Irrigation effects on nitrogen efficiency

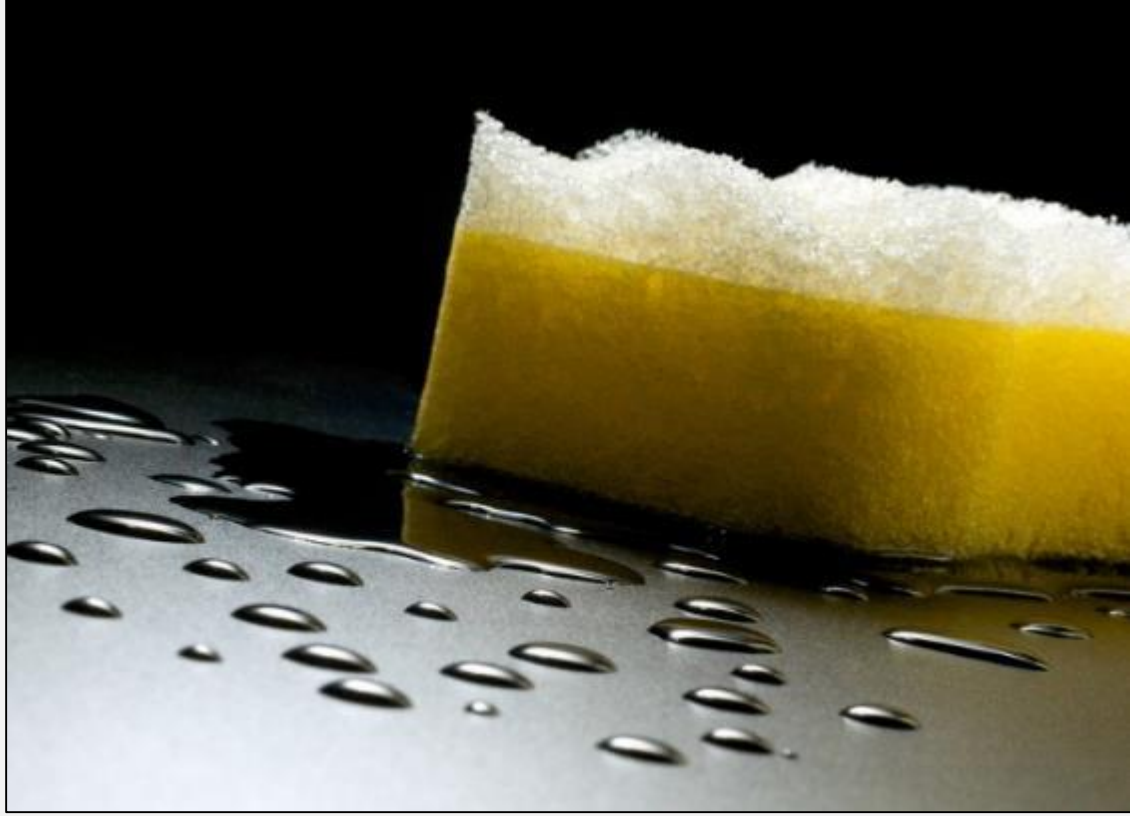
- Nitrate-nitrogen (NO_3-N) moves freely with water in the soil
- Irrigation in excess of soil water holding capacity takes NO_3-N with it as it leaches

How much NO_3-N can leachate carry?

- Soil test NO_3-N is commonly in the range of 5 - 20 PPM
- As a *rough approximation*, multiplying a soil test NO_3-N concentration by a factor (1.1 for sandy soil, 0.8 for clay soil) estimates the pounds of N contained in an acre inch of soil solution

Example:

Sandy soil NO_3-N of 10 PPM x 1.1 = *approximately* 11 pounds of N per acre inch of soil solution; actual leaching loss somewhat less due to dilution effect

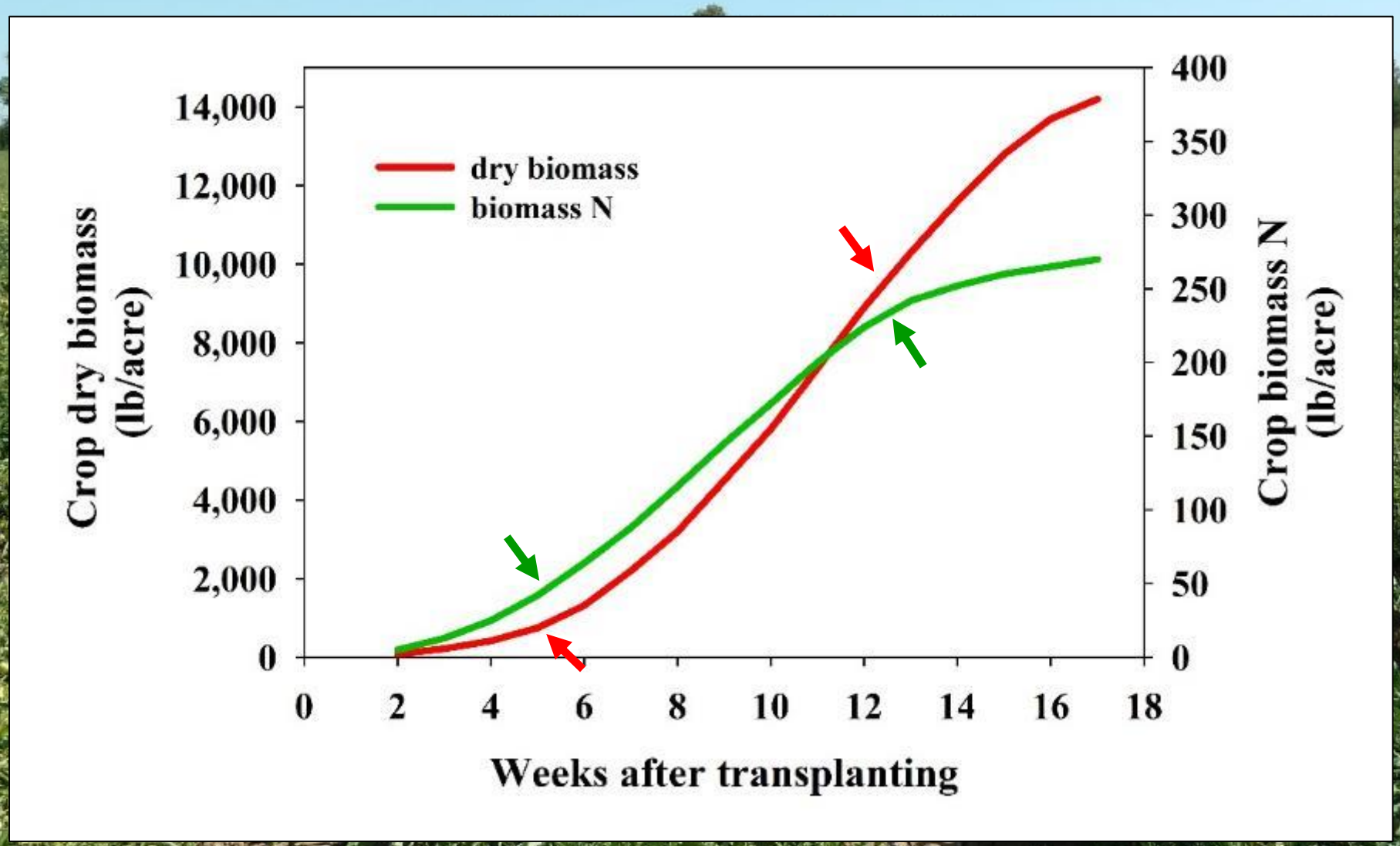


Importance of N '*residence time*' in the root zone:

- 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

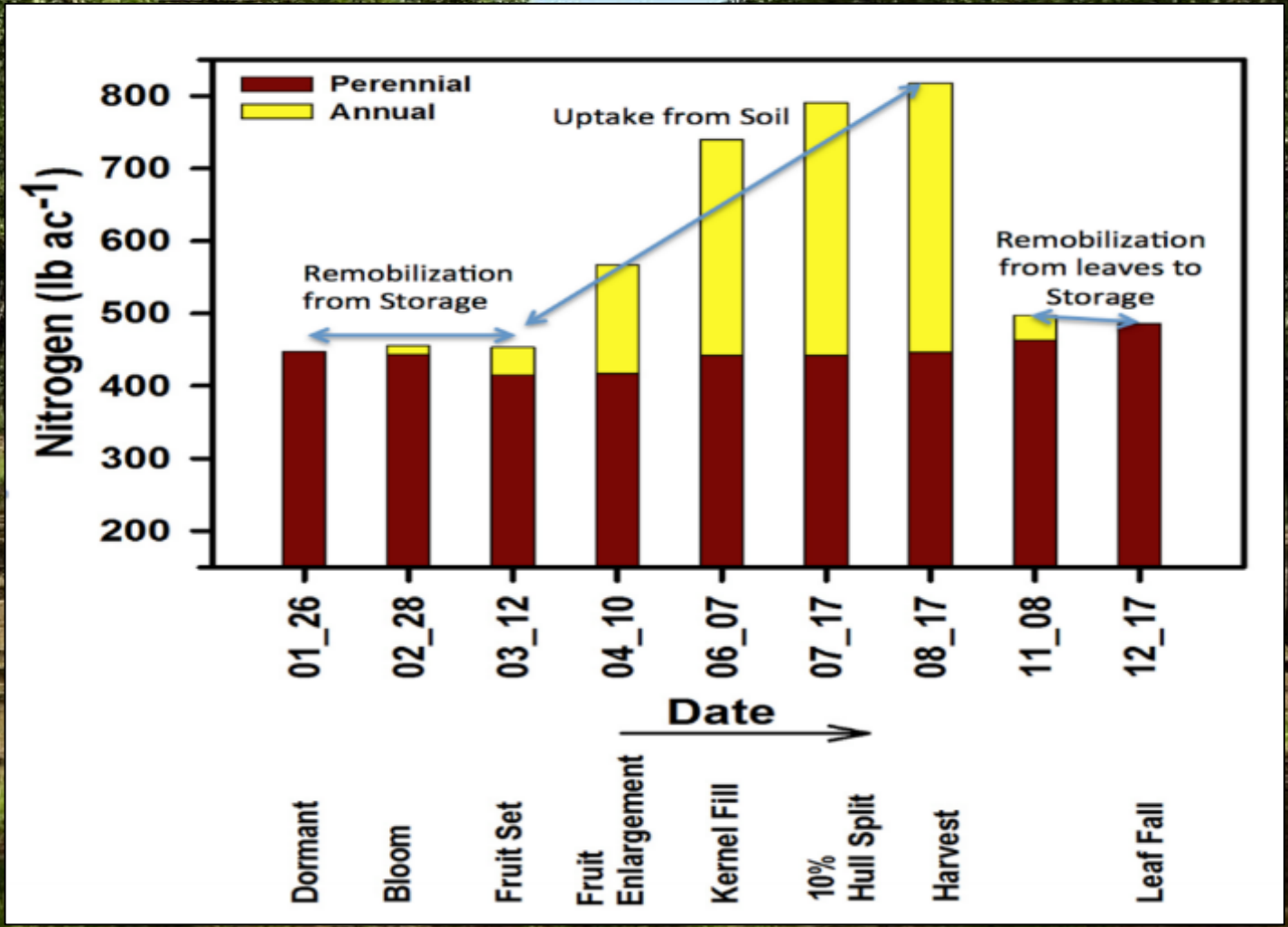
Plant growth and N uptake are tightly linked:

