Water Use of Alfalfa

-- for Irrigation Planning and Scheduling --

Workshop on Efficient Water Management for Forage Crops

Beckwourth, CA – May 20th, 2024

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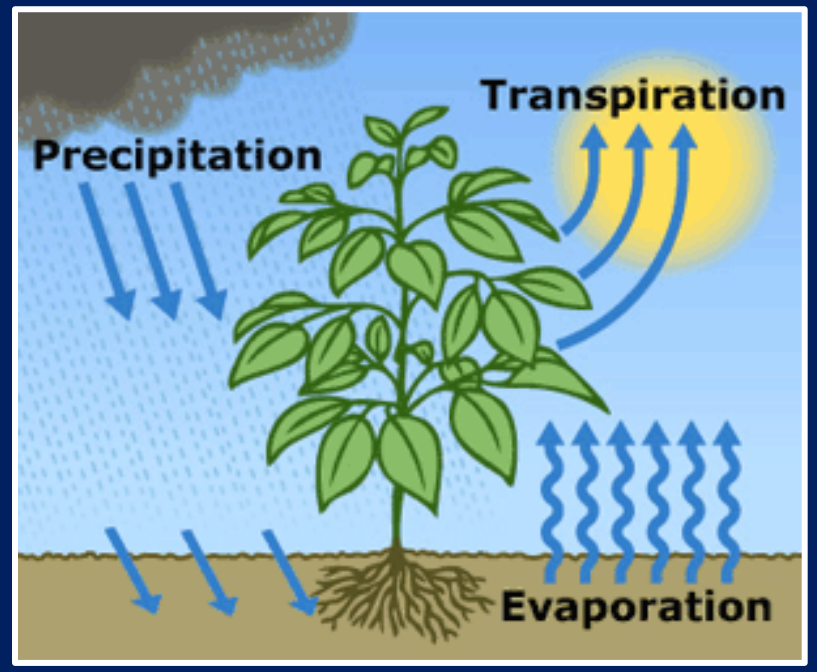
OBJECTIVES

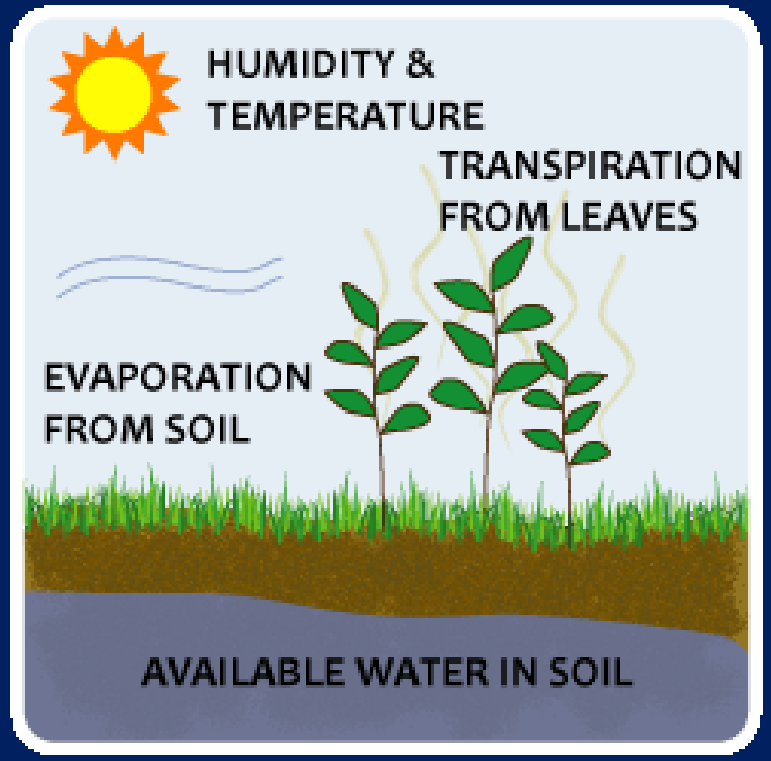
1) Background Information on Reference ET (ETo) vs. Crop ET (ETc)

2) Review Information on Water Use of Alfalfa from most recent studies

WHAT IS ET?

Evapotranspiration or ET is the total amount of water lost to atmosphere from a cropped surface through evaporation from soil and plants' canopy, and transpiration ("breathing") through the plants.





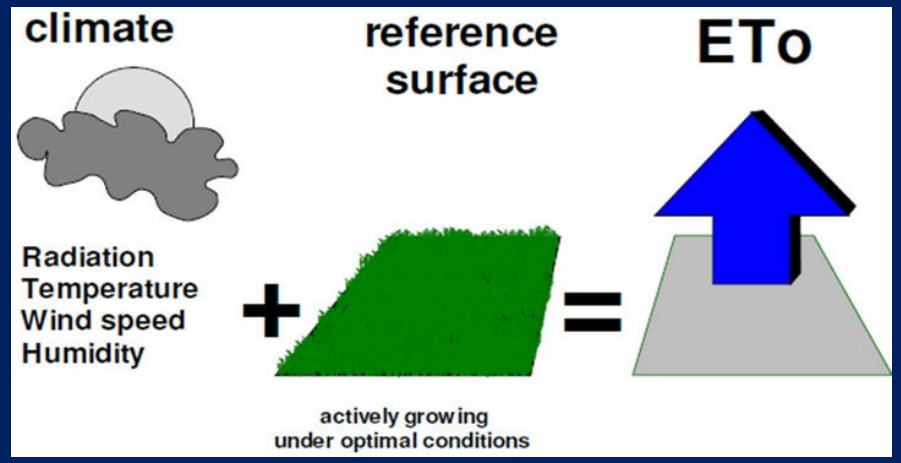
ET rate

- ✓ Crop & growth stage ↑
- ✓ Solar Radiation ↑
- ✓ Air Temperature ↑
- ✓ Relative Humidity ↓
- ✓ Wind Speed ↑
- ✓ Soil Moisture ↑

Reference ET (ETo) vs. Crop ET (ETc)

ETo or **Reference Evapotranspiration** is the water lost to atmosphere from:

- ✓ an extensive surface of green grass (CA)
- ✓ with uniform height (4.7 in. = 0.12 m)
- ✓ actively growing without limitations
- ✓ well-watered & well-nourished
- ✓ free of water stress and diseases
- ✓completely shading the ground.



