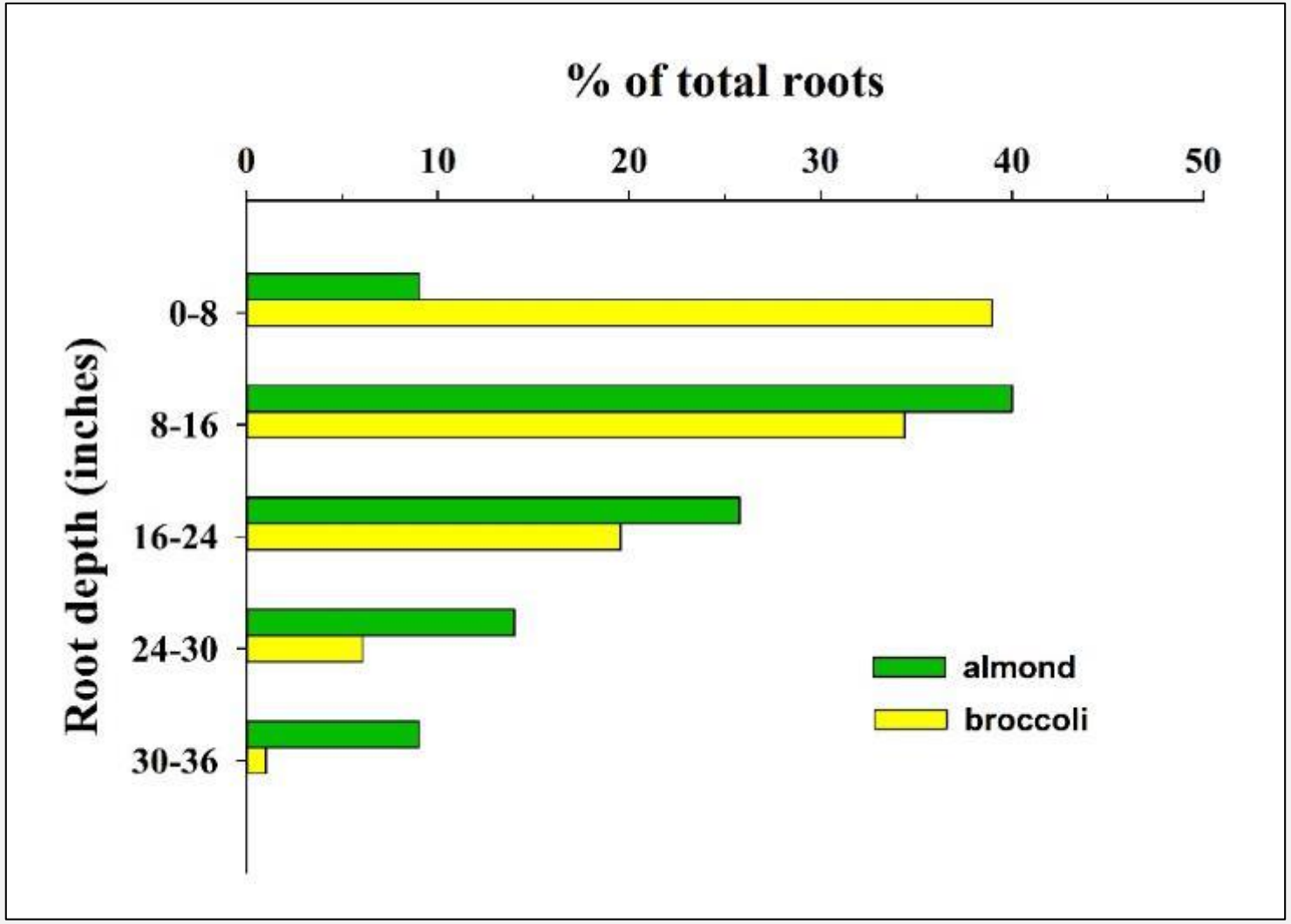
Residence time of fertilizer N is important :
Florida pepper study
- Weekly NO_3-N fertigations, with a leaching irrigation applied 1, 3 or 7 days later



Reference: Scholberg et al., 2009. Comm. Soil Sci. Plant Anal. 40 (13-14): 2111-2131.

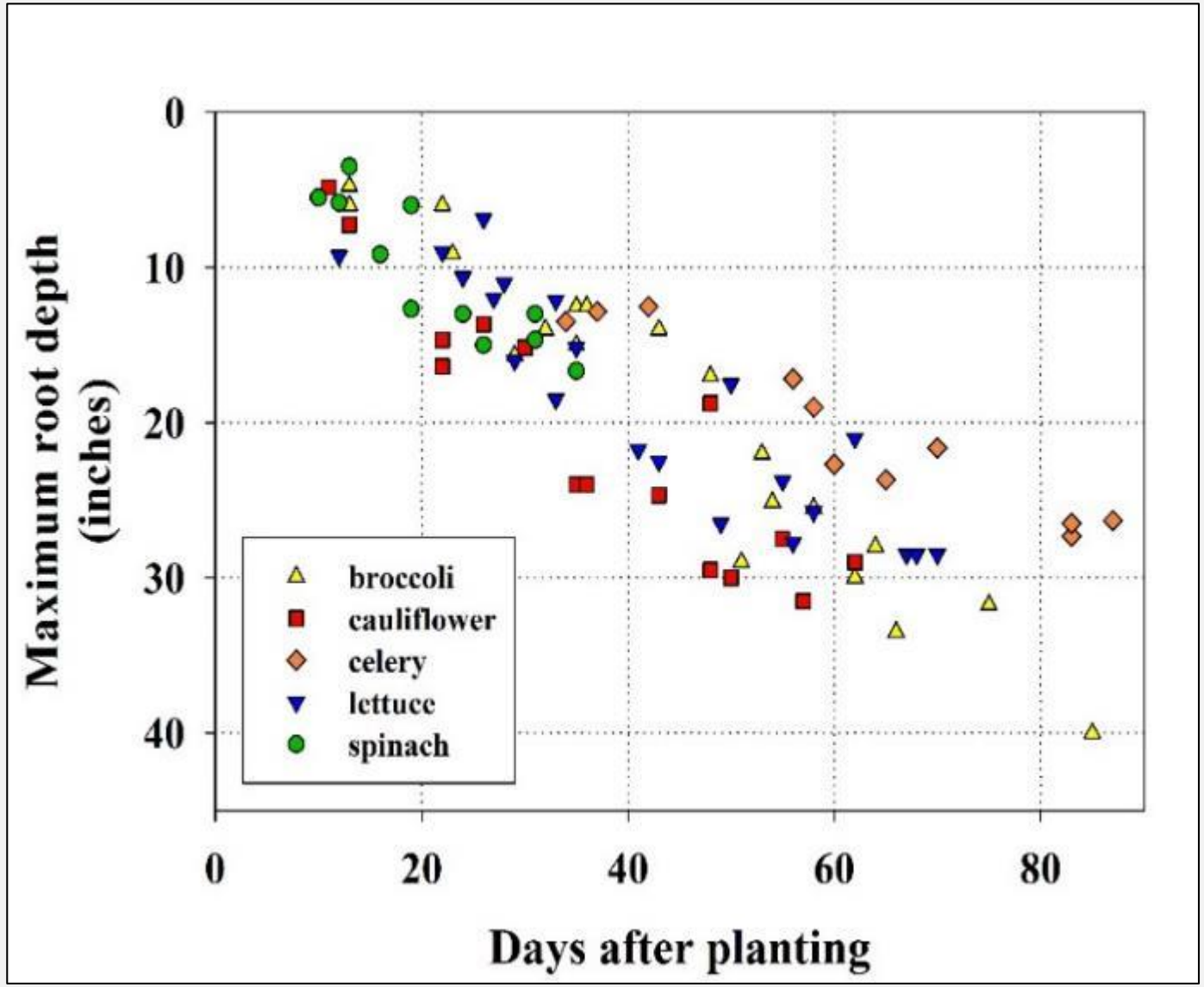
Efficiency of N recovery declines with soil depth:

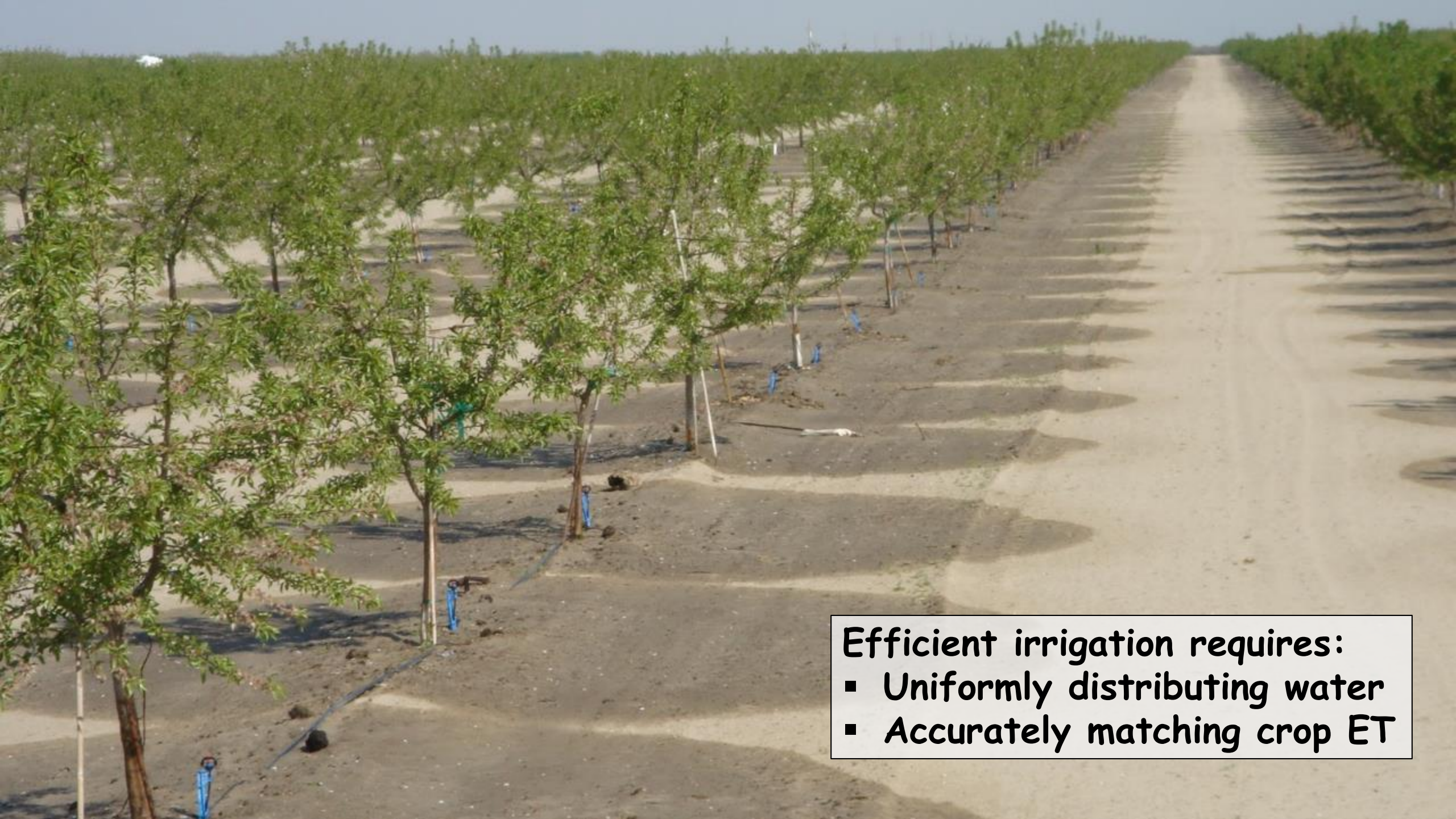
≈ 75% of roots in top half of the root zone



Rooting depth a function of time

- N leaching especially problematic early in the season



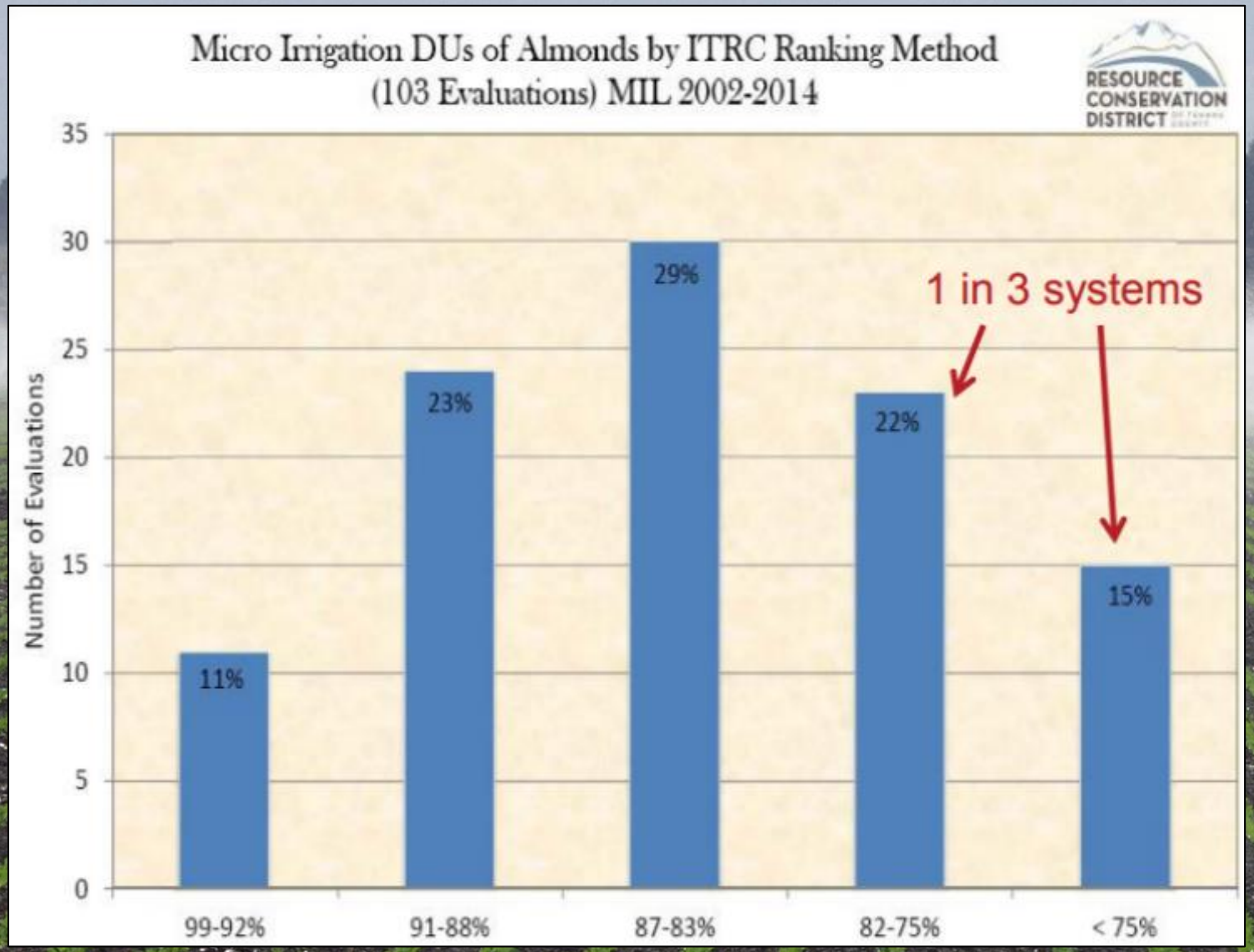


Efficient irrigation requires:

- Uniformly distributing water
- Accurately matching crop ET

Distribution uniformity (D.U.)

% D.U. = (inches applied to driest quarter of field / field average inches applied)*100



Source: Allan Fulton, UCCE

N efficiency is impossible with poor irrigation efficiency:

Why Care about DU?