Tomato:



Plant growth and N uptake are tightly linked:

Almond:



Crops vary in peak N uptake rate:

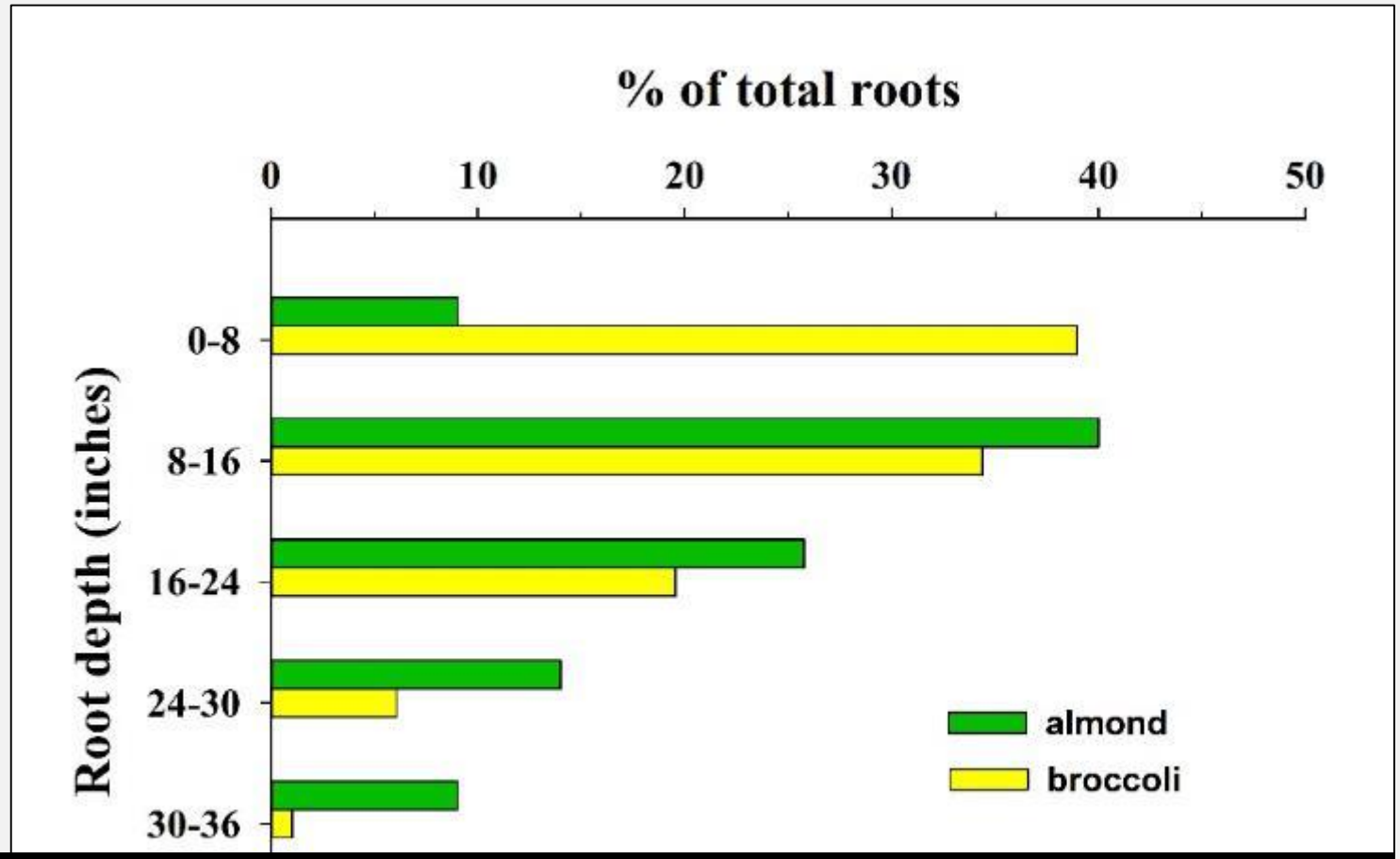
- Pounds of N per acre per day during rapid growth

Low (< 3 lb/A/d)	Medium (3-5 lb/A/d)	High (> 5 lb/A/d)
Almond	Cotton	Corn (grain or silage)
Citrus	Melon	
Grape	Tomato	
Pistachio		

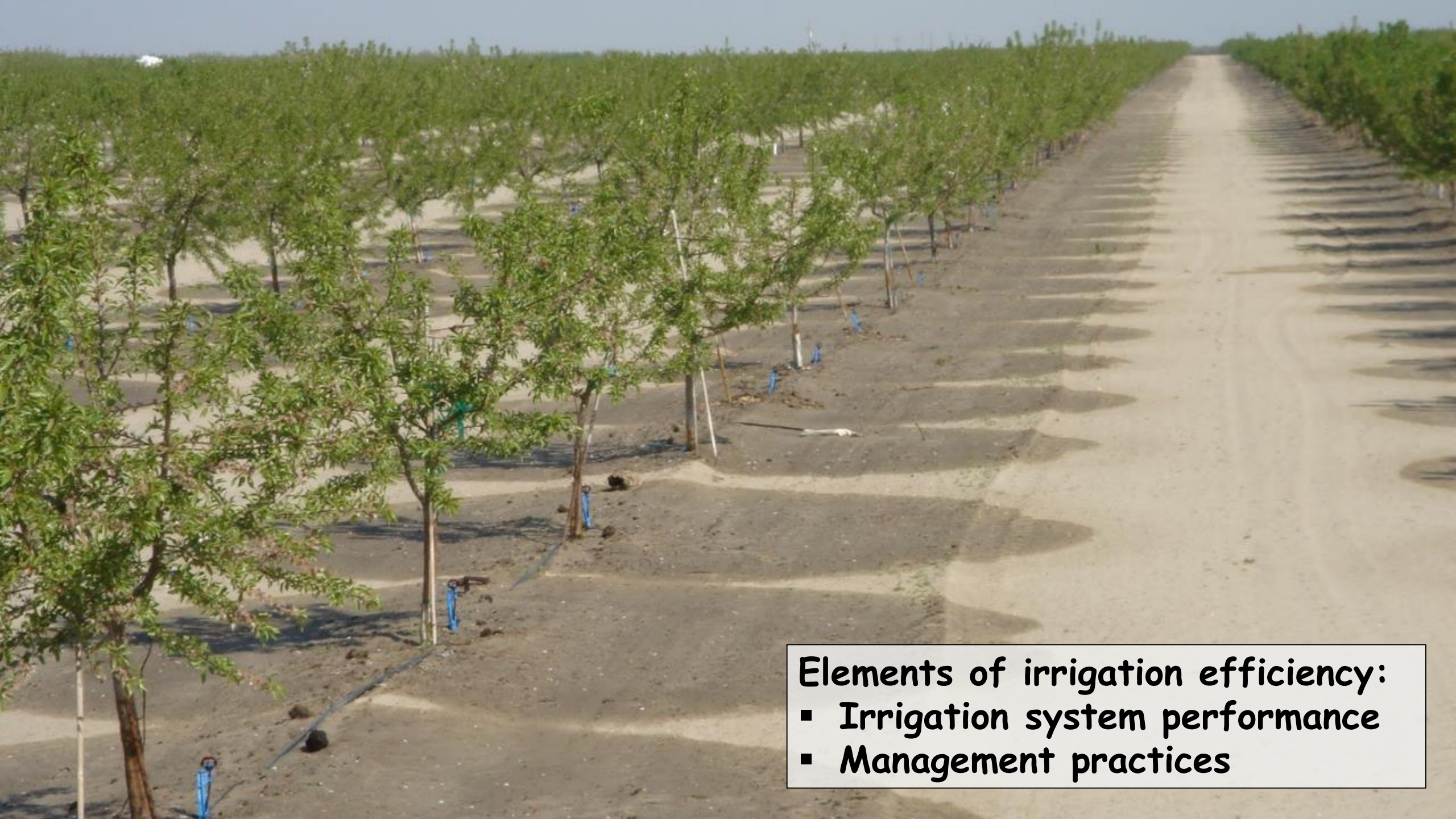
a typical N application takes many days (and multiple irrigation cycles) to be fully utilized by the crop

Efficiency of N recovery declines with soil depth:

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



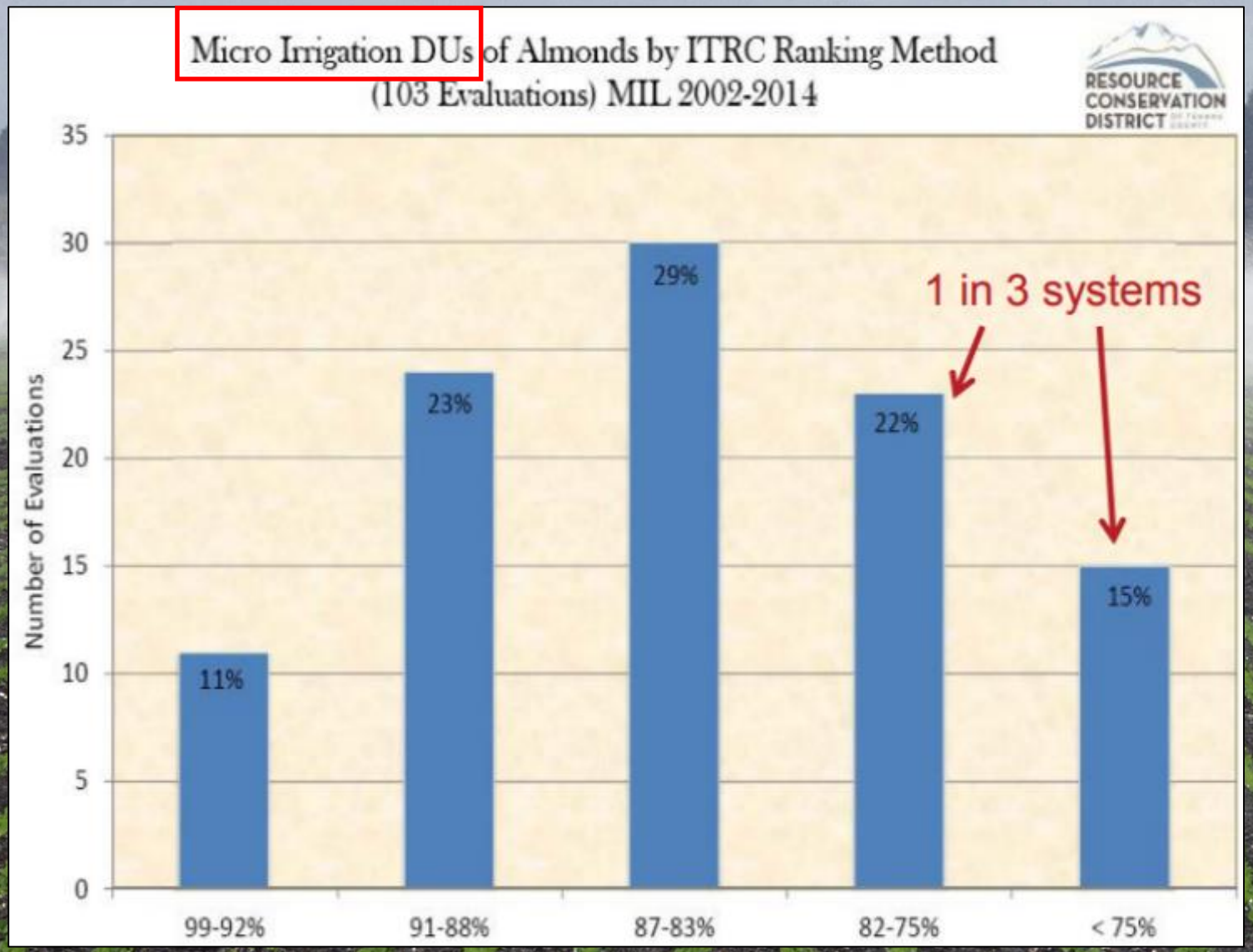
Bottom line:
It is easy to move nitrogen below the *effective* root zone with inefficient irrigation



Elements of irrigation efficiency:

- Irrigation system performance
- Management practices

Irrigation system performance:
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

Irrigation management:

- **How much water does my crop use, and when?**

How much water does my crop use, and when?

- Reference evapotranspiration (ET_o) x crop coefficient (K_c) = crop evapotranspiration (ET_c)

Almond crop coefficients (UC Publication 8515):

		Zone 12[4]		Zone 14[5]		Zone 15[6]	
Month	K_c[3]	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
Feb	0.41	1.96	0.81	2.24	0.92	2.24	0.92
Mar	0.62	3.41	2.11	3.72	2.30	3.72	2.30
Apr	0.80	5.10	4.09	5.10	4.09	5.70	4.57
May	0.94	6.82	6.44	6.82	6.44	7.44	7.02
Jun	1.05	7.80	8.20	7.80	8.20	8.10	8.51
Jul	1.11	8.06	8.93	8.68	9.61	8.68	9.61
Aug	1.11	7.13	7.90	7.75	8.59	7.75	8.59
Sep	1.06	5.40	5.73	5.70	6.05	5.70	6.05
Oct	0.92	3.72	3.41	4.03	3.69	4.03	3.69
Nov	0.69	1.80	1.23	2.10	1.44	2.10	1.44
Dec	0.43	0.93	0.40	1.55	0.66	1.24	0.53
Total (in)			49.73		52.61		53.73

How much water does my crop use, and when?

- Reference evapotranspiration (ET_o) x crop coefficient (K_c) = crop evapotranspiration (ET_c)

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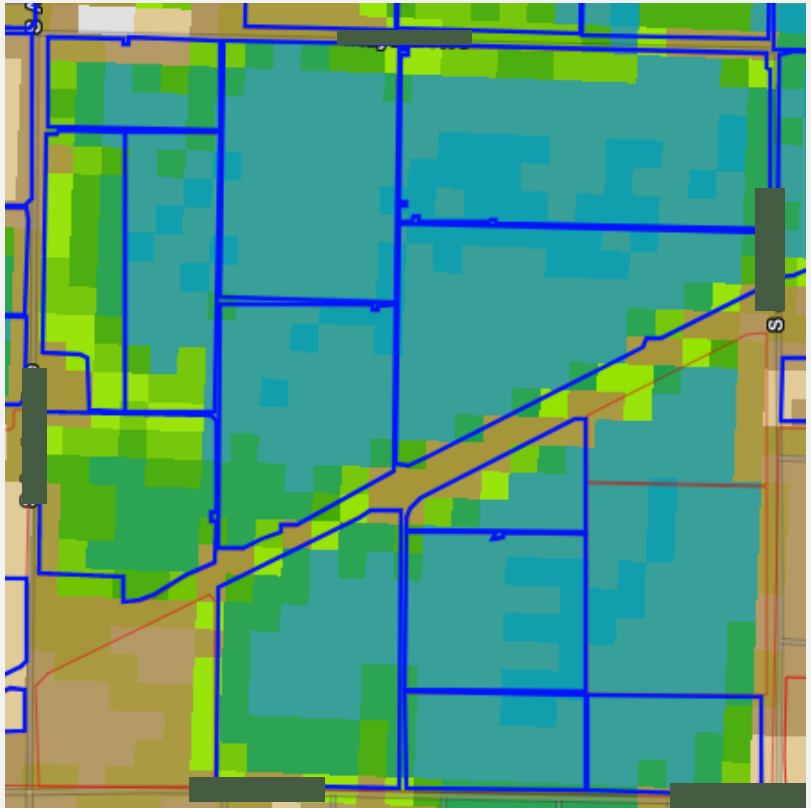
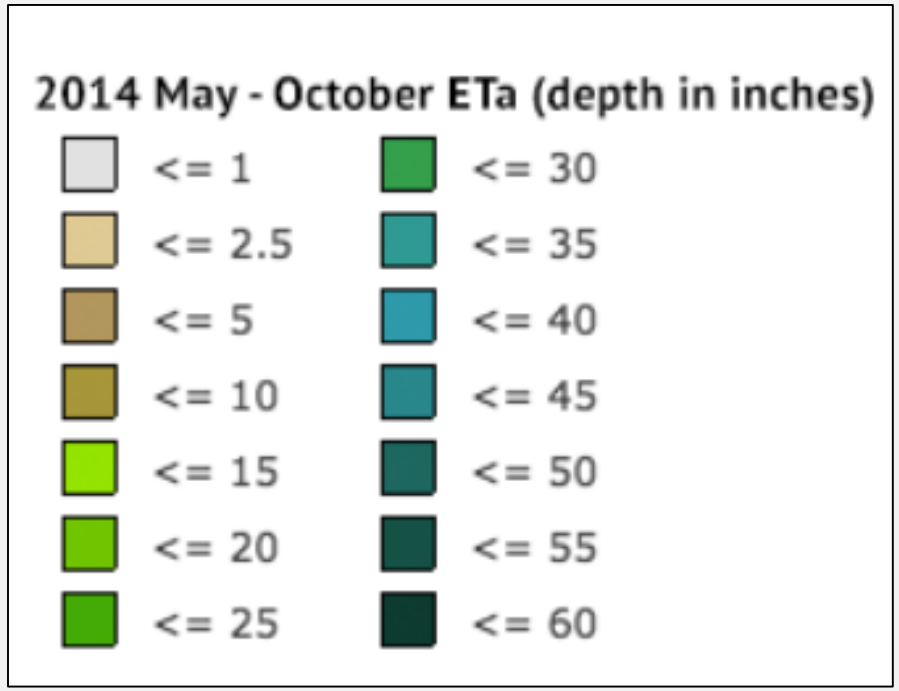
Dec	0.43	0.93	0.40	1.55	0.66	1.24	0.53
Total (in)			49.73		52.61		53.73

These ET_c estimates represent well-watered, vigorous, high-yield orchards

Actual crop evapotranspiration (ET_a):

- 30 m (100 ft) spatial resolution satellite data, augmented by spatial CIMIS
- Provides field-by-field ET_a data from 2010-2016
- Shows within-field variability in ET_a