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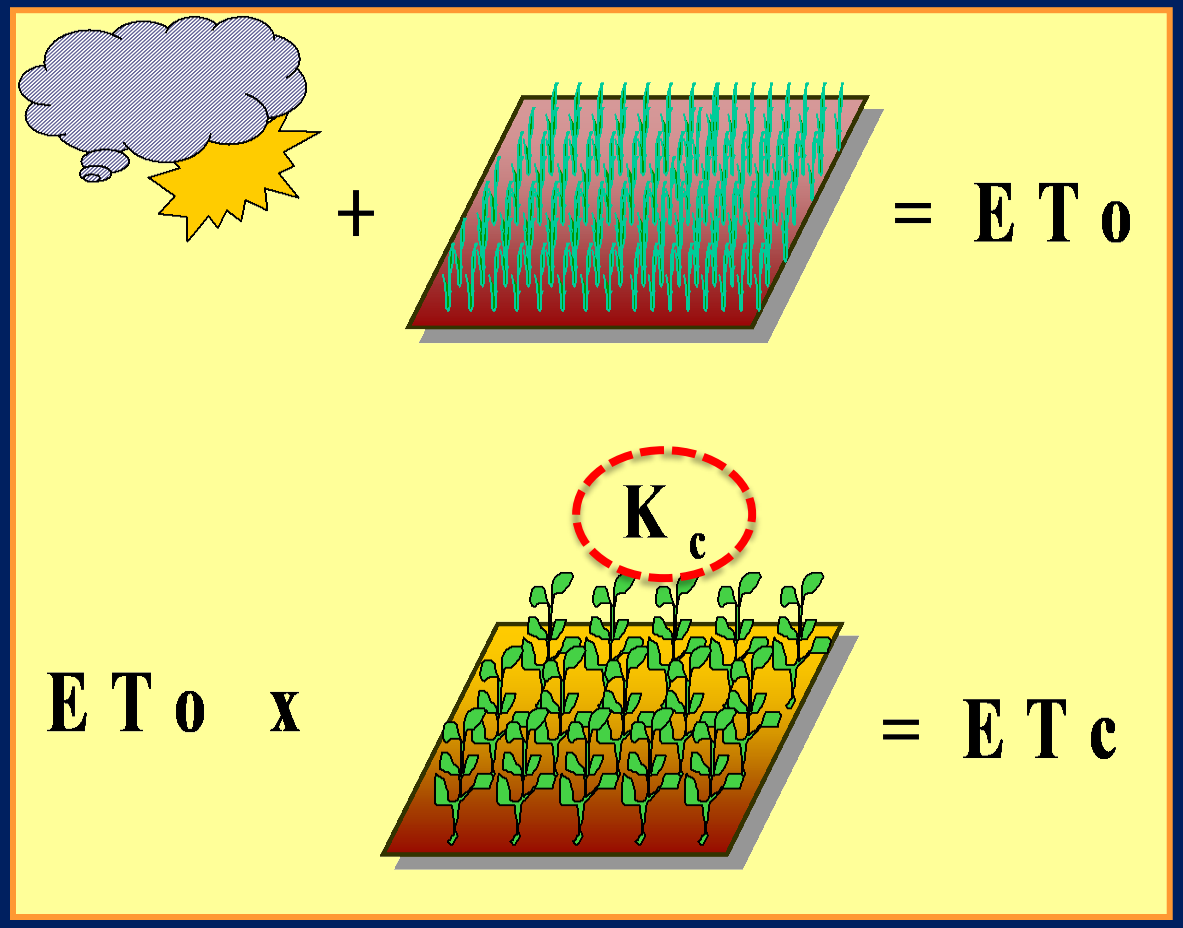
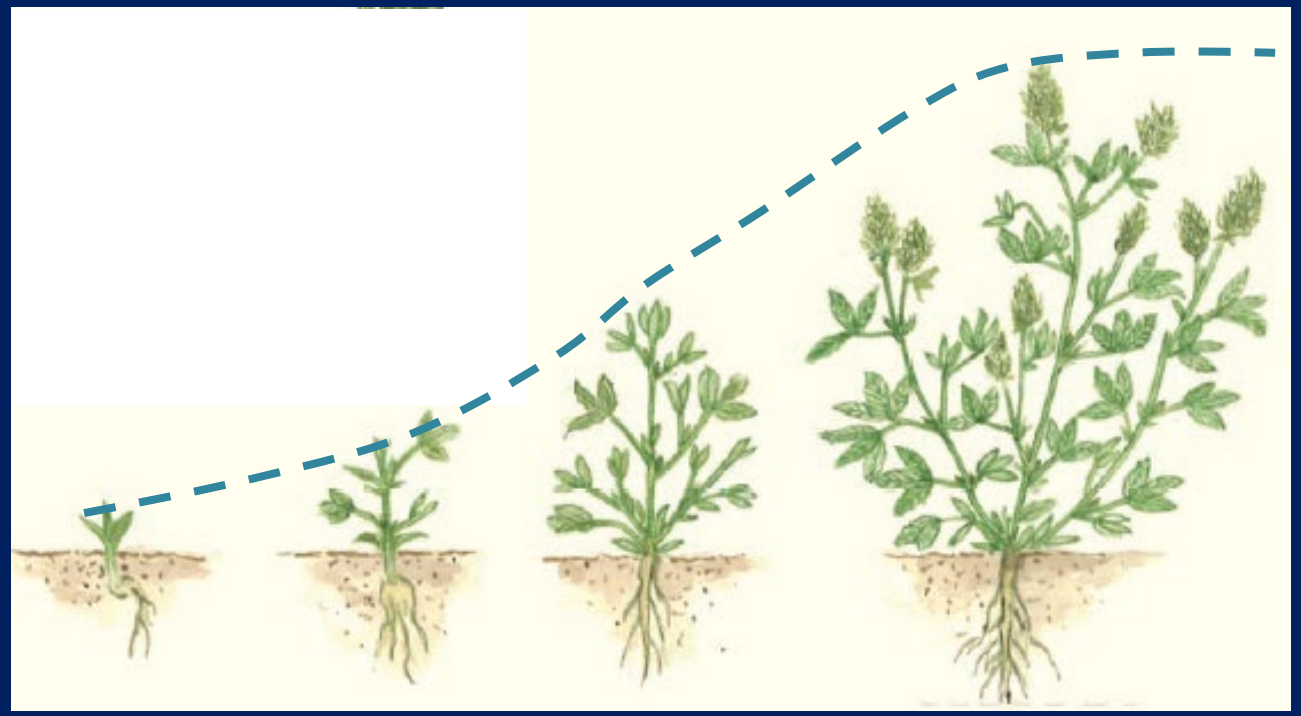
ETc or **Crop Evapotranspiration** is the amount of water used by:

- ✓ a disease-free, well-watered and well-fertilized crop
- ✓ grown in large fields
- ✓ under optimum soil-water and nutrient conditions
- ✓ achieving full production under the given climatic conditions