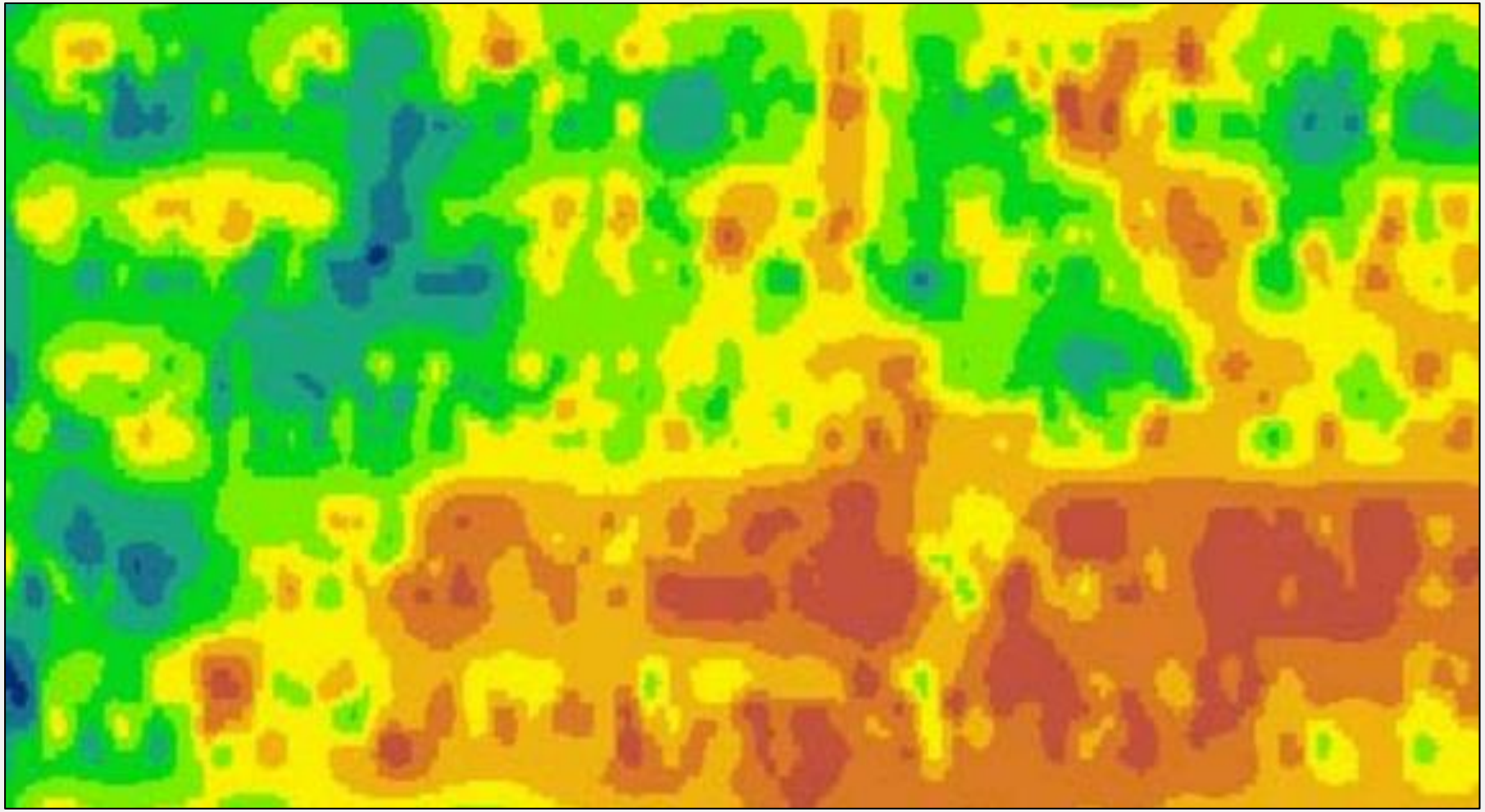
Example: Target application 1.0 inch water

DU	Water Applied High ¼ of orchard	Water Applied Low ¼ of orchard	Difference across orchard one irrigation	Difference thirty irrigation cycles
	---------- Inches applied			----------
90	1.12	0.90	0.22	6.6
80	1.27	0.80	0.47	14.1
70	1.42	0.70	0.72	21.6

Source: Allan Fulton, UCCE

How about variability in crop water use ?

- crop performance is spatially variable, but our ability to quantify that variability has been limited



How about variability in crop water use ?

THE SOUTHERN SAN JOAQUIN VALLEY MANAGEMENT PRACTICES EVALUATION PROGRAM

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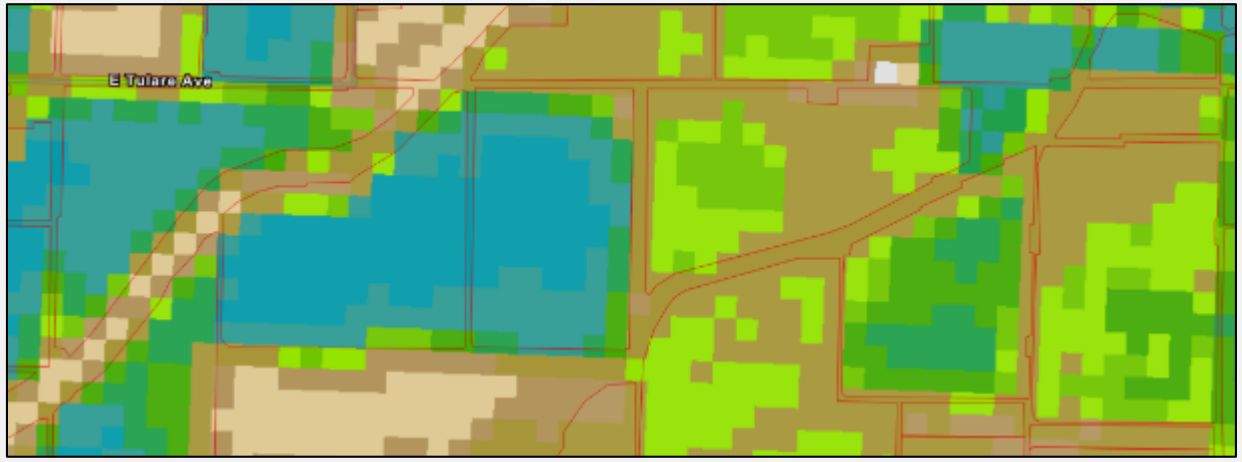


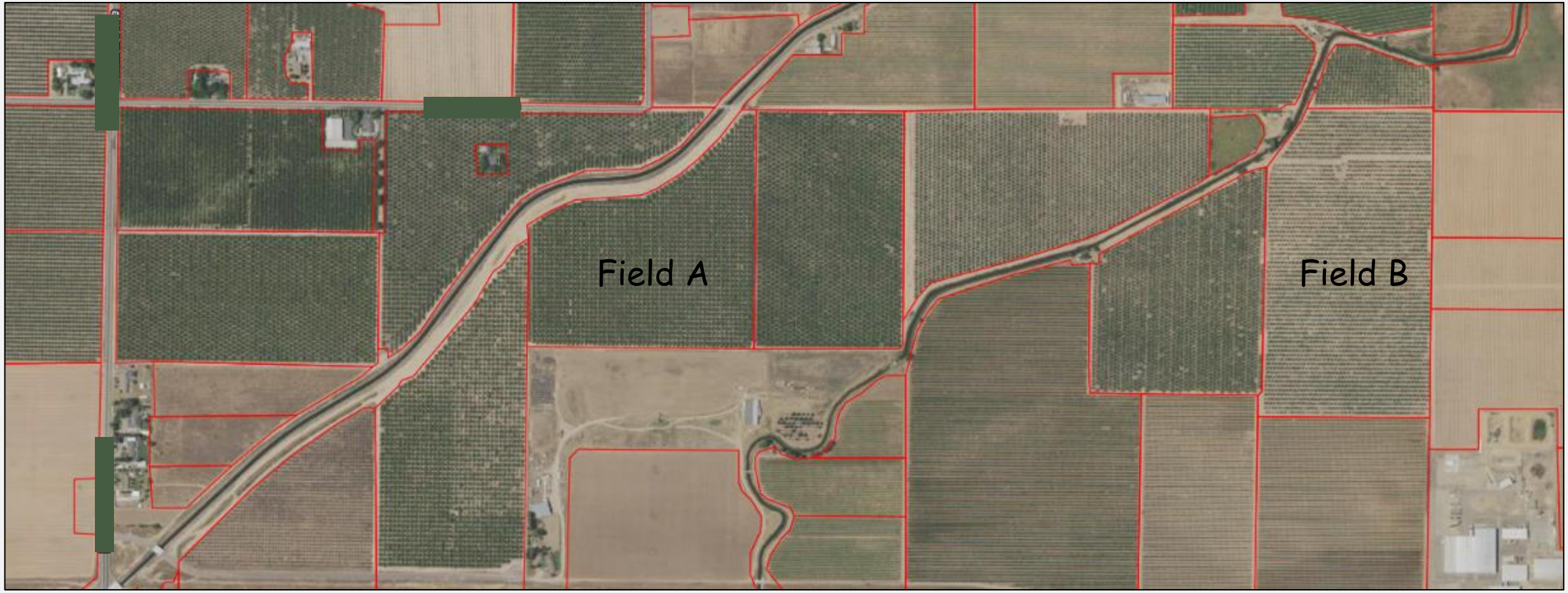
Actual crop evapotranspiration (ET_a):