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MANAGEMENT PRACTICES EVALUATION PROGRAM

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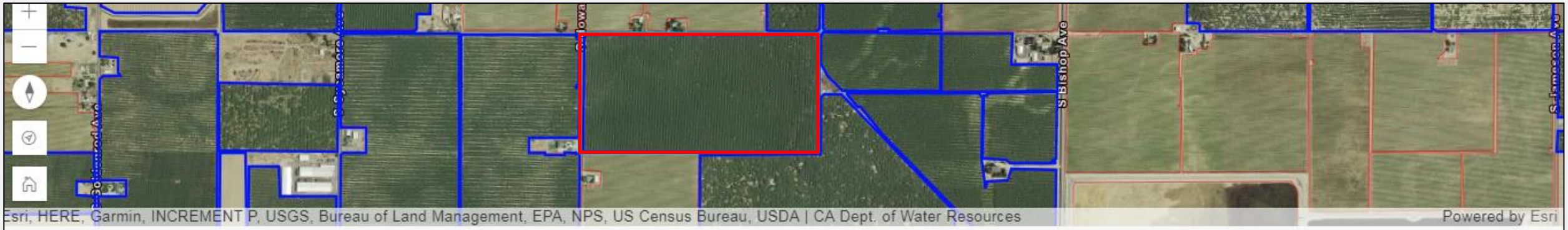
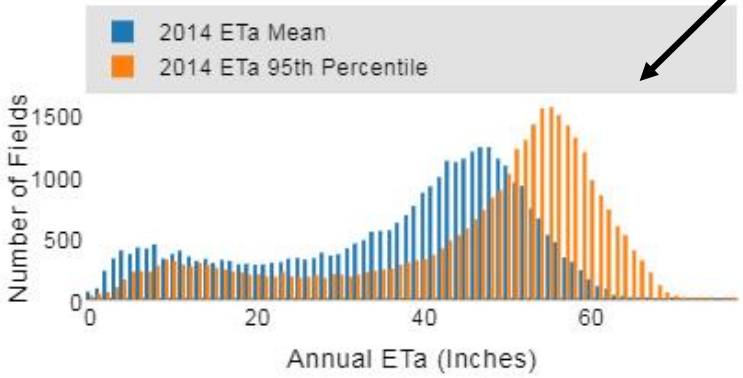


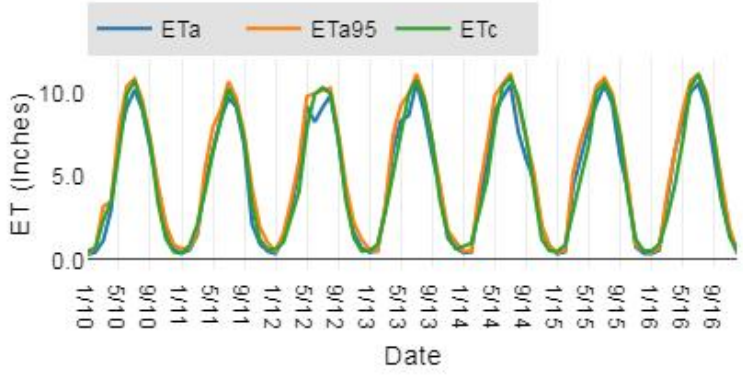
Field Summary for FieldID: 236195 | Acreage: 76.1

2014 Crop: Almonds, DWR Legend: D | DECIDUOUS FRUITS AND NUTS, County: Fresno

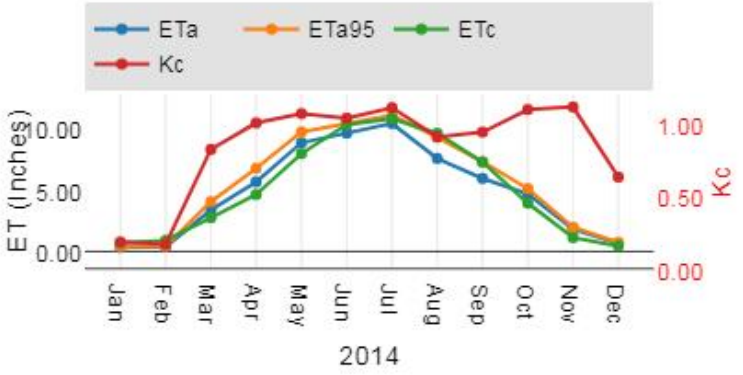
Annual ET_a of all fields of that crop

Statewide (32580 fields in 2014):





Selected Field: 2014 | Annual Totals: ETc=60.1, ETa=58.8, ET95=66.9



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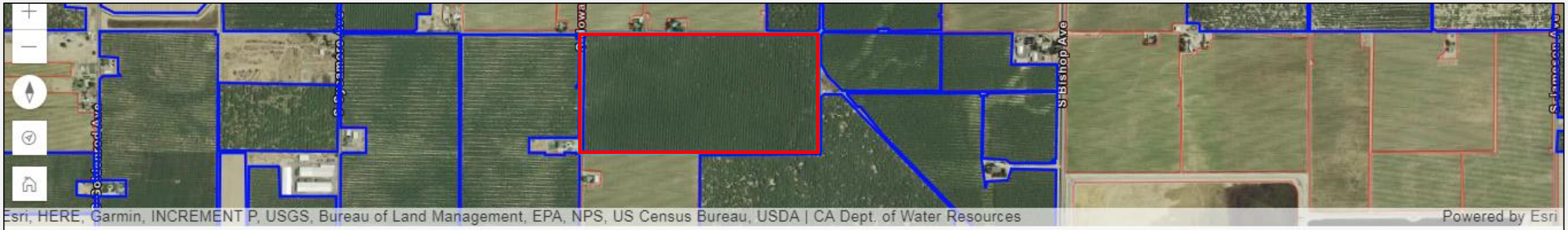
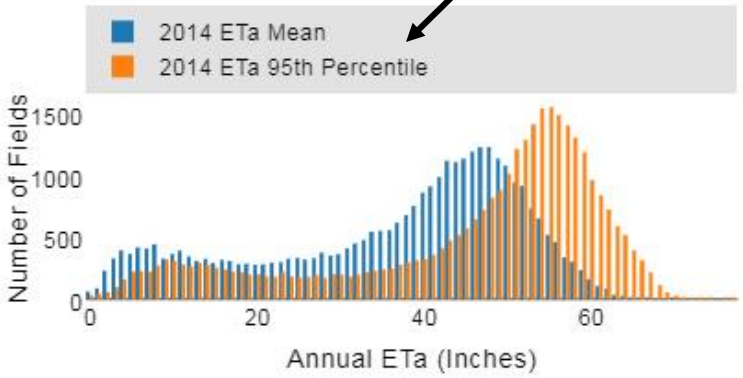


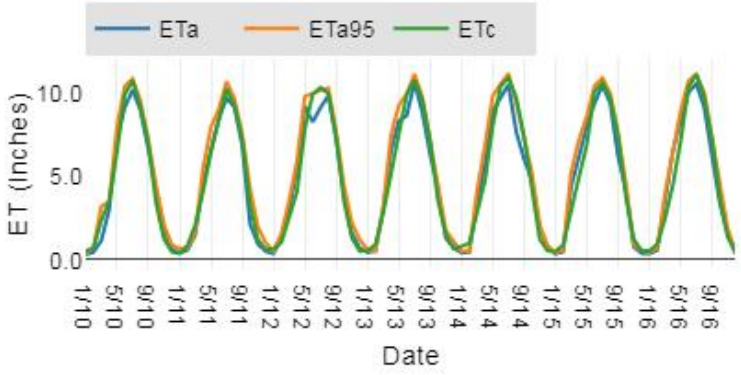
Field Summary for FieldID: 236195 | Acreage: 76.1

2014 Crop: Almonds, DWR Legend: D | DECIDUOUS FRUITS AND NUTS, County: Fresno

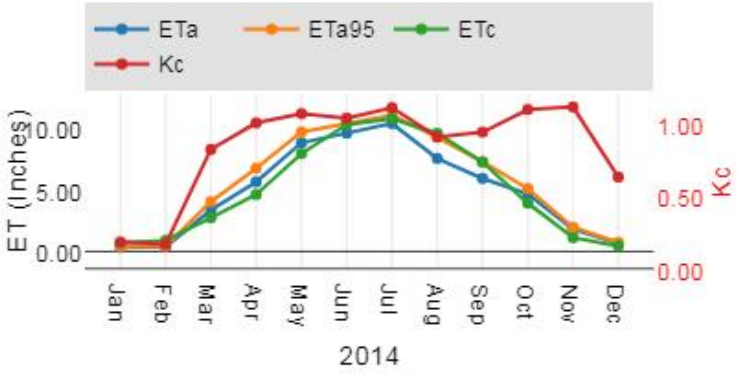
ET_{a95} = 95% of field at or below this level

Statewide (32580 fields in 2014):





Selected Field: 2014 | Annual Totals: ETc=60.1, ETa=58.8, ET95=66.9



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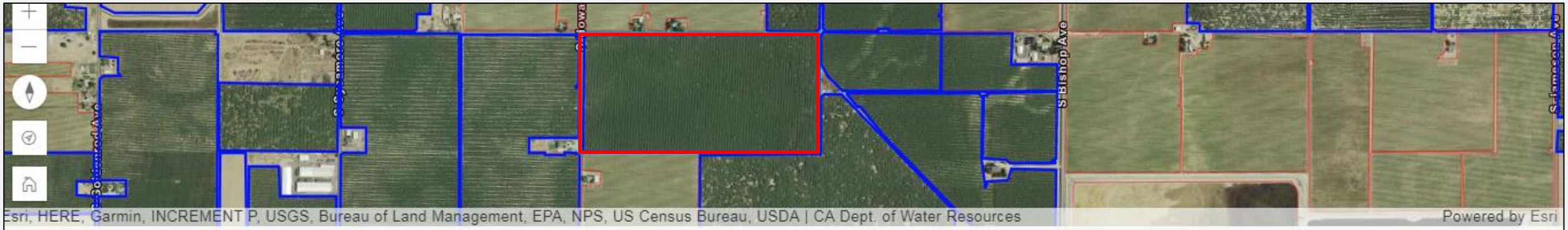
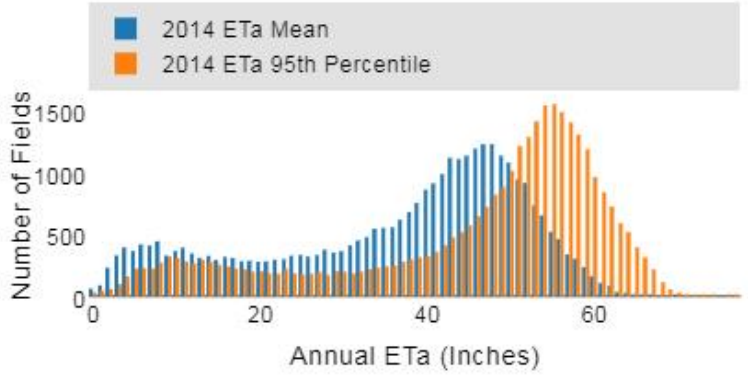