ETo vs. ETc



(EVAPORATION + TRANSPIRATION) = EVAPOTRANSPIRATION

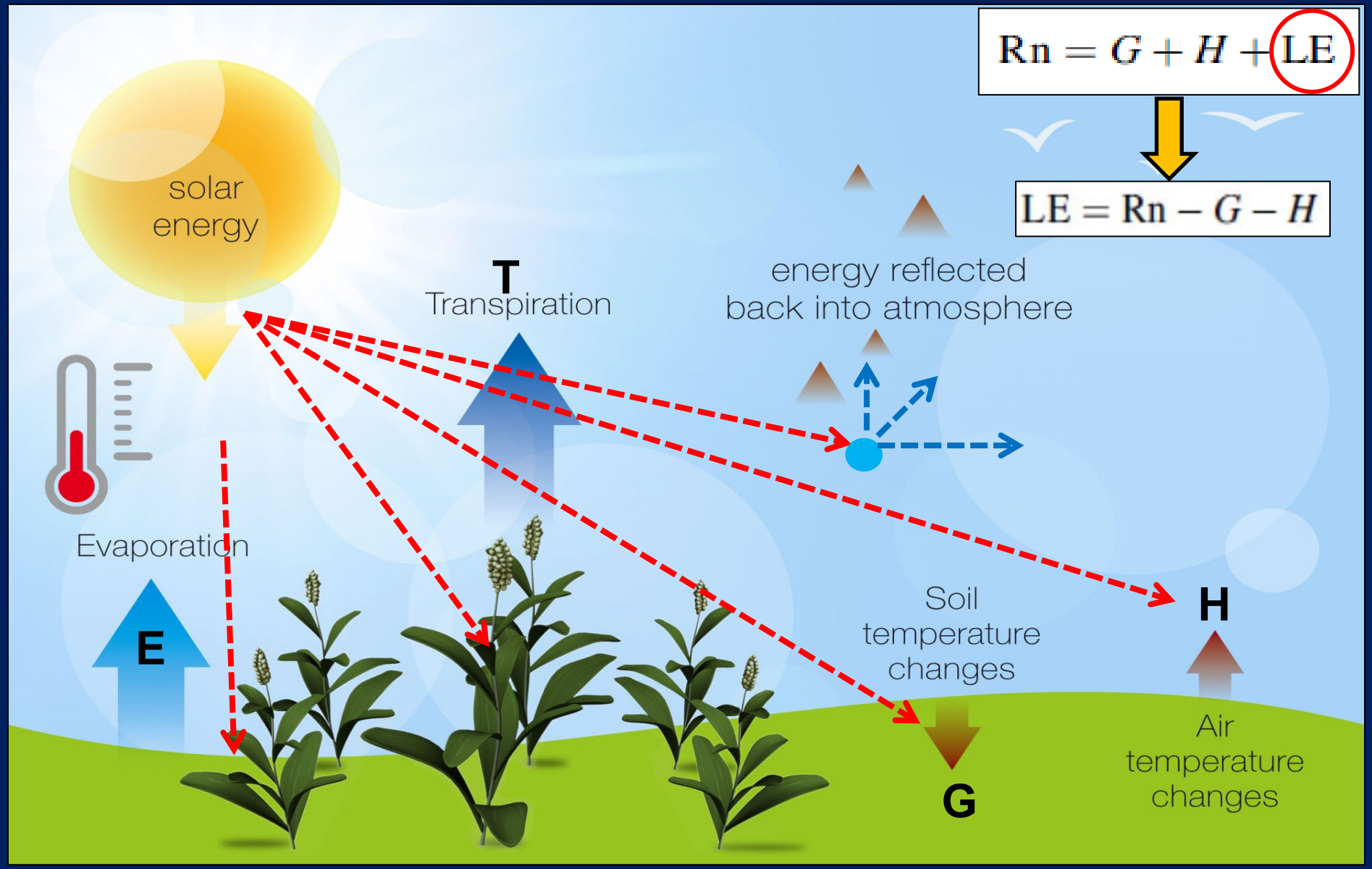


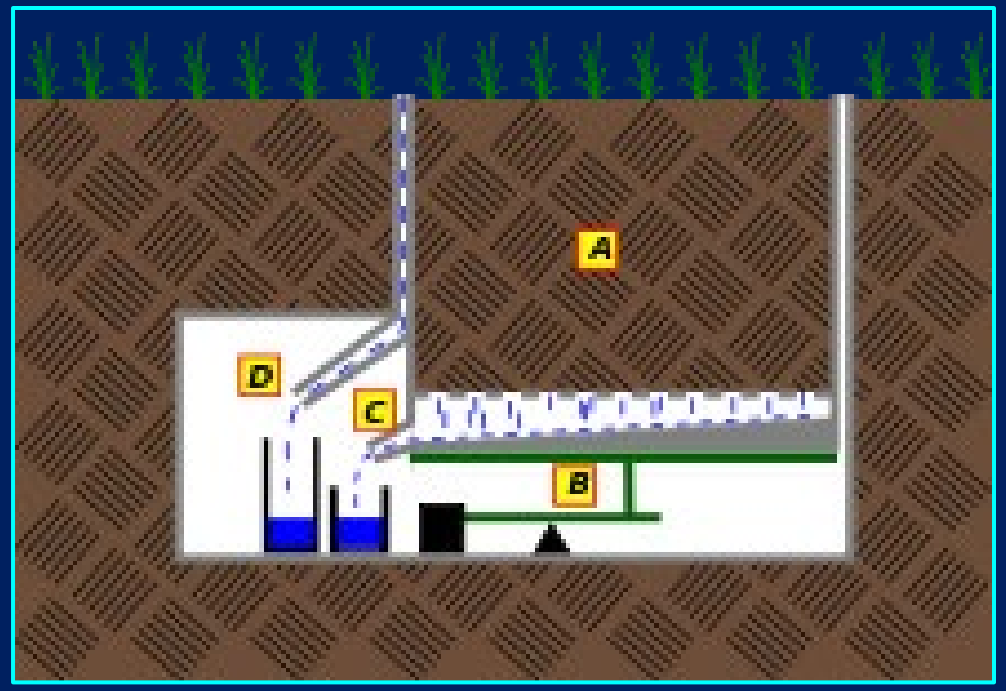
At the initial stages of the crop (or during re-growth), ETc is small and most of the water is lost by evaporation from soil surface

When plant canopy grows, ETc increases and most of water is lost by transpiration from leaves and canopy

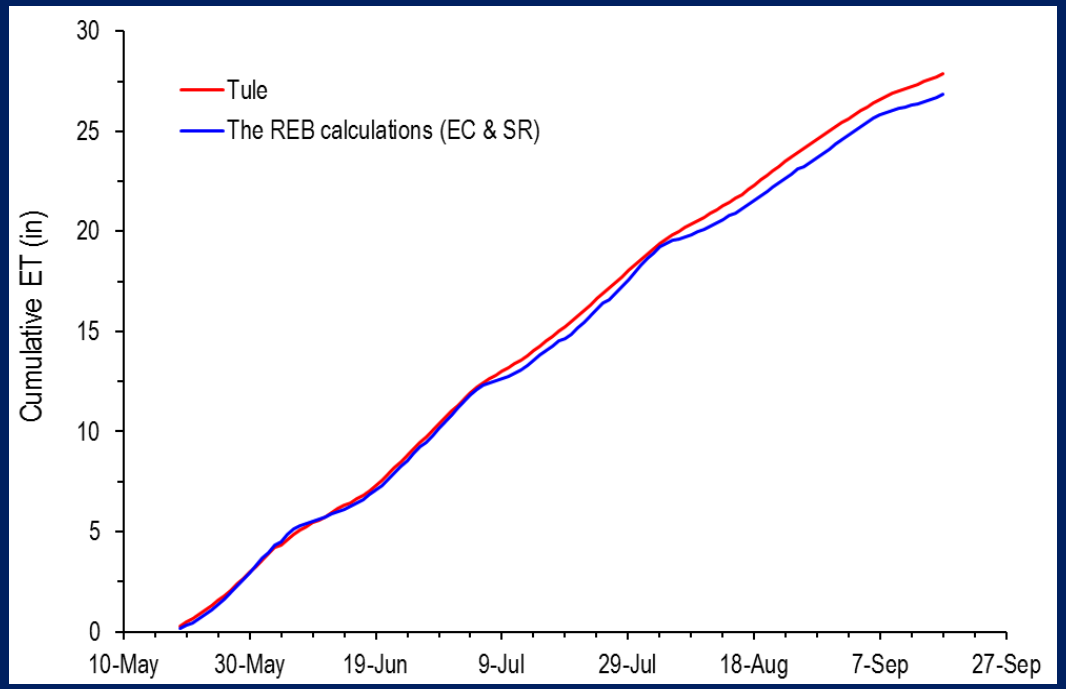
EVAPOTRANSPIRATION IS AN ENERGY-DRIVEN PROCESS

SOLAR RADIATION IS THE MAIN ENERGY SOURCE FOR CROP ET




A
B
C
D


tule


Tule
The REB calculations (EC & SR)
Cumulative ET (in)
0
5
10
15
20
25
30
10-May
30-May
19-Jun
9-Jul
29-Jul
18-Aug
7-Sep
27-Sep