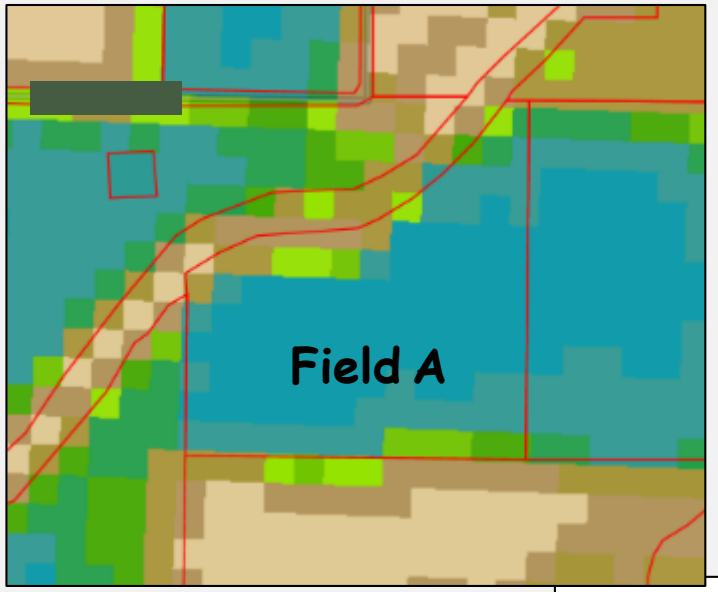
- 30 m spatial resolution satellite data, augmented by spatial CIMIS
- Statewide field-by-field ET_a data from 2010-2017

2014 May - October ETa (depth in inches)

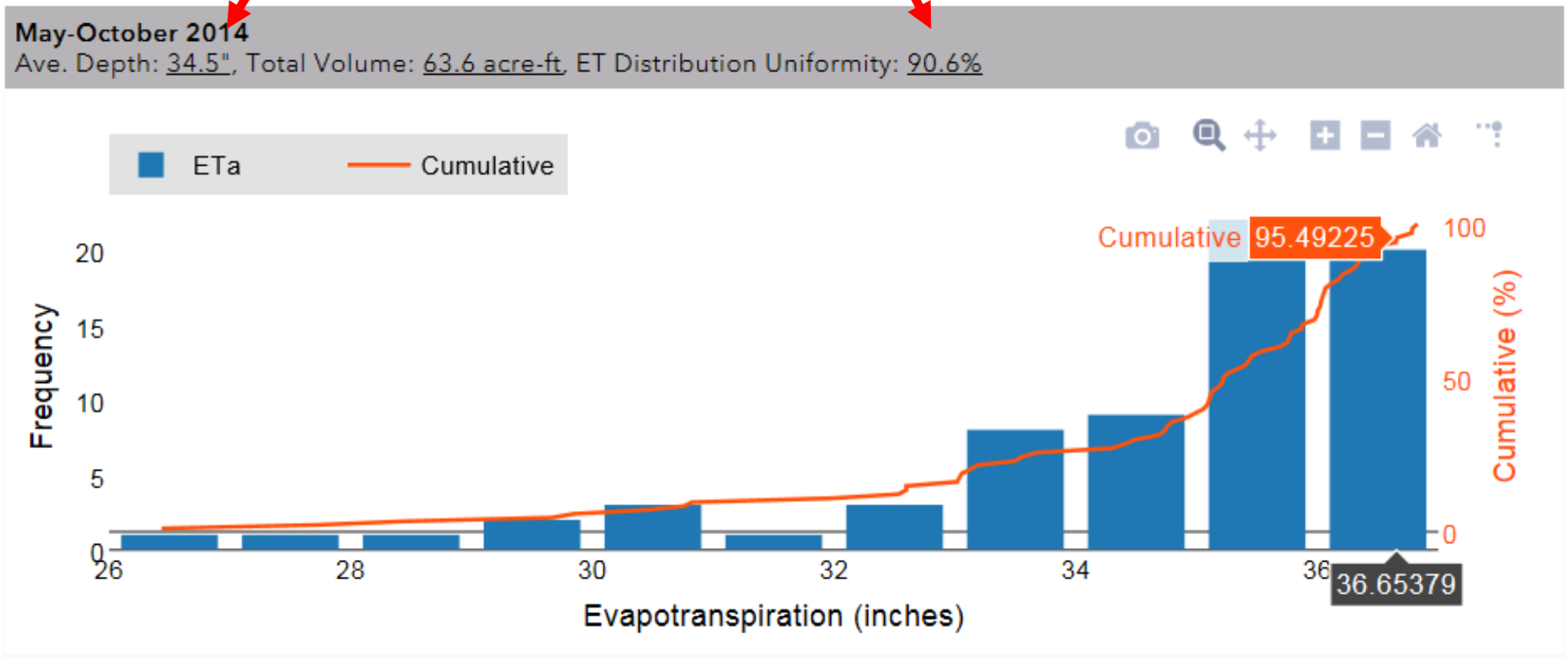
<= 1	<= 30
<= 2.5	<= 35
<= 5	<= 40
<= 10	<= 45
<= 15	<= 50
<= 20	<= 55
<= 25	<= 60

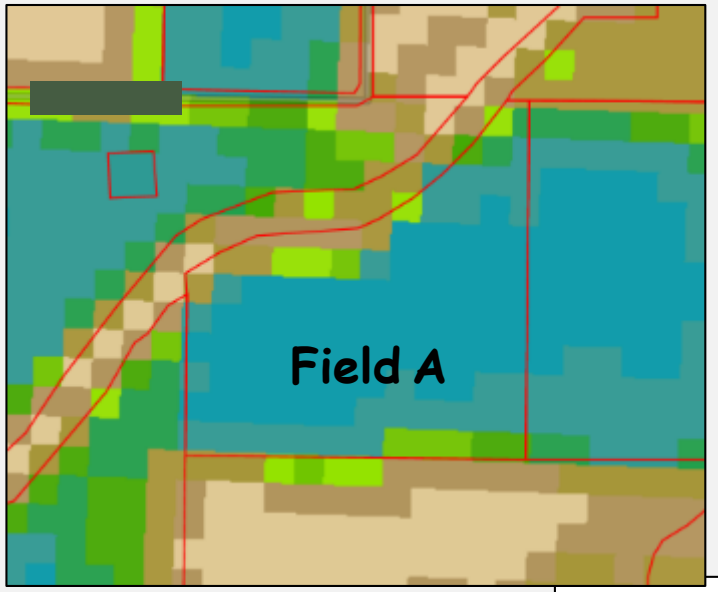
Comparing ET_a in highly uniform and highly variable orchards:





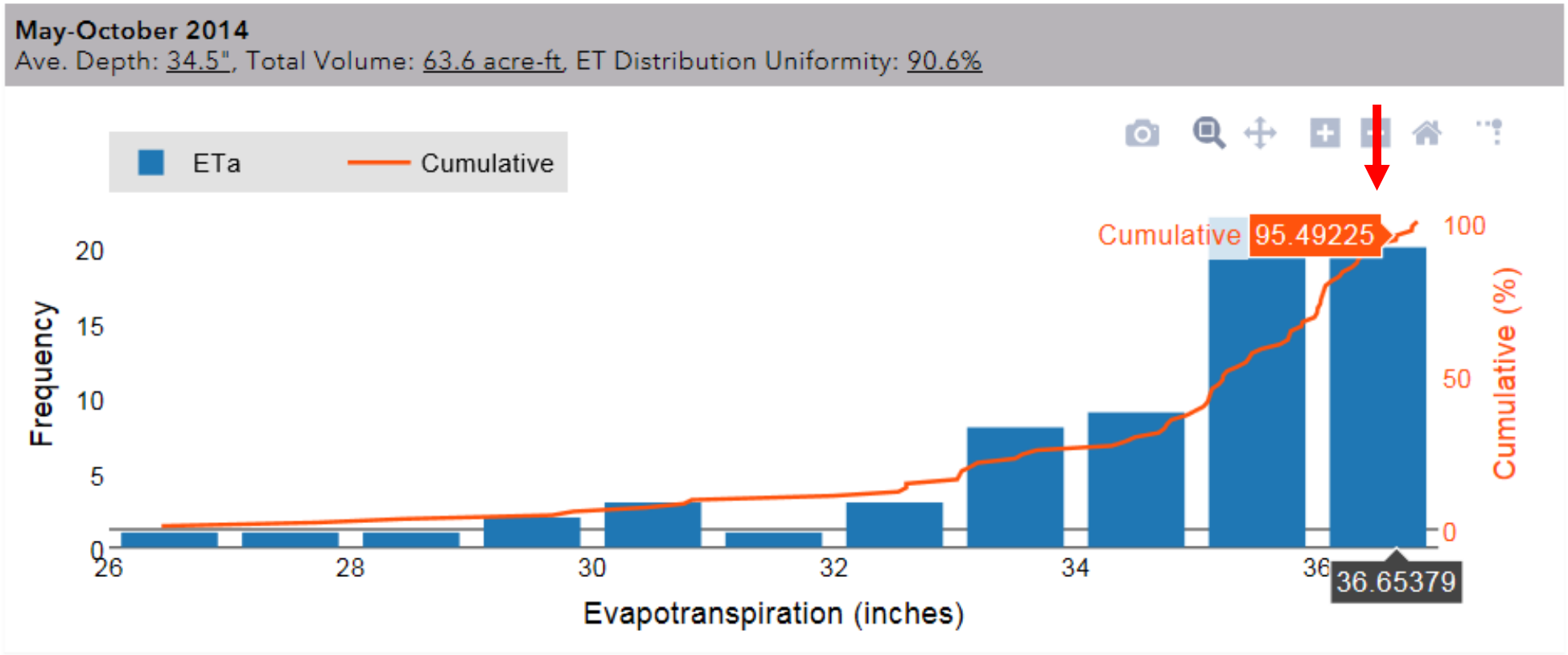
Highly uniform orchard (91% ET_a D.U.)
Mean ET_a = 34.5"