Field Summary for FieldID: 236195 | Acreage: 76.1

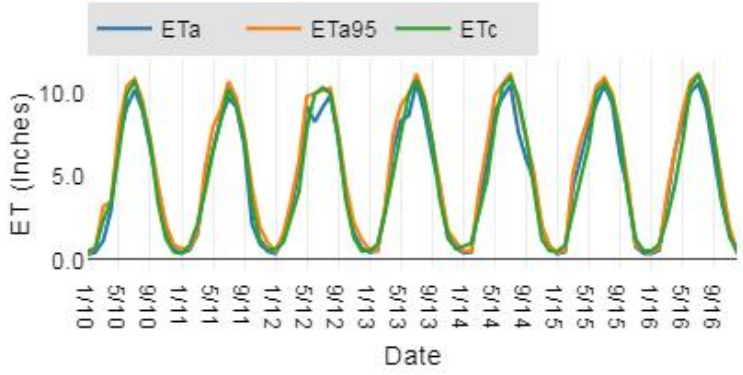
Comparison of ET_a and ET_c across 7 years

2014 Crop: Almonds, DWR Legend: D | DECIDUOUS FRUITS AND NUTS, County: Fresno

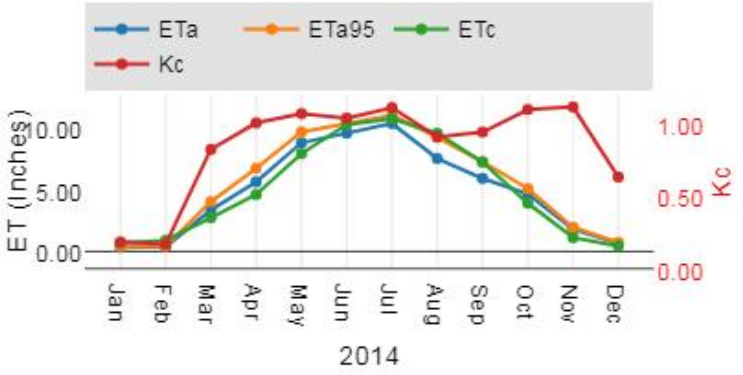
Statewide (32580 fields in 2014):



Selected Field: All Years



Selected Field: 2014 | Annual Totals: ETc=60.1, ETa=58.8, ET95=66.9



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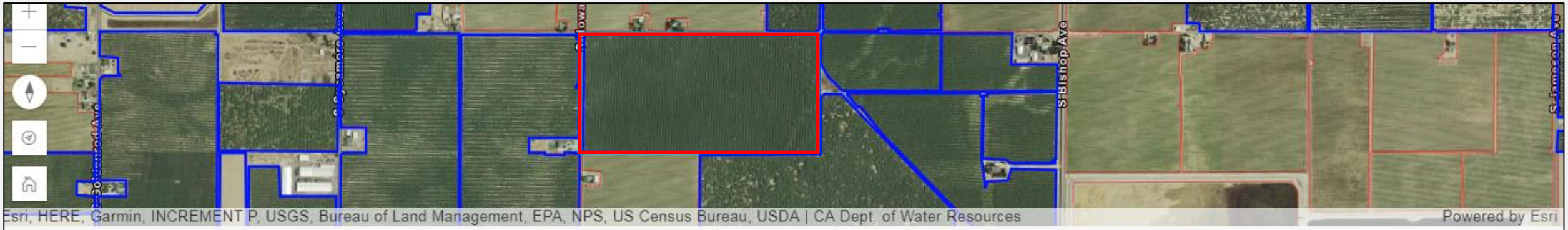
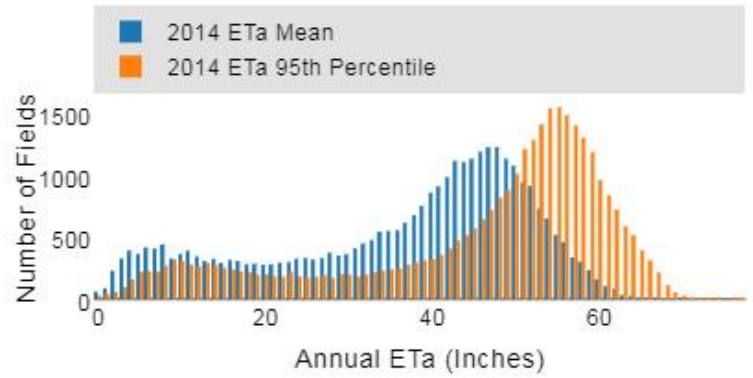


Field Summary for FieldID: 236195 | Acreage: 76.1

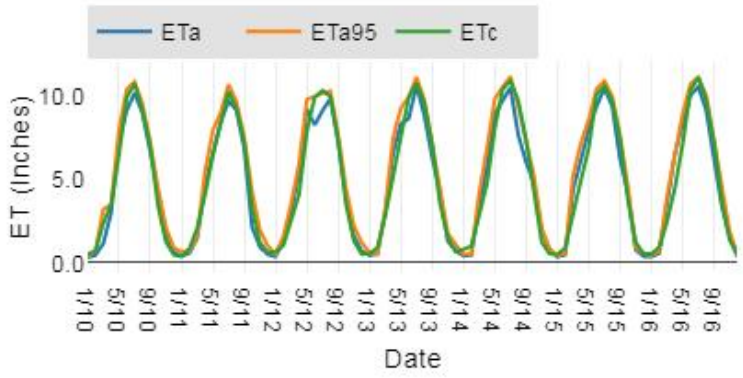
2014 Crop: Almonds, DWR Legend: D | DECIDUOUS FRUITS AND NUTS, County: Fresno

Monthly comparison of ET_a and ET_c

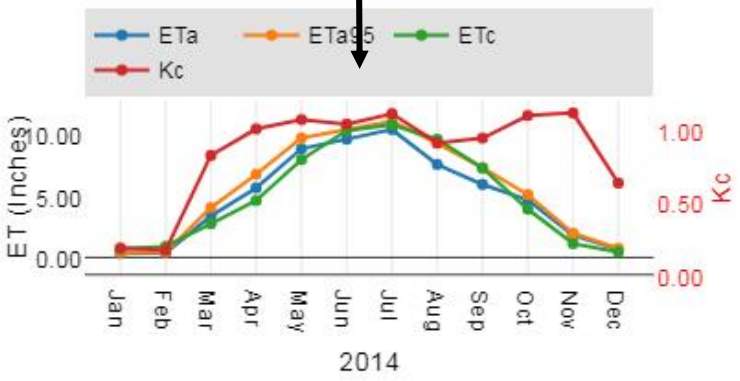
Statewide (32580 fields in 2014):



Selected Field: All Years



Selected Field: 2014 | Annual Totals: ETc=60.1, ETa=58.8, ET95=66.9



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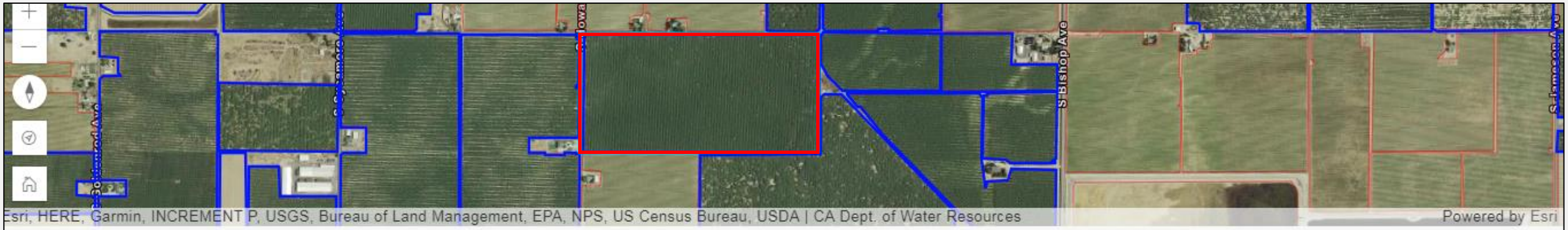
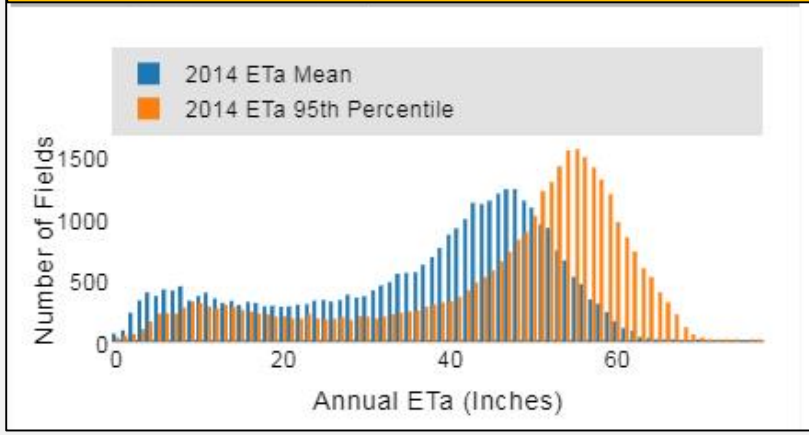