Residual of Energy Balance Method for Calculating Actual Crop Evapotranspiration

$$\mathrm{Rn} = G + H + \mathrm{LE}$$

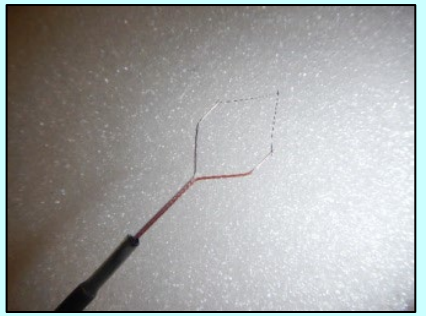
MEASURED

$$LE = R_n - G - H$$

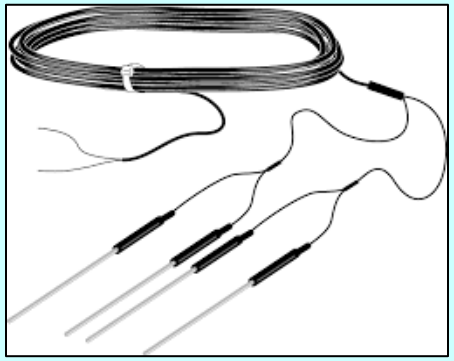
Sensible Heat Flux

Eddy Covariance

Surface Renewal

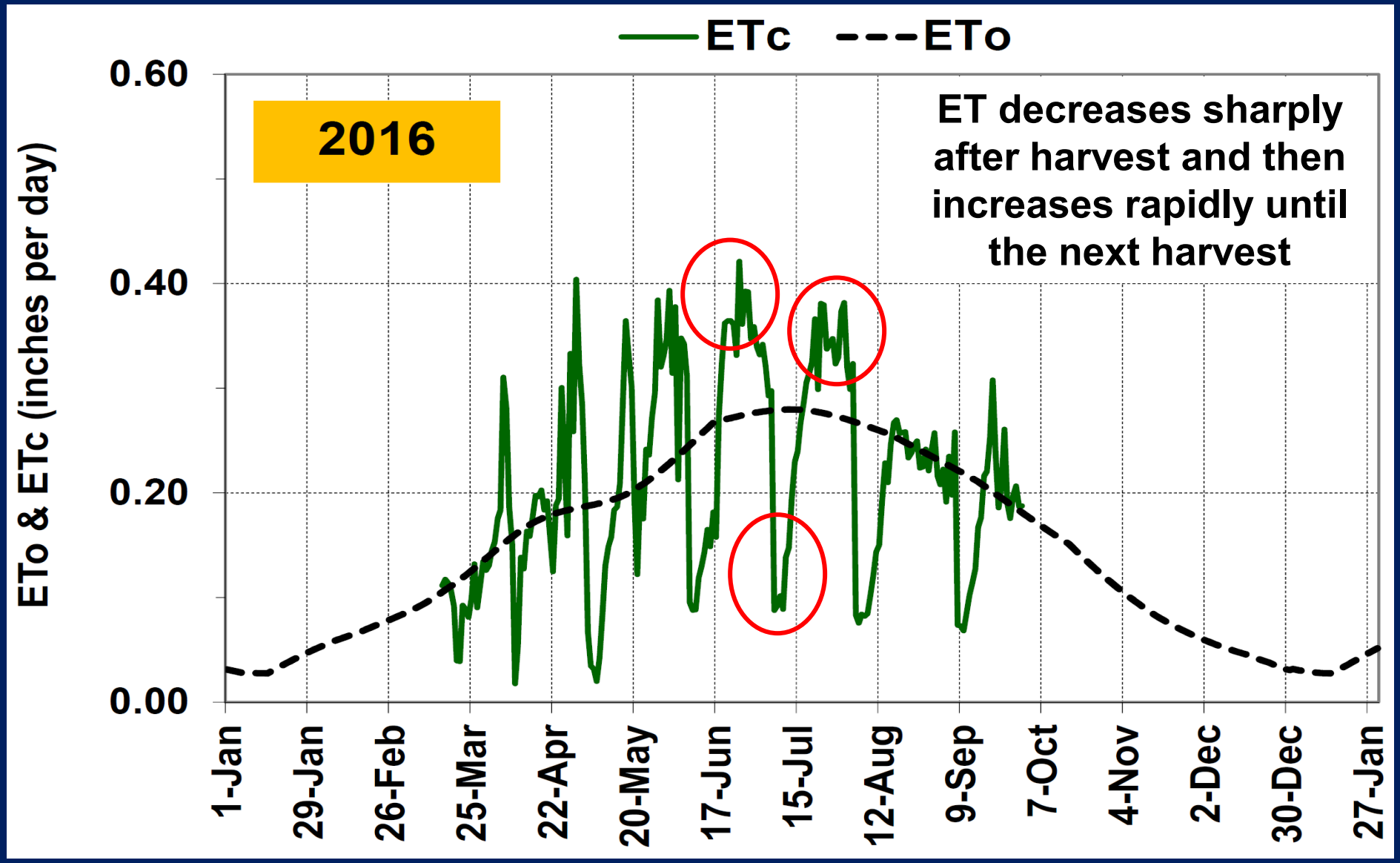


Net Radiation



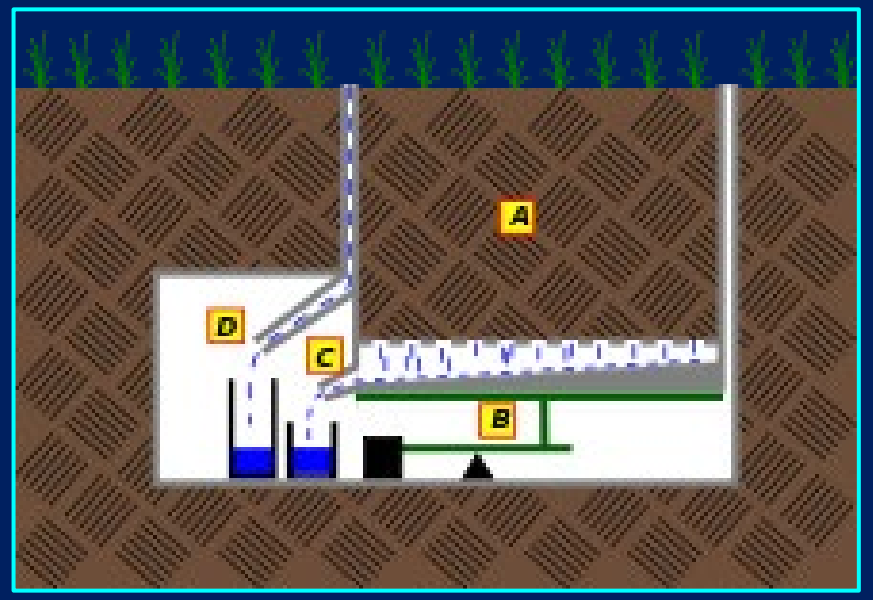
Ground Heat Flux

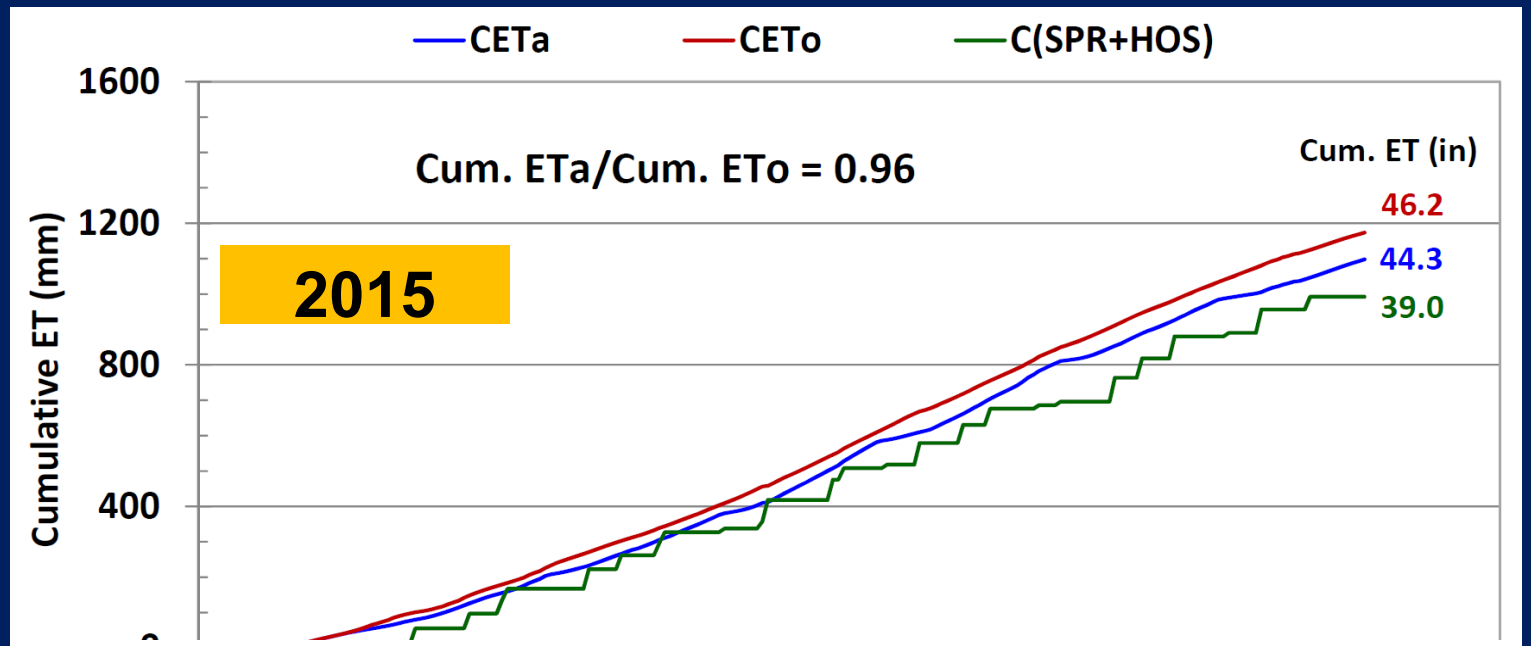
Alfalfa ET varies along the growing season as it is affected by weather, growth & periodic cuttings

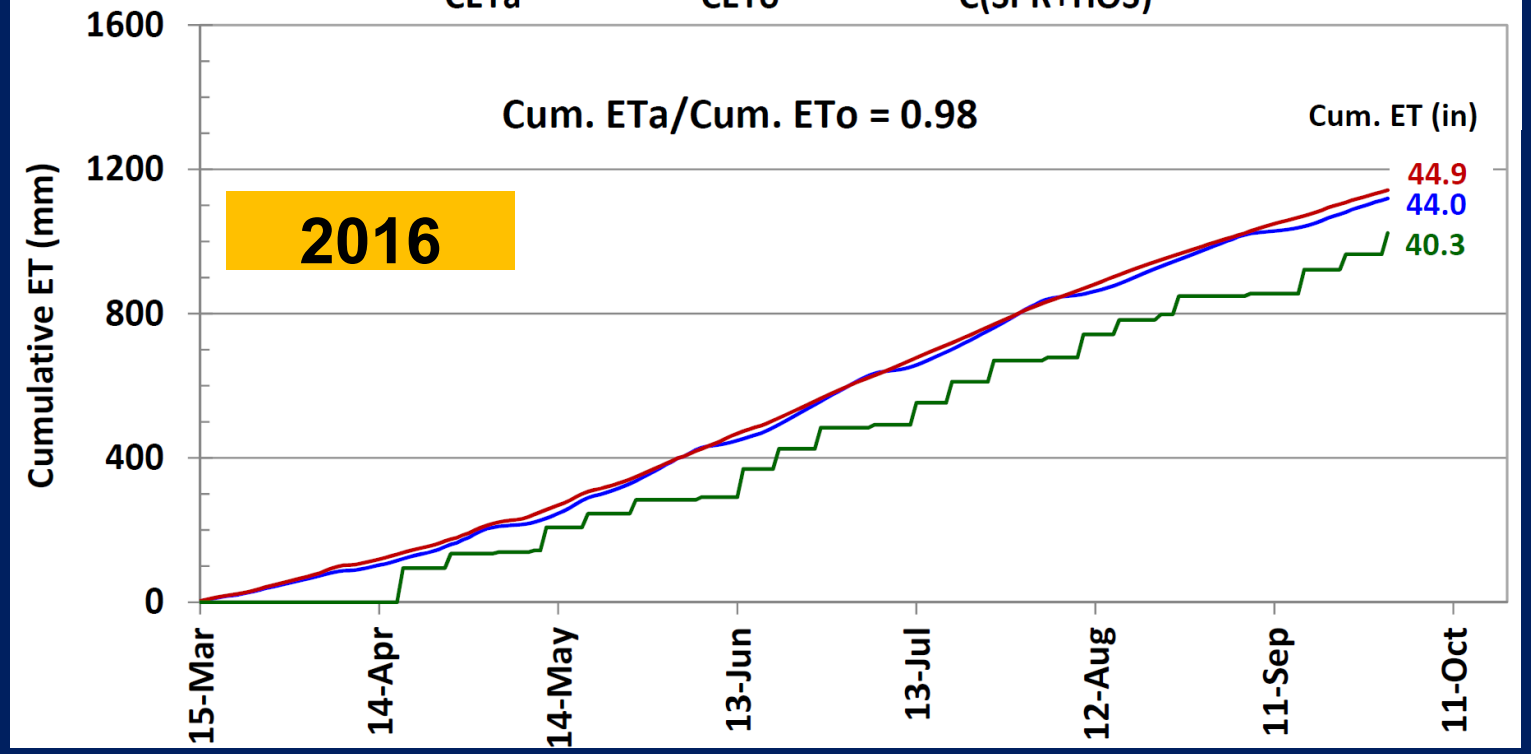


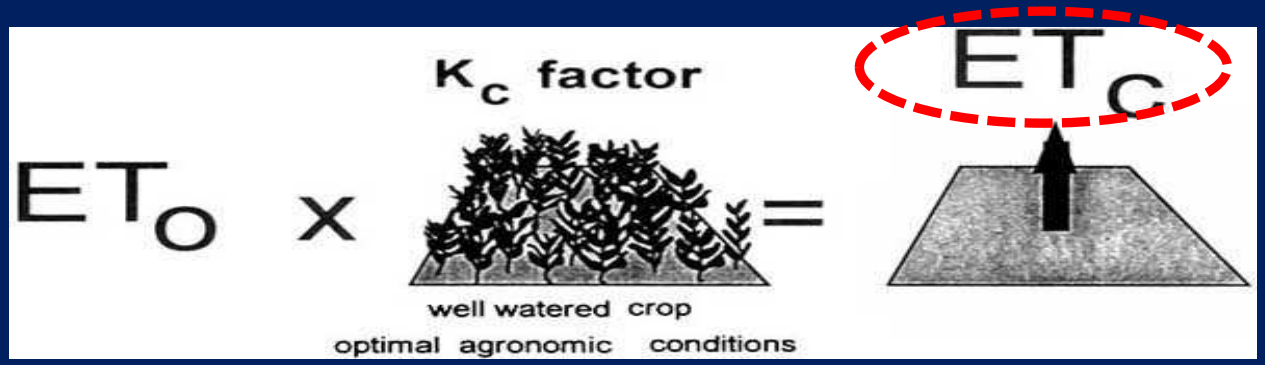
Region	Site	Year	Age Of alfalfa	Seasonal ET (inches)	Reference ET (inches)
Imperial Valley	LM1	2007	3	55.8	73.2
	LM2	2008	2	66.0	73.3
	LM2	2009	3	55.6	67.9
	GR	2010	2	63.5	73.2
	EL	2010	2	59.8	70.0
	WA	2010	2	65.8	70.0
San Joaquin Valley	KC	2007	2	56.6	57.0
	KC	2008	3	59.4	59.3
Sacramento Valley	CH1	2005	3	49.4	63.6
	CH2	2006	2	54.8	55.9
	CH2	2007	3	55.0	58.0
	CH2	2008	4	50.4	59.4
	EE	2010	3	46.3	48.8
	EW	2010	4	42.5	48.8
Scott Valley/Shasta Valley	EN	2007	2	39.6	44.0
	EN	2008	3	32.8	42.6
	EN	2009	4	33.8	40.4
	FI	2009	5	36.1	37.4
	SH	2009	4	38.8	40.4
	AP	2010	5	37.3	37.4
	FI	2010	2	34.7	37.4
	FA	2010	6	38.8	41.1
Tulelake	TU	2007	4	39.0	40.5
	TU	2008	5	34.3	36.5

Ave. 37 in.