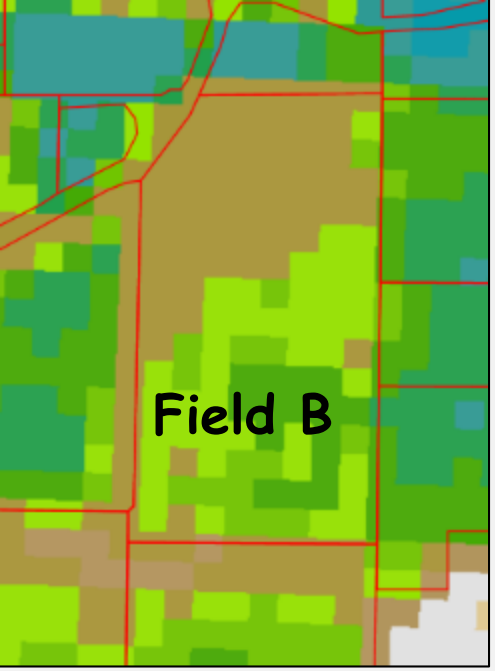




Highly uniform orchard (91% ET_a D.U.)
Mean ET_a = 34.5"
ET_{a95} = 36.7"

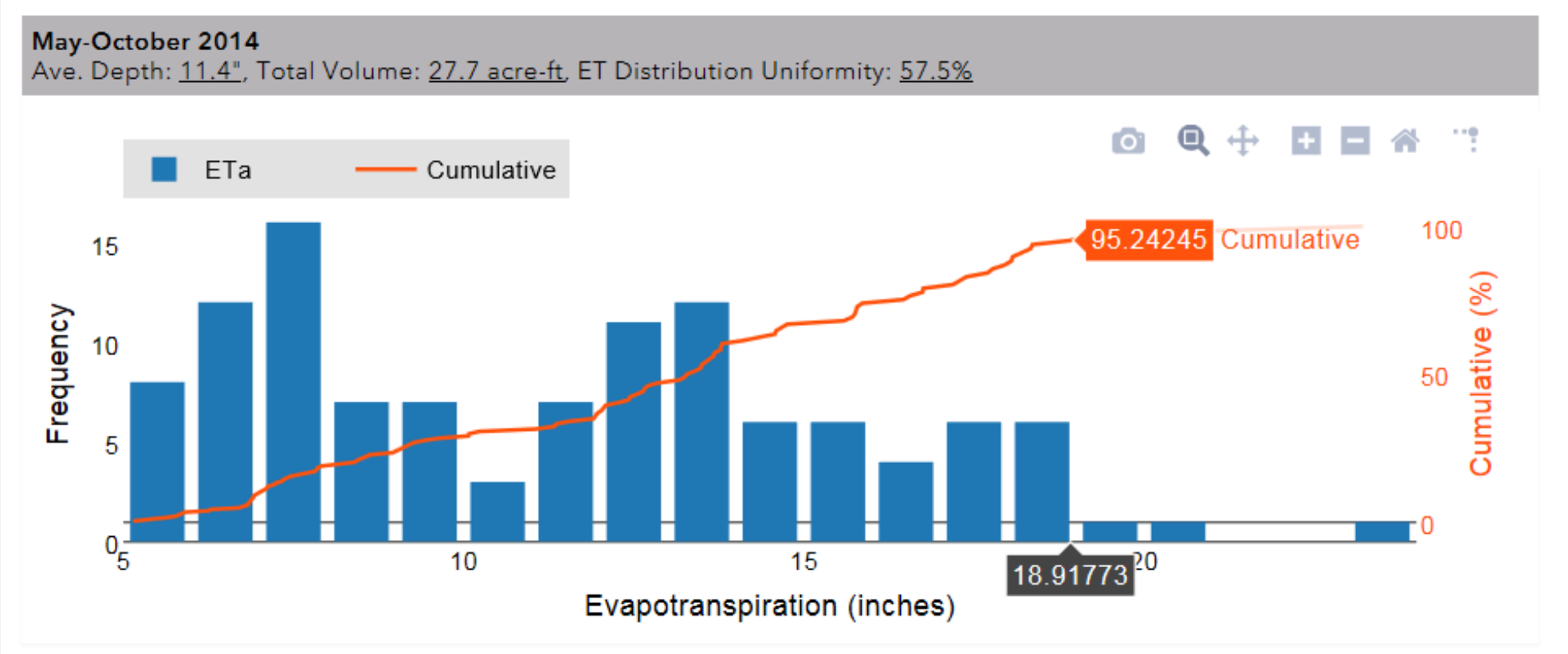
95% of the orchard at or below this ET_a level





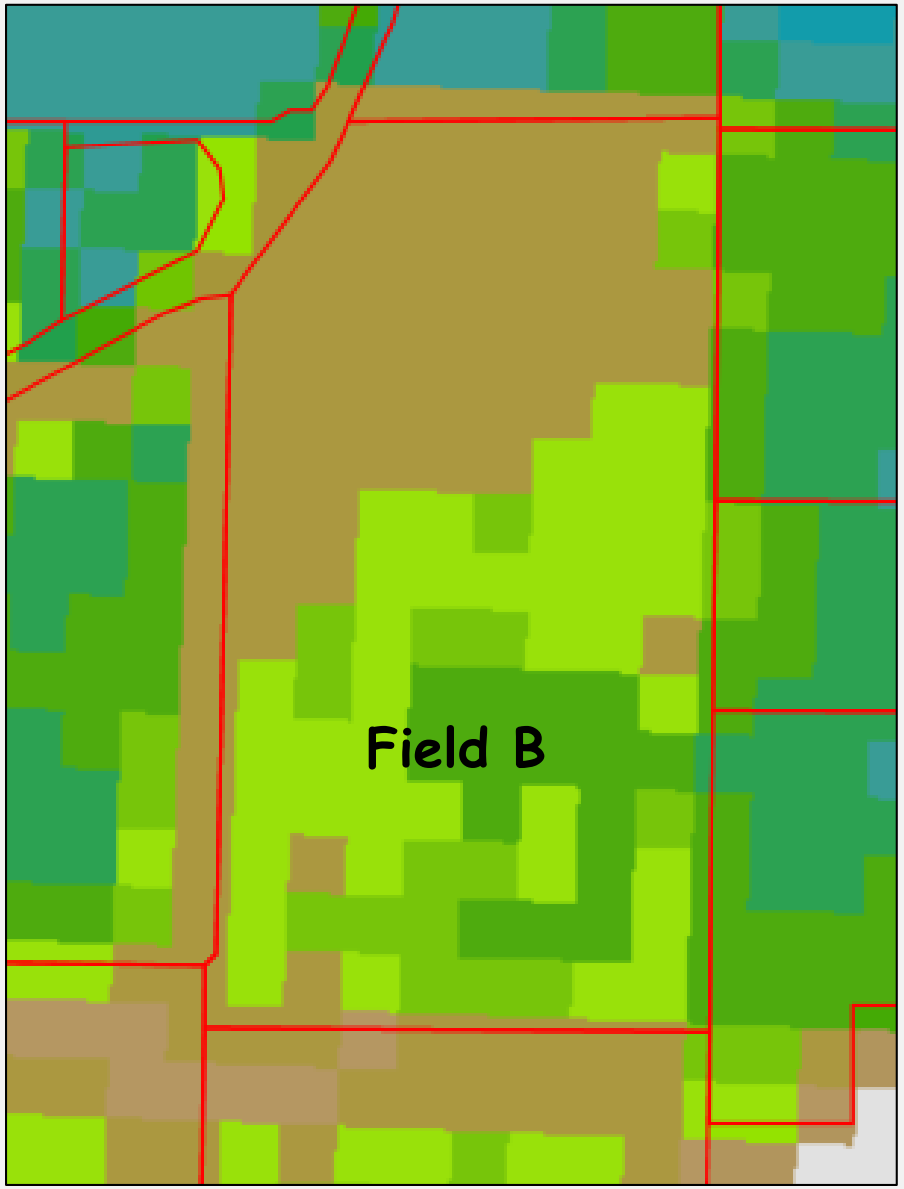
Low uniformity orchard (58% ET_a D.U.)
Mean ET_a = 11.4"
ET_{a95} = 18.9"