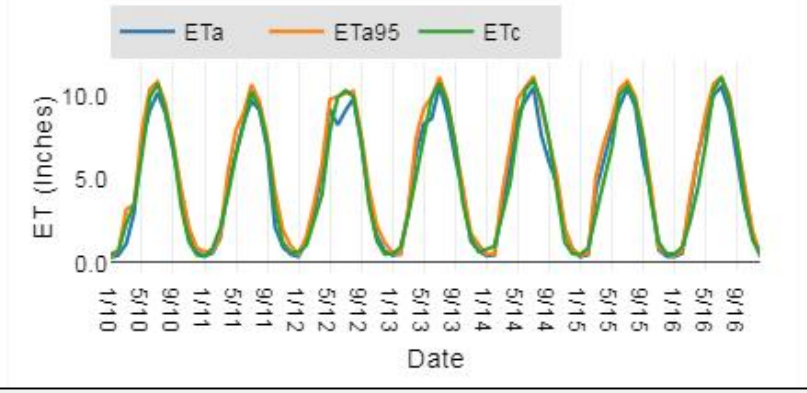
Field Summary for FieldID: 236195 | Acreage: 76.1

2014 Crop: Almonds, DWR Legend: D | DECIDUOUS FRUITS AND NUTS, County: Fresno

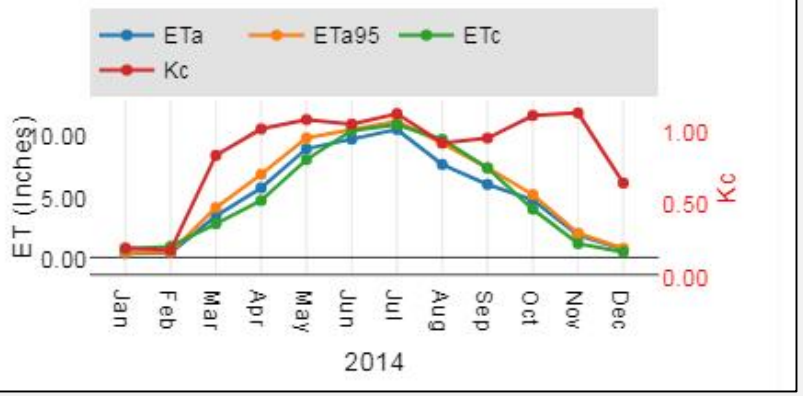
ET_a differs significantly among fields



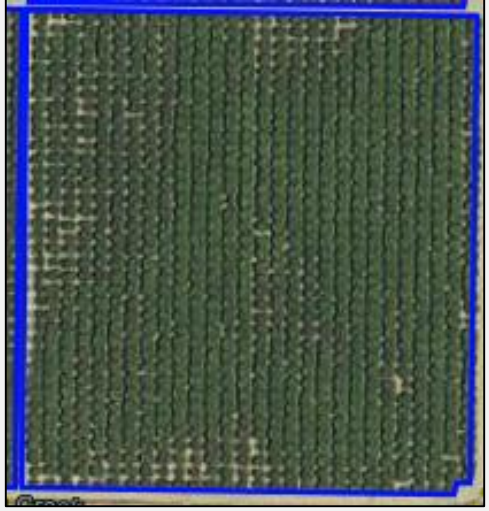
Selected Field: All Years

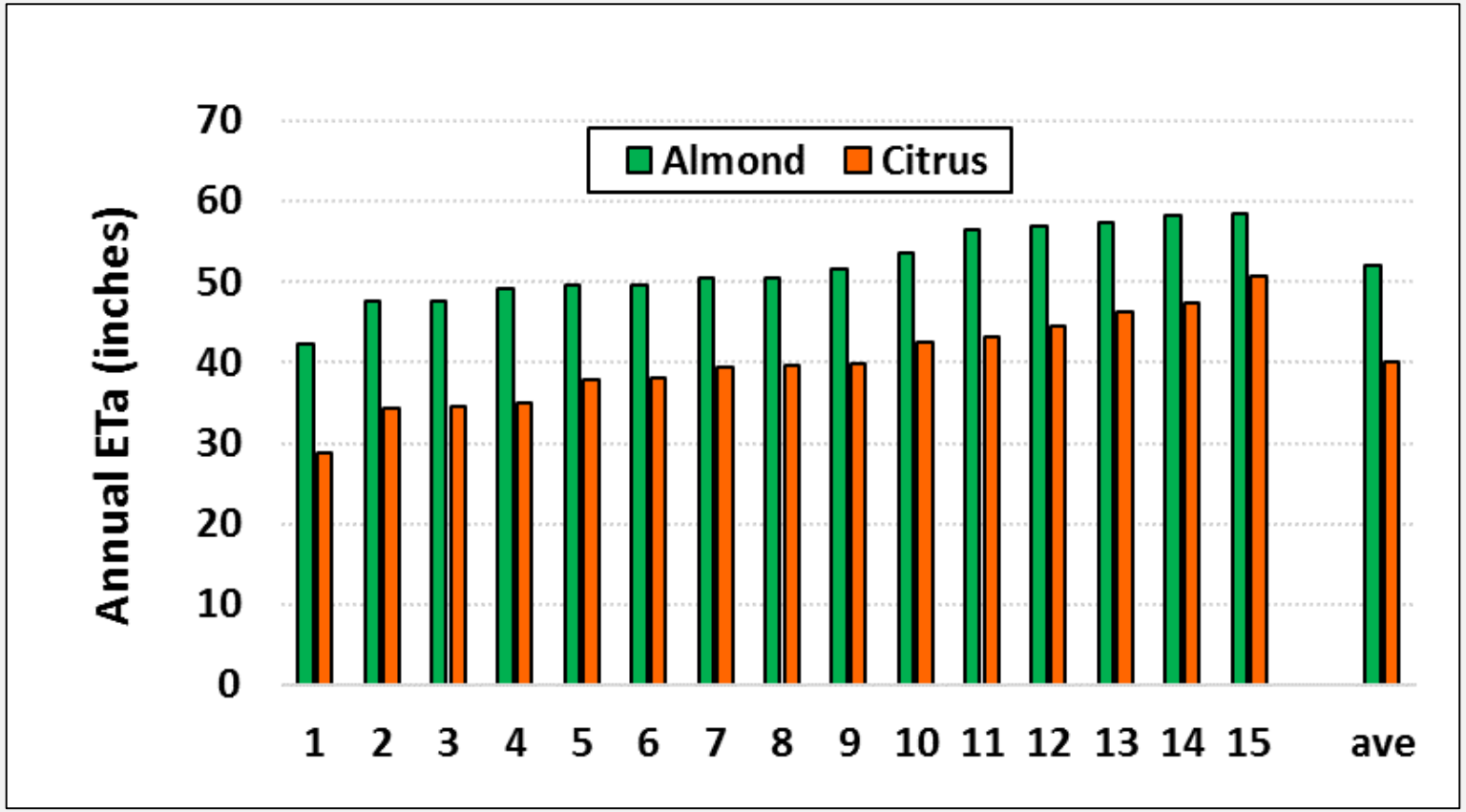


Selected Field: 2014 | Annual Totals: ETc=60.1, ETa=58.8, ET95=66.9



Representative *mature* almond orchards and citrus groves in the Kings River Water Quality Coalition area