A
B
C
D


CETa
CETo
C(SPR+HOS)
Cumulative ET (mm)
1600
1200
800
400
Cum. ETa/Cum. ETo = 0.96
Cum. ET (in)
46.2
44.3
39.0
2015


CETa
CETo
C(SPR+HOS)
Cumulative ET (mm)
1600
1200
800
400
0
Cum. ETa/Cum. ETo = 0.98
Cum. ET (in)
44.9
44.0
40.3
2016
15-Mar
14-Apr
14-May
13-Jun
13-Jul
12-Aug
11-Sep
11-Oct



Amount of water lost by alfalfa for ET

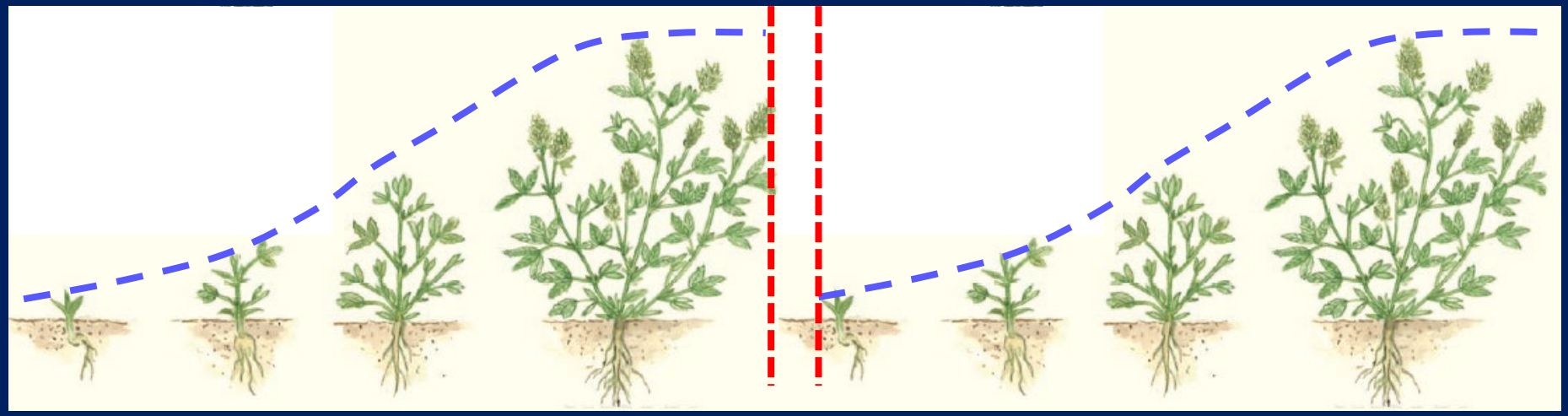
Seasonal Crop Coefficient (Kc) for commercial field conditions:

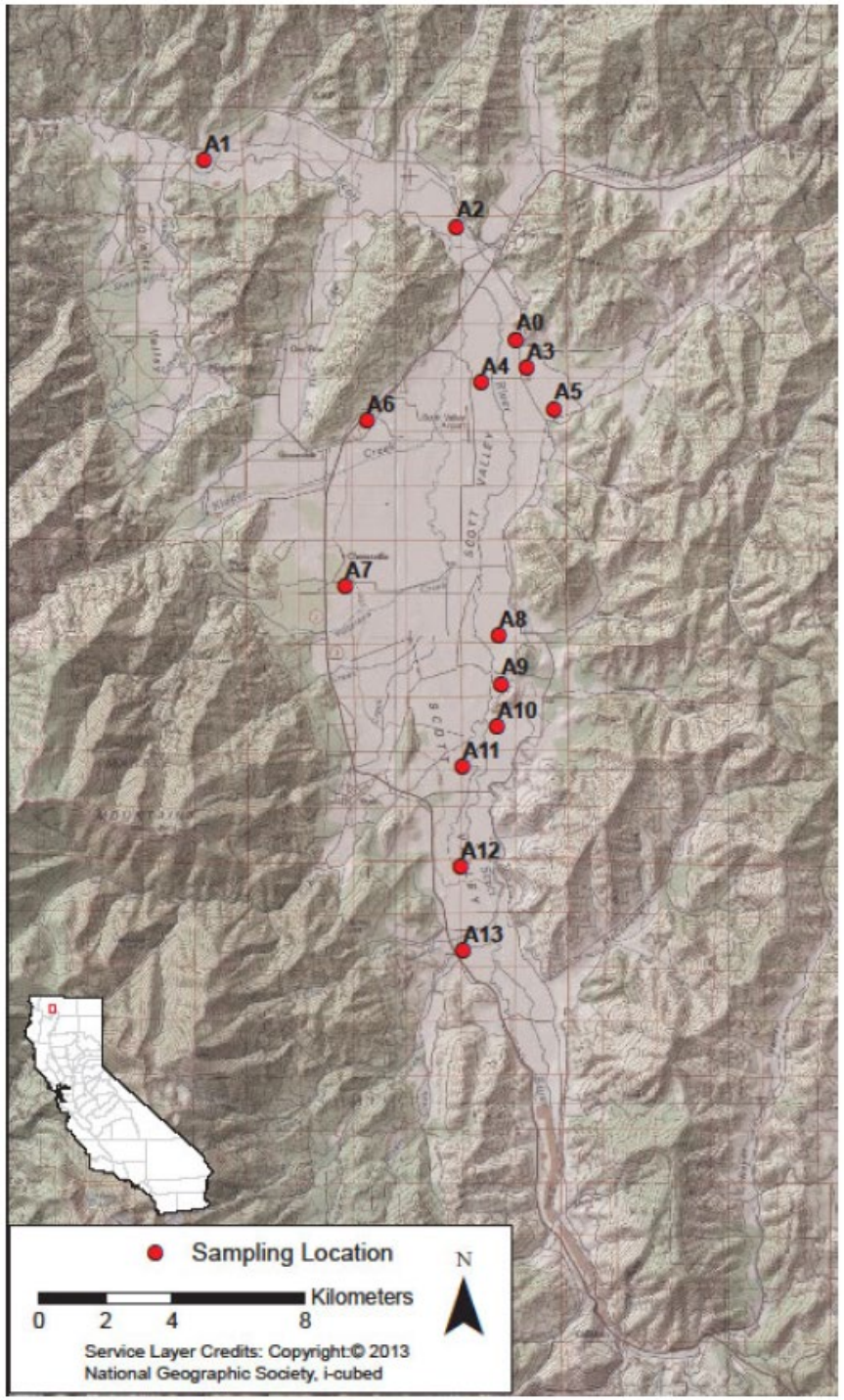
K_c = 0.96 - 0.98 (averaged over the entire crop season – Sacramento Valley)