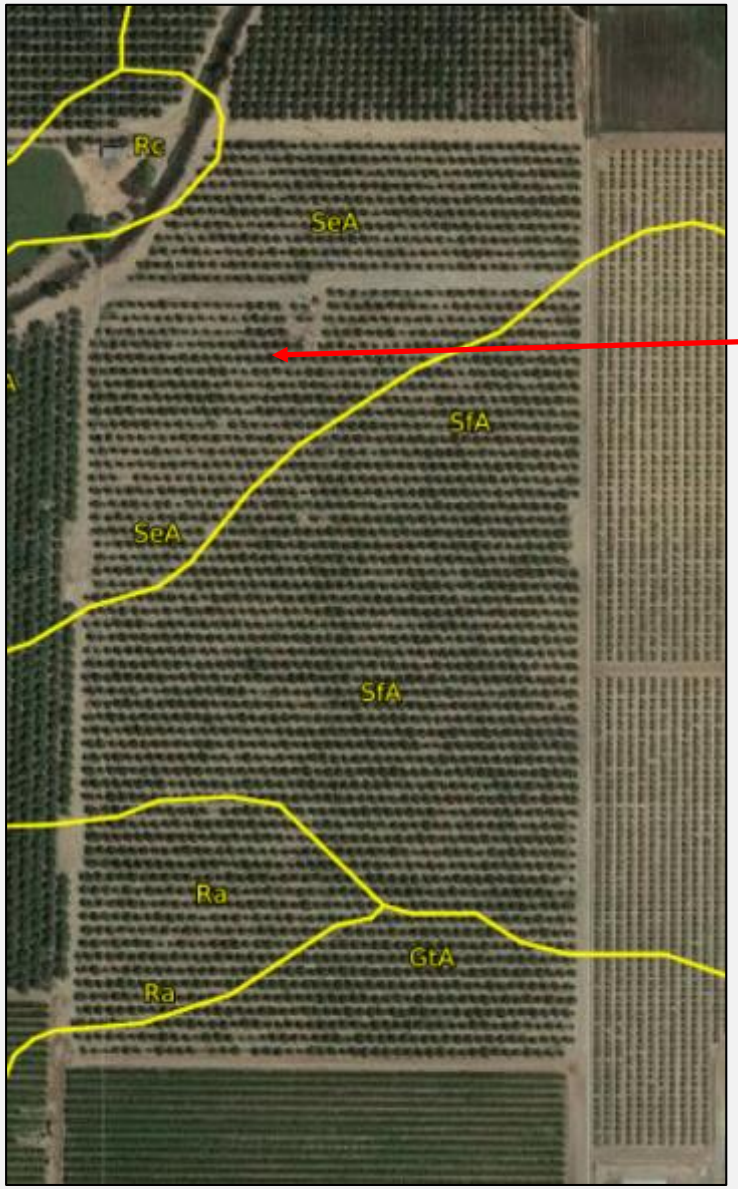
Cause of non-uniformity?



SoilWeb: An Online Soil

Secure | https://casoilresource.lawr.ucdavis.edu/gmap/





Lower soil WHC; water stress between weekly irrigations?

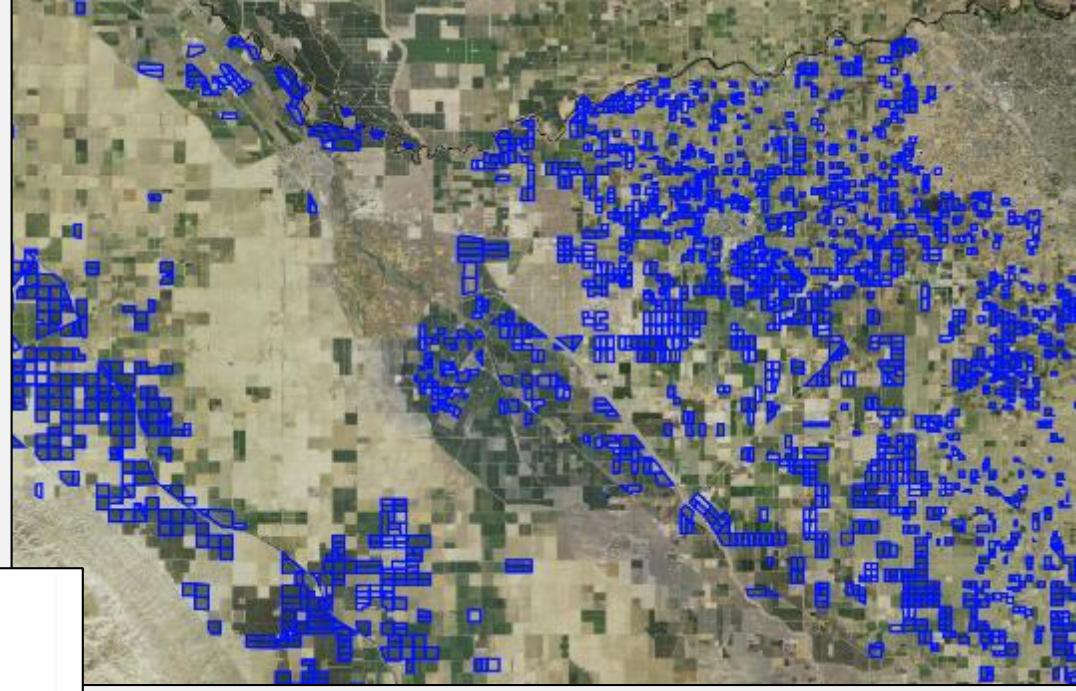
Does irrigation match actual crop use?

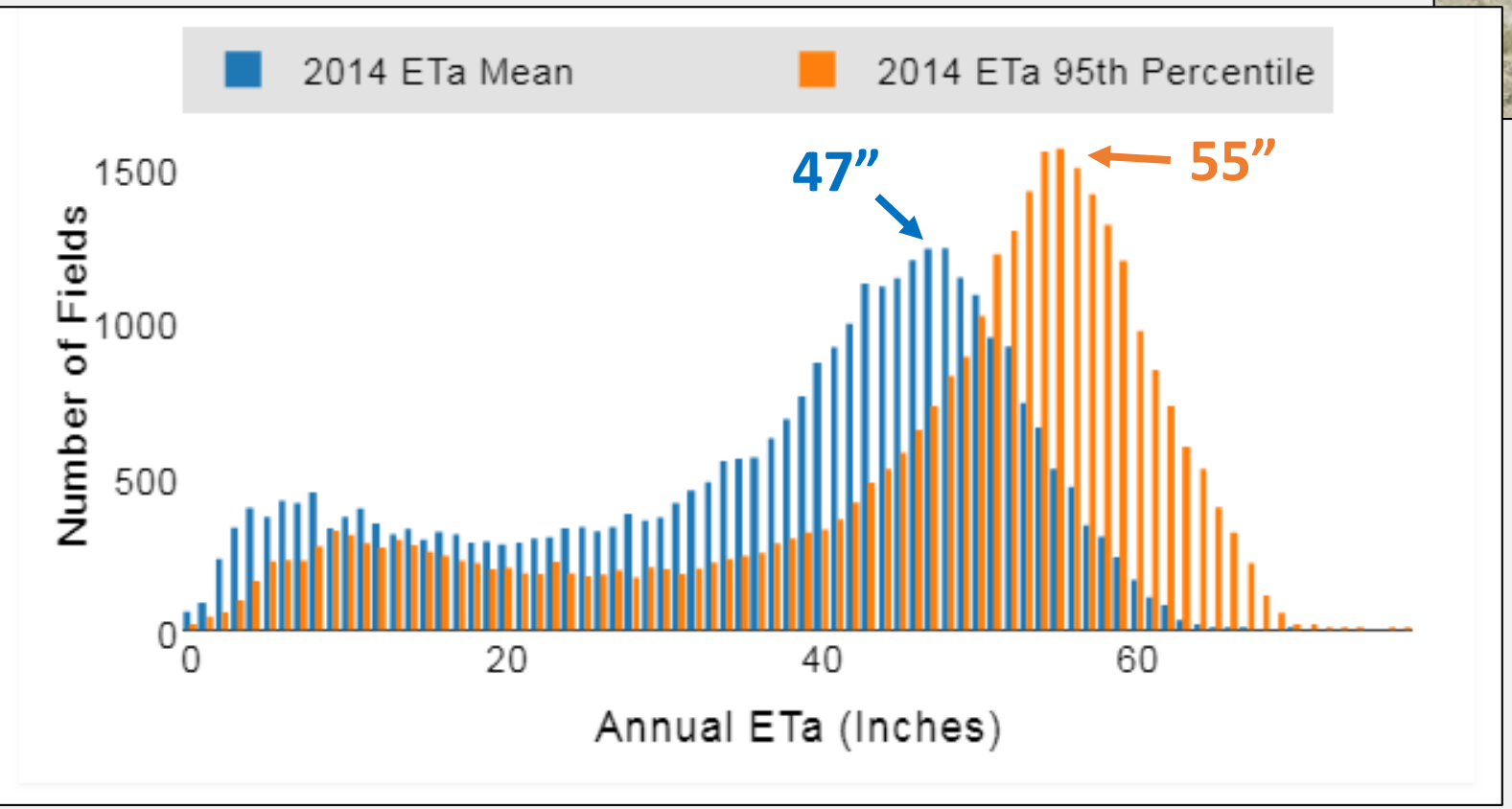
Almond crop coefficients (UC Publication 8515):

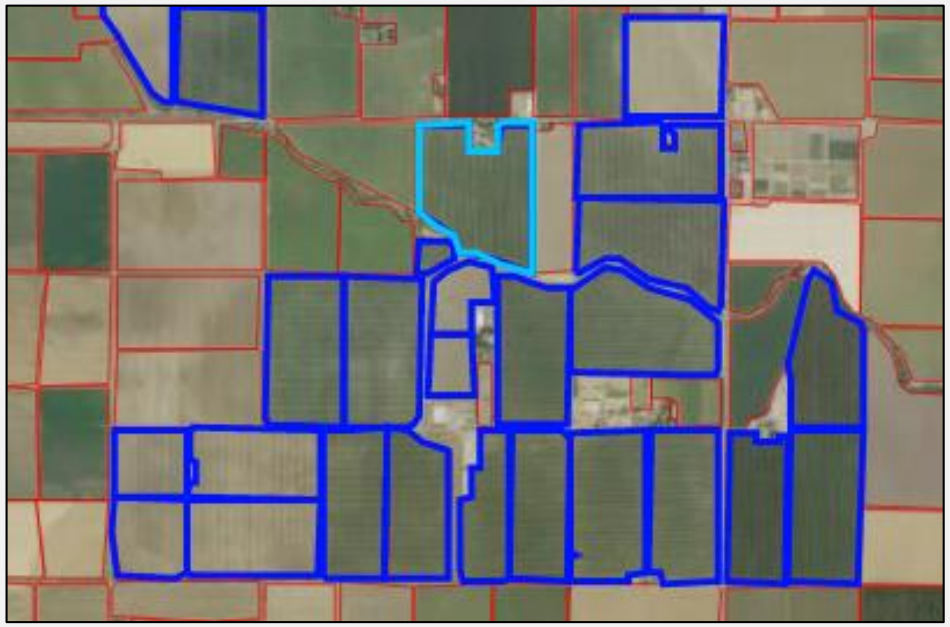
		Zone 12[4]		Zone 14[5]		Zone 15[6]		Zone 16[7]	
Month	K_c[3]	ET_o	ET_c	ET_o	ET_c	ET_o	ET_c	ET_o	ET_c
Jan	0.40	1.24	0.50	1.55	0.62	1.24	0.50	1.55	0.62
Feb	0.41	1.96	0.81	2.24	0.92	2.24	0.92	2.52	1.04
Mar	0.62	3.41	2.11	3.72	2.30	3.72	2.30	4.03	2.49
Apr	0.80	5.10	4.09	5.10	4.09	5.70	4.57	5.70	4.57
May	0.94	6.82	6.44	6.82	6.44	7.44	7.02	7.75	7.31
Jun	1.05	7.80	8.20	7.80	8.20	8.10	8.51	8.70	9.14
Jul	1.11	8.06	8.93	8.68	9.61	8.68	9.61	9.30	10.30
Aug	1.11	7.13	7.90	7.75	8.59	7.75	8.59	8.37	9.28
Sep	1.06	5.40	5.73	5.70	6.05	5.70	6.05	6.30	6.68
Oct	0.92	3.72	3.41	4.03	3.69	4.03	3.69	4.34	3.97
Nov	0.69	1.80	1.23	2.10	1.44	2.10	1.44	2.40	1.64
Dec	0.43	0.93	0.40	1.55	0.66	1.24	0.53	1.55	0.66
Total (in)			49.73		52.61		53.73		57.72

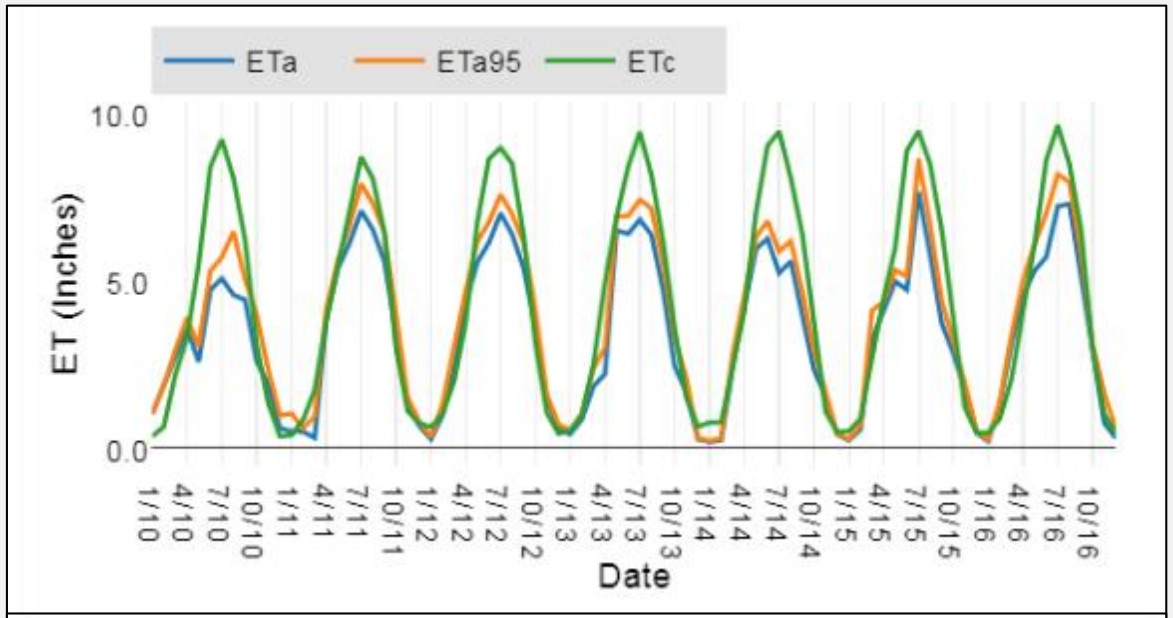
Well-watered, high yield almonds *can* use up to 50-58" of water annually

ET_a data from > 30,000 almond orchards …



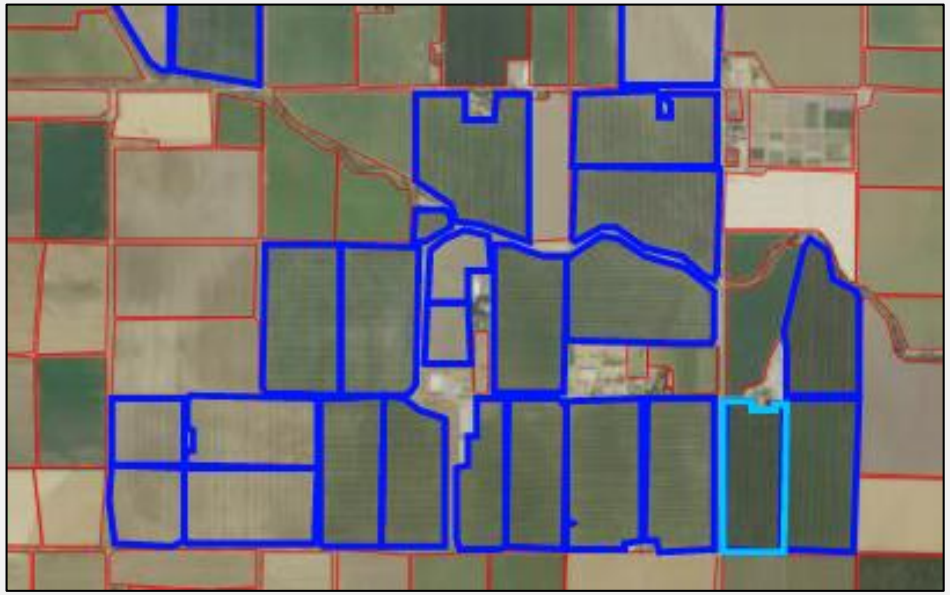


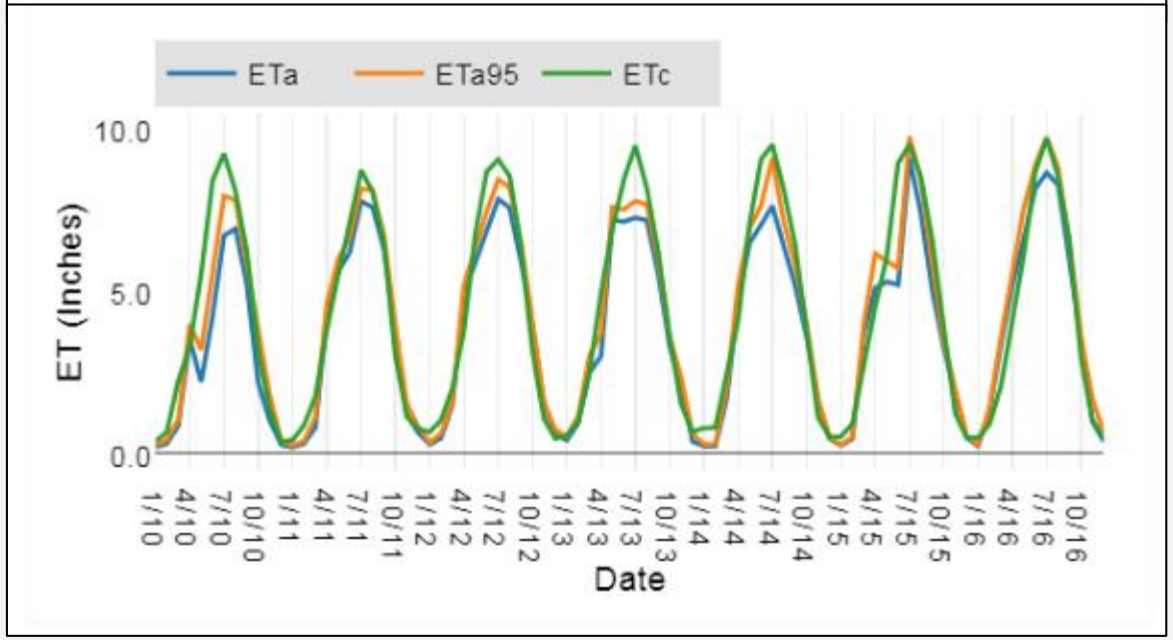




7 year average

ET_a = 40"
ET_{a95} = 44"





ET_a = 45"
ET_{a95} = 46"

Well-watered, high yield almonds *can* use up to 50-58" of water annually

How to credit NO_3-N in irrigation water?

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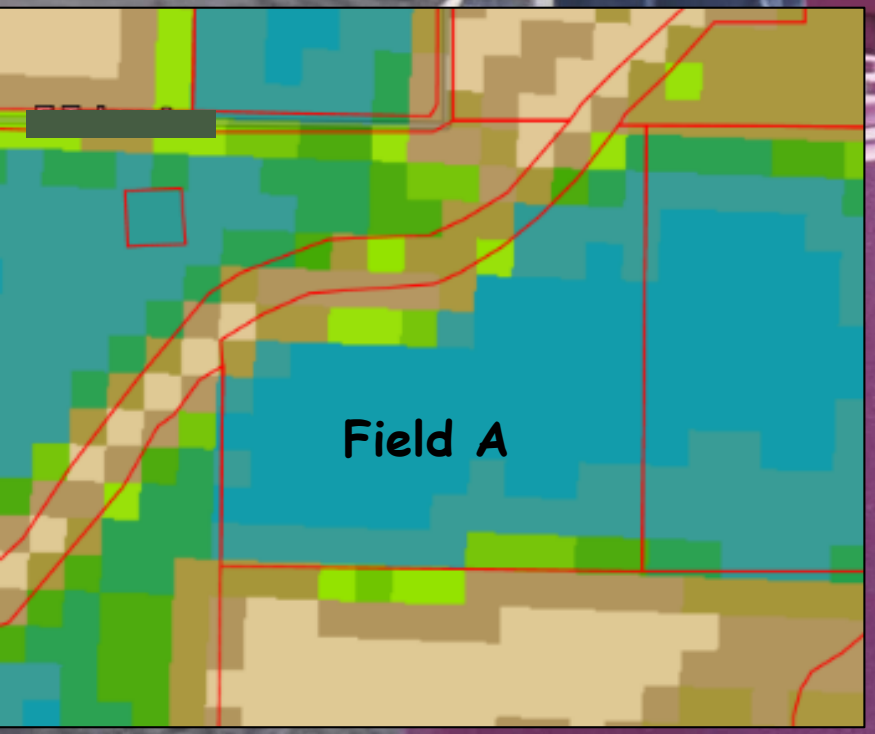

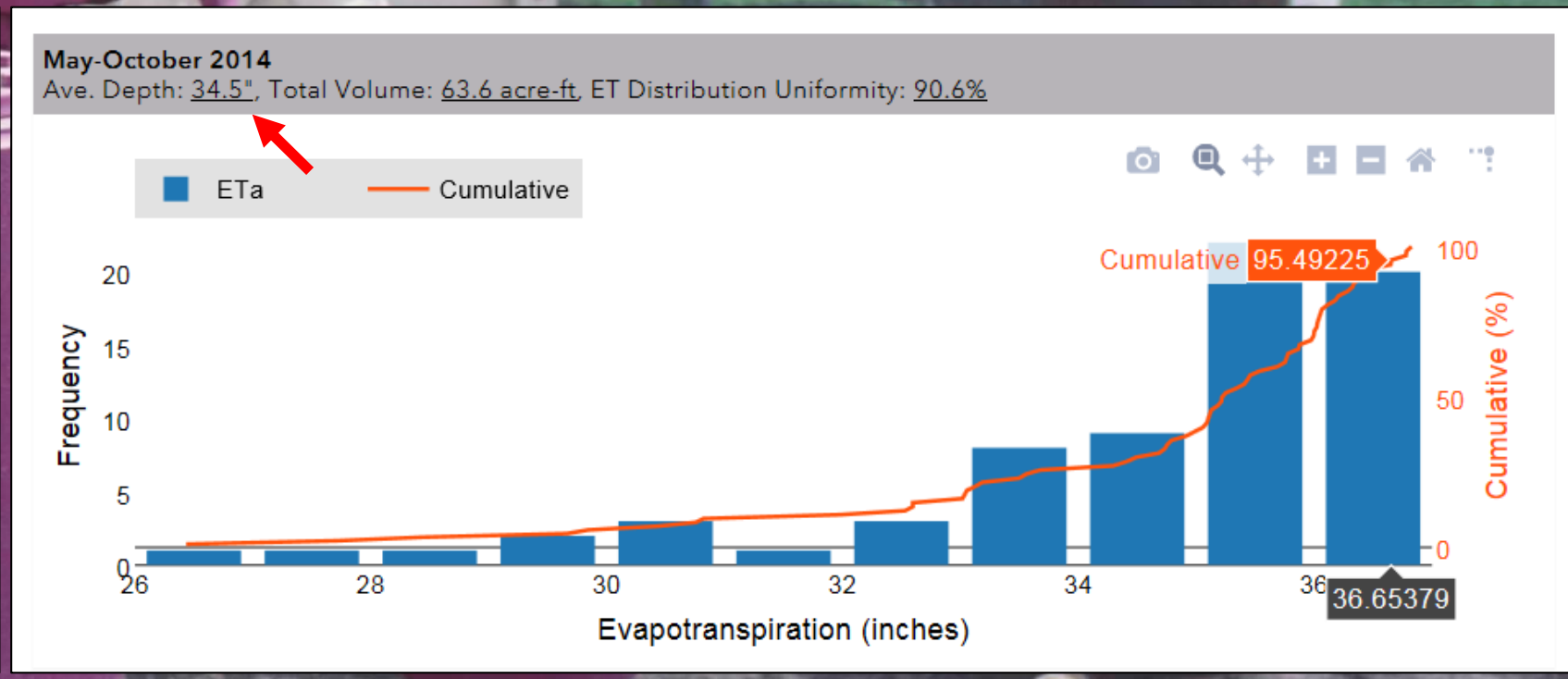

- Credit 100% of N in irrigation water transpired

In summary :

- NO_3-N content of leached water can be substantial
- Maximizing N residence time in the active root zone must be a priority
- Future environmental and resource challenges will incentivize irrigation efficiency; significant improvement is possible