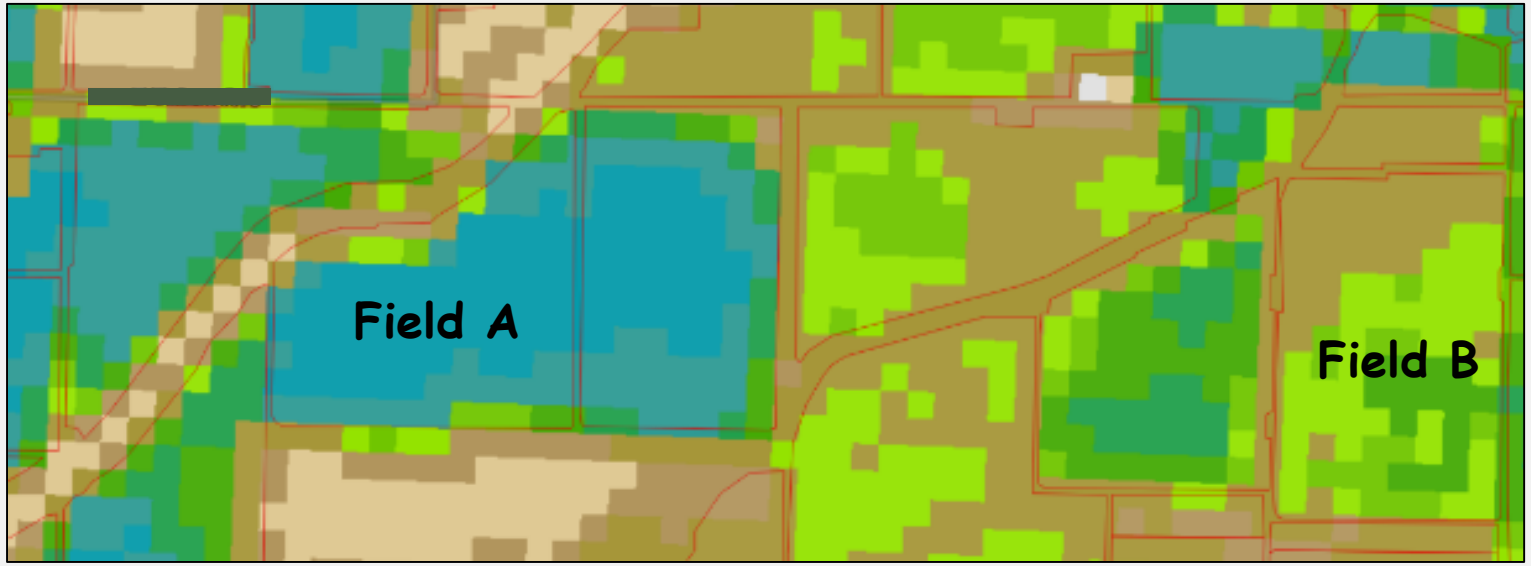


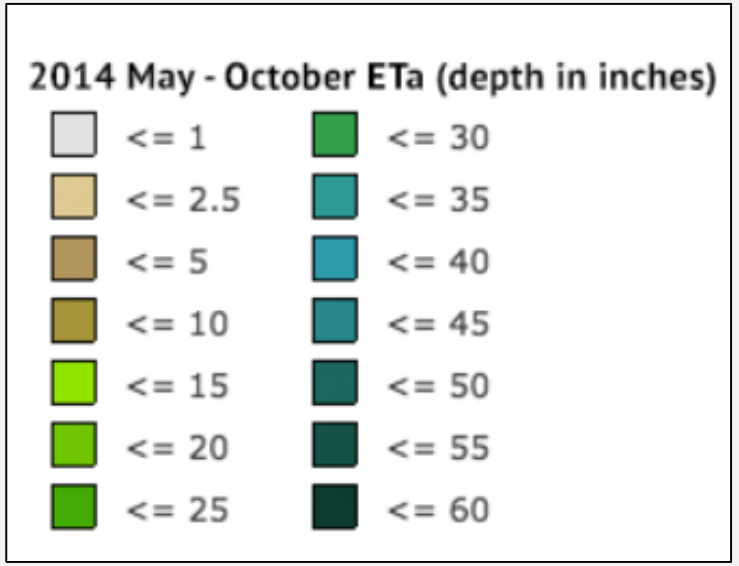


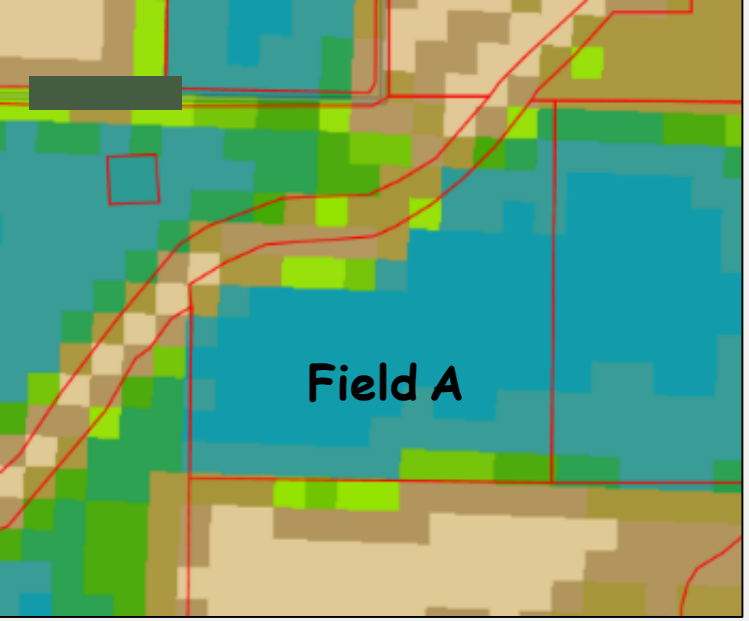
With limited rainfall, vast majority of this comes from applied irrigation:

- Are you keeping up with crop water demand?
- Are you irrigating too much?

How about within-field variability in ET_a?







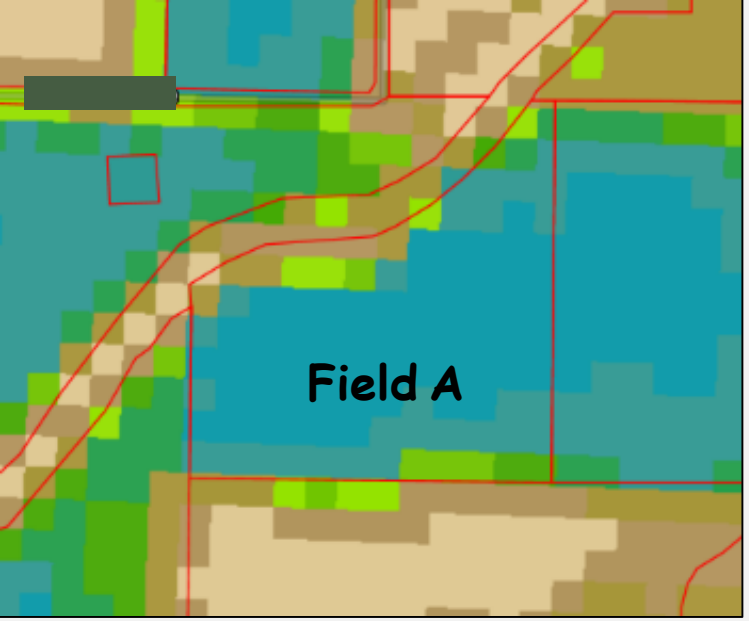
Highly uniform orchard (91% ET_a D.U.)

Mean ET_a = 34.5"

ET_{a95} = 36.7"

Difference of only 2.2", or 6% of mean ET_a

95% of the orchard at or below this ET_a level



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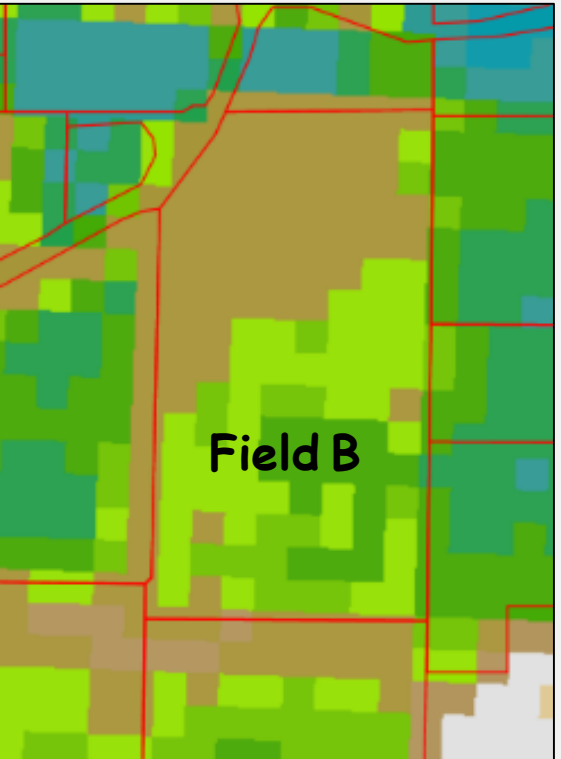


Low uniformity orchard (58% ET_a D.U.)

Mean ET_a = 11.4"

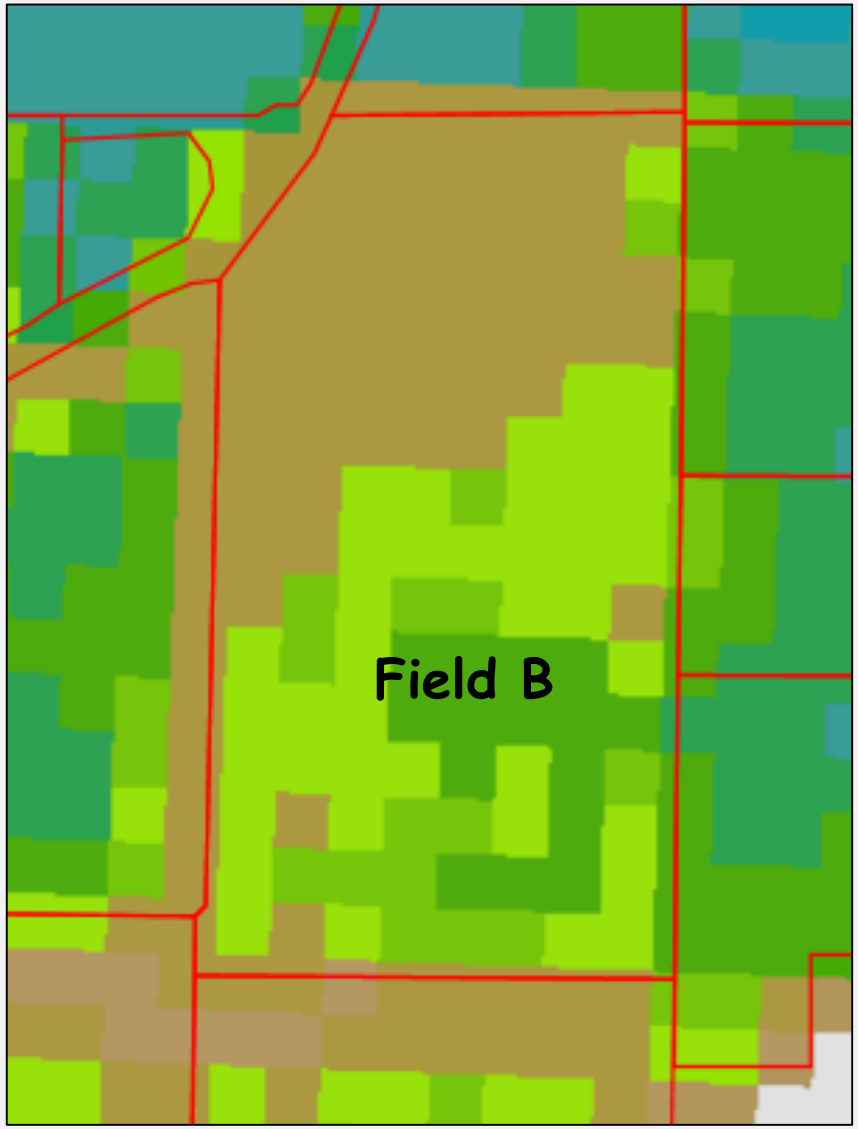
ET_{a95} = 18.9"

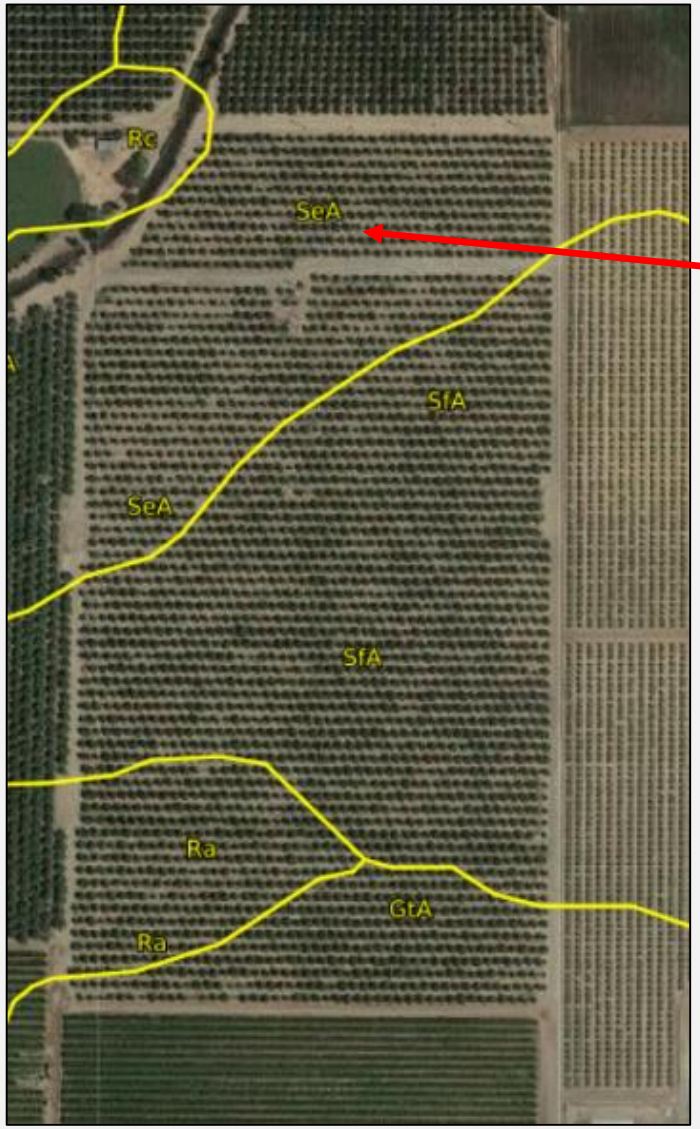
Difference of 7.5", or 66% of mean ET_a

What is the cause of this non-uniformity in ET_a?

SoilWeb: An Online Soil S

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





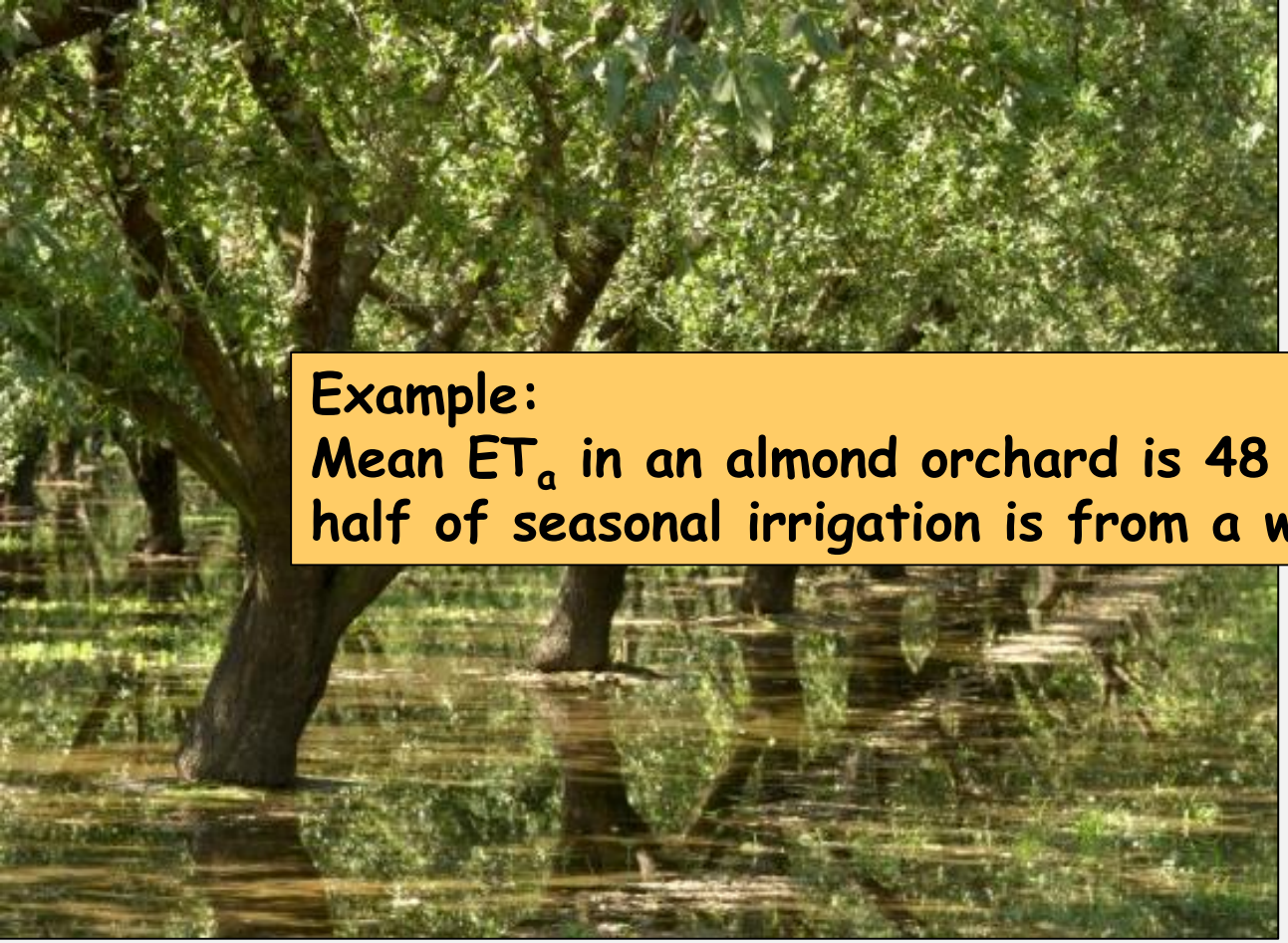
Lower soil water holding capacity; water stress between irrigations?

How to credit NO_3-N in irrigation water?

- Some wells in the KRWQC area have reasonably high NO_3-N concentration
- Where crops receive large annual volumes of this water the N loading is significant enough to justify reduced N fertilizer rates

How to credit NO_3-N in irrigation water?

- It is safe to credit all NO_3-N in *transpired water*
  - all transpired water leaves NO_3 ions at a root surface



Example:
Mean ET_a in an almond orchard is 48 inches during the irrigation season; half of seasonal irrigation is from a well containing 10 PPM NO_3-N

How to credit NO_3-N in irrigation water?

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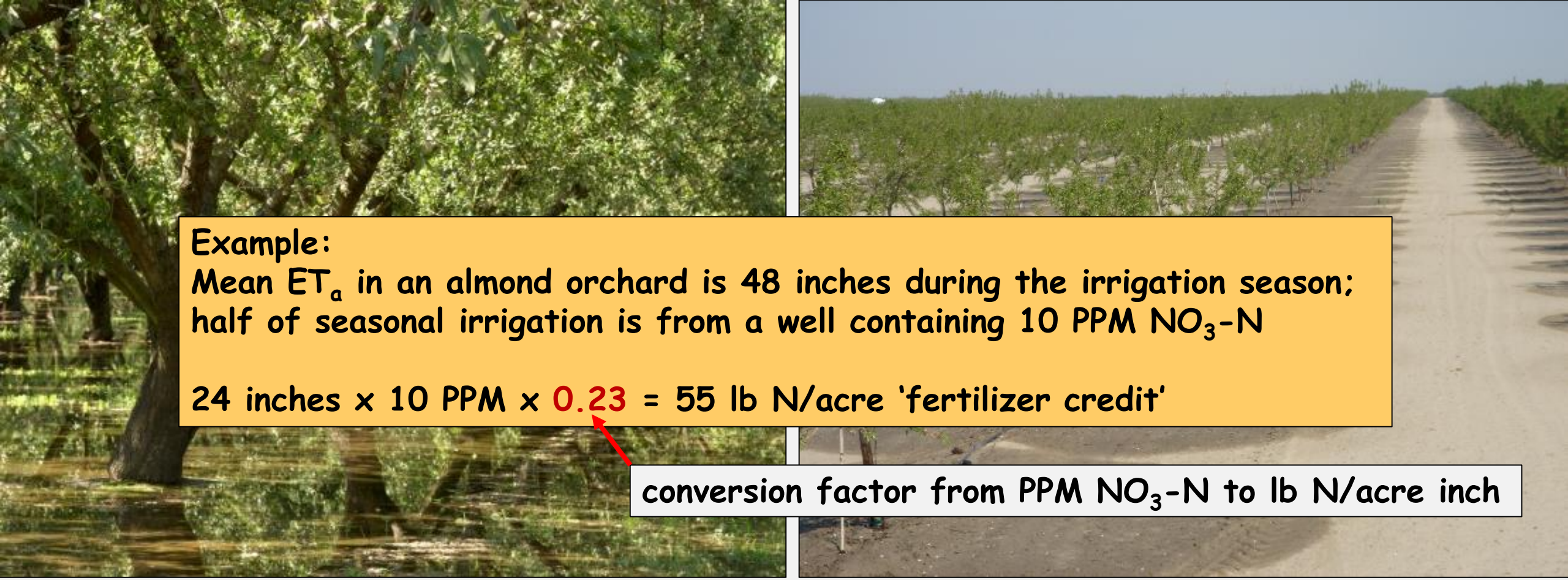

Example:
Mean ET_a in an almond orchard is 48 inches during the irrigation season; half of seasonal irrigation is from a well containing 10 PPM NO_3-N

24 inches x 10 PPM x 0.23 = 55 lb N/acre 'fertilizer credit'

conversion factor from PPM NO_3-N to lb N/acre inch

How to credit NO_3-N in irrigation water?

- It is safe to credit all NO_3-N in *transpired water*
  - all transpired water leaves NO_3 ions at a root surface

In summary :

- NO_3-N content of leached water can be substantial
- Maximizing N residence time in the active root zone is a priority
- Irrigation management can make or break N efficiency; use of ET_a data can make you a better irrigator