Within-cycle Crop Coefficient (Kc): **Average Yield (dry matter) = 9.3 – 9.6 Ton/ac**

$K_c \approx$ 0.35 - 0.40 after cutting until irrigation, and for 3-4 days after

$K_c \approx$ 1.05 - 1.10 from 3-4 days after irrigation till the next cutting





In 2012-2013-2014, a UC Team measured Alfalfa ET in 3 center pivot irrigated, well-managed fields in Scott Valley for 3 years (from March 15 onwards)

R.L. Snyder, P. D.Thamer, N. Stevens, T.H. Harter, and S.B. Orloff

Year	Field	ET_{os}	ET_{cs}	K_{cs}	Ending date
		in.	in.		
	A5	32.5	27.9	0.86	11-Sep
2012	A7	32.3	29.7	0.92	10-Sep
	A8	31.5	27.7	0.88	6-Sep
	A1	37.8	32.7	0.87	5-Oct
2013	A2	36.8	34.8	0.95	26-Sep
	A5	29.0	25.5	0.88	5-Sep
	A1	35.3	32.8	0.93	6-Sep
2014	A2	33.5	28.8	0.86	27-Aug
	A5	37.3	31.0	0.83	16-Sep
	Means	**34.0**	**30.1**	**0.89**	**12-Sep**

Seasonal ET_o, ET_c, and K_c (ET_{os}, ET_{cs}, *and* K_{cs}) for the three seasons in Scott Valley. The season start date is 15 March and the season ends on the indicated dates.

SCOTT VALLEY

Seasonal ETo, ETc, and Kc

Average year-long Kc = 0.89

Year	Field	ET_{os}	ET_{cs}	K_{cs}	Ending date
		in.	in.		
	A5	32.5	27.9	0.86	11-Sep
2012	A7	32.3	29.7	0.92	10-Sep
	A8	31.5	27.7	0.88	6-Sep
	A1	37.8	32.7	0.87	5-Oct
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Seasonal ET_o, ET_c, and K_c (ET_{os}, ET_{cs}, *and* K_{cs}) for the three seasons in Scott Valley. The season start date is 15 March and the season ends on the indicated dates.

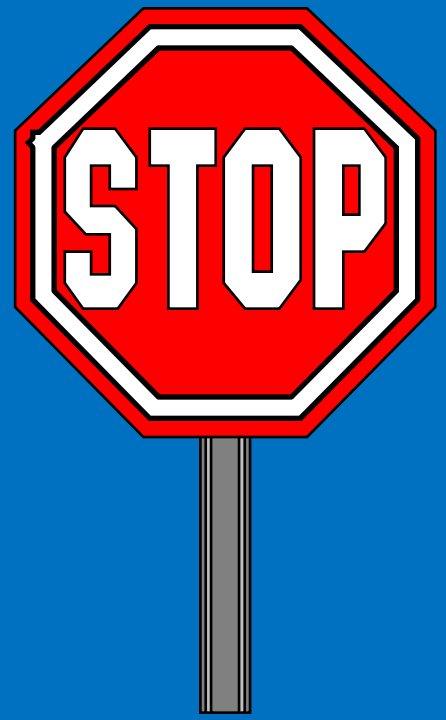
Average off-season Kc = 0.80

Annual ETo, ETc, and Kc

Average seasonal Kc = 0.84

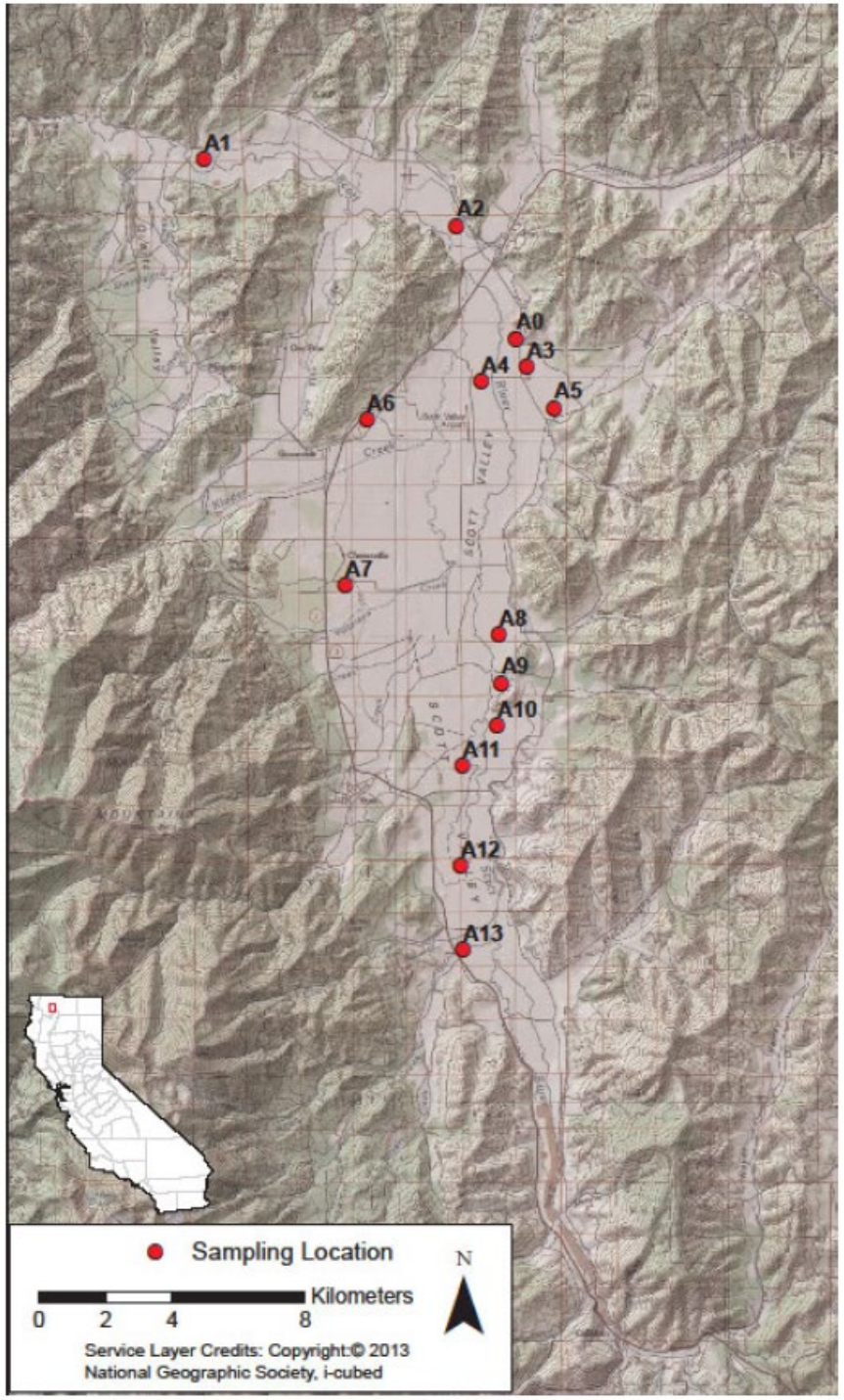
Year	Field	ET_{oc}	ET_{cc}	K_{cc}
		in.	in.	
	A5	45.7	37.3	0.82
2012	A7	45.7	39.5	0.86
	A8	45.7	38.4	0.84
	A1	47.7	40.0	0.84
2013	A2	47.7	43.0	0.90
	A5	47.7	40.2	0.84
	A1	48.6	42.5	0.87
2014	A2	48.6	38.9	0.80
	A5	48.6	39.7	0.82
	Means	**47.3**	**40.0**	**0.84**

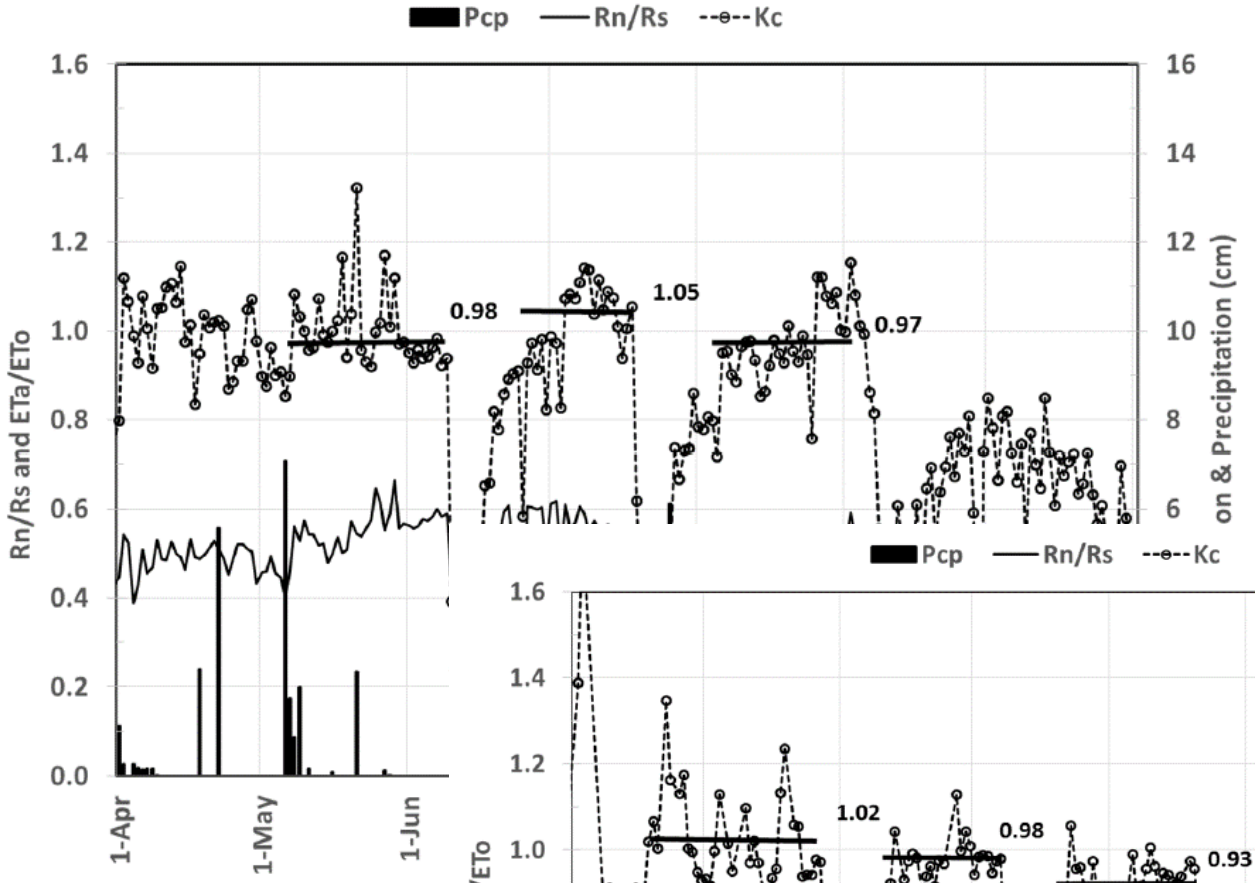
Annual cumulative ET_o, ET_c, and K_c (ET_{oc}, ET_{cc}, and K_{cc}) for the three fields in Scott Valley by year. The annual starting and ending dates are 1 January 1 and December 31.

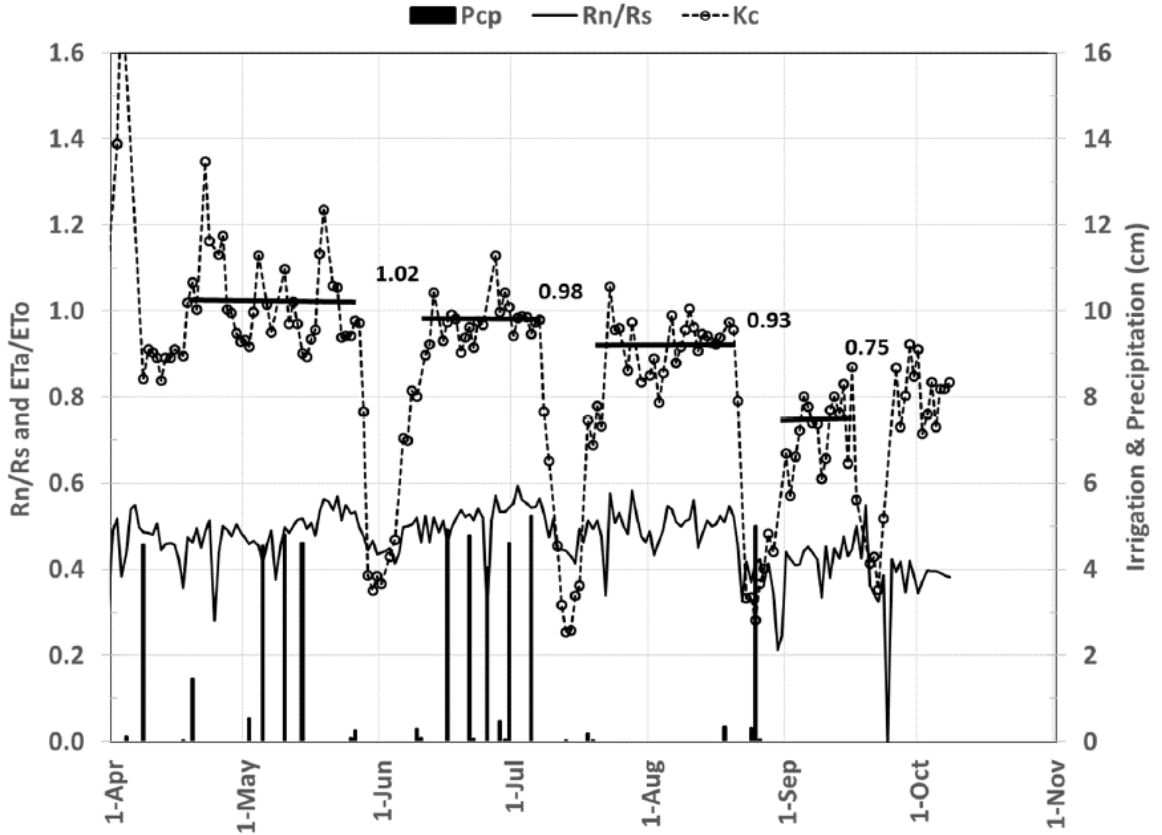


THANK YOU !!

QUESTIONS OR COMMENTS?


A1
A2
A0
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
Sampling Location
Kilometers
0 2 4 8
N
Service Layer Credits: Copyright:© 2013
National Geographic Society, i-cubed


Pcp
Rn/Rs
Kc
Rn/Rs and ETa/ETo
on & Precipitation (cm)
0.98
1.05
0.97
1-Apr
1-May
1-Jun


Pcp
Rn/Rs
Kc
Rn/Rs and ETa/ETo
Irrigation & Precipitation (cm)
1.02
0.98
0.93
0.75
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov