Promises and Pitfalls of Adapting New Technology…

Studies on Subsurface Drip Irrigation (SDI) in Alfalfa – What we've learned to date.

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Drip irrigated alfalfa field, California

University of Arizona-August 12, 2016

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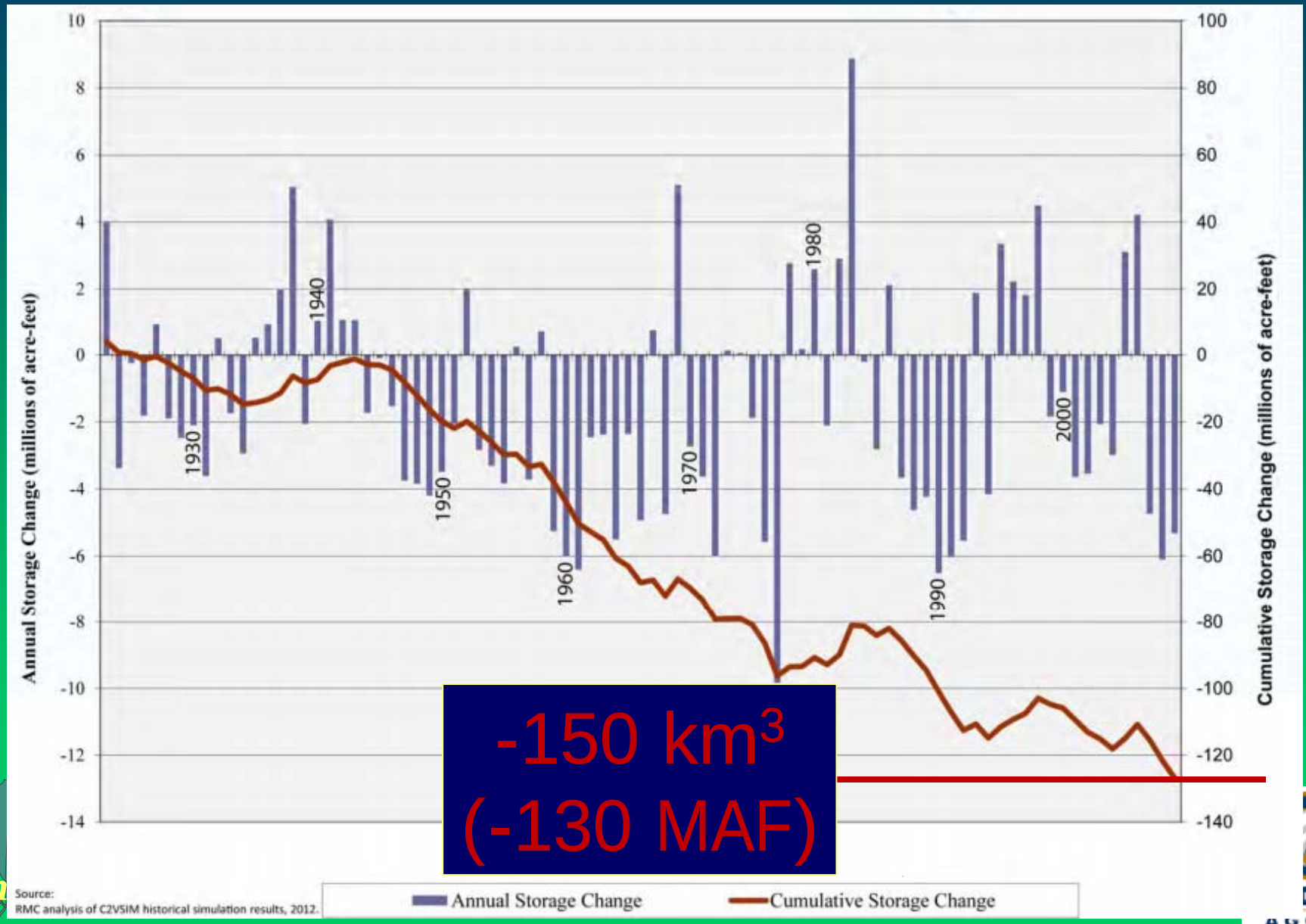
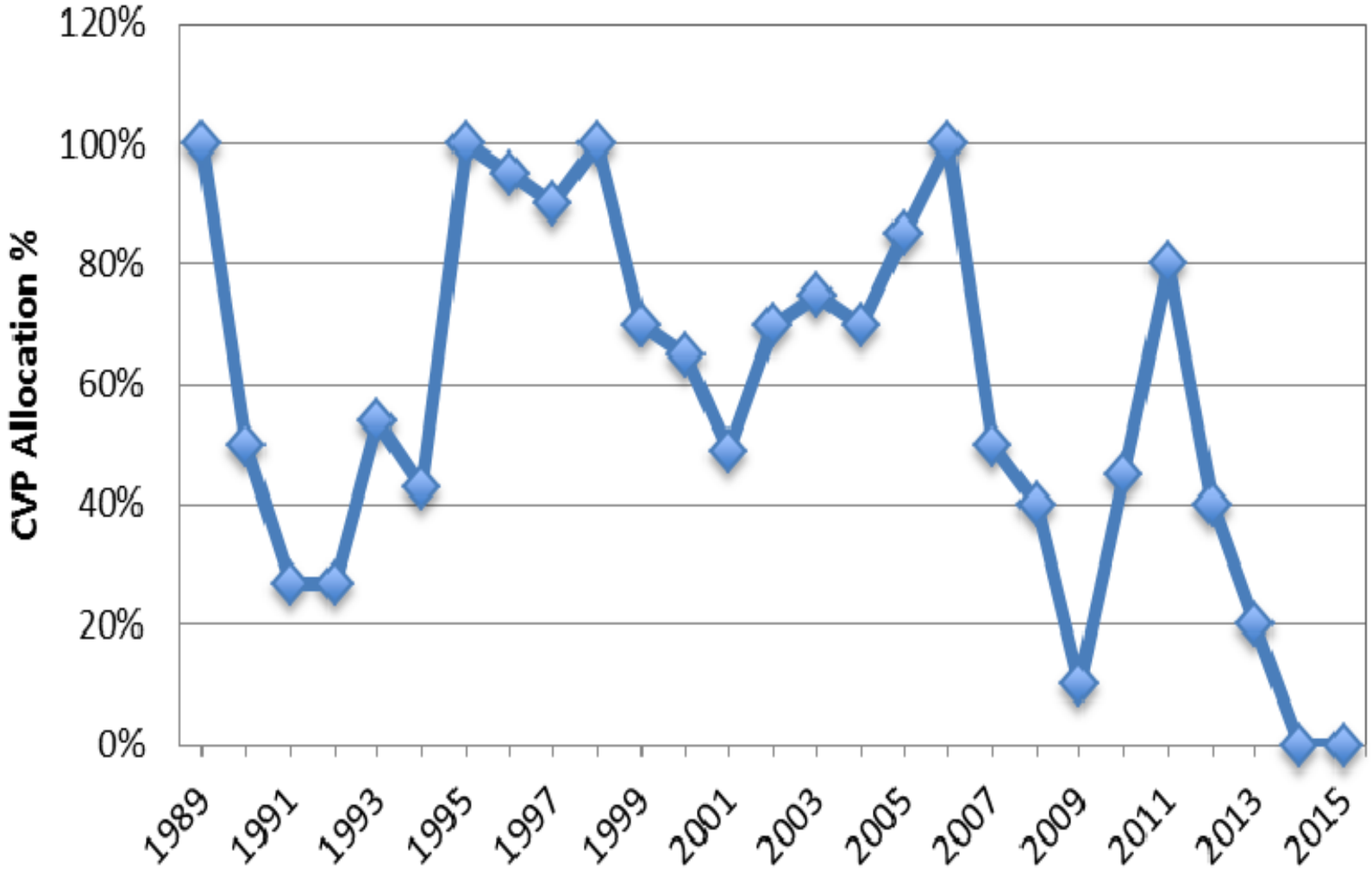
What does the future hold?

Change in Groundwater Storage in the Central Valley, 1920 - 2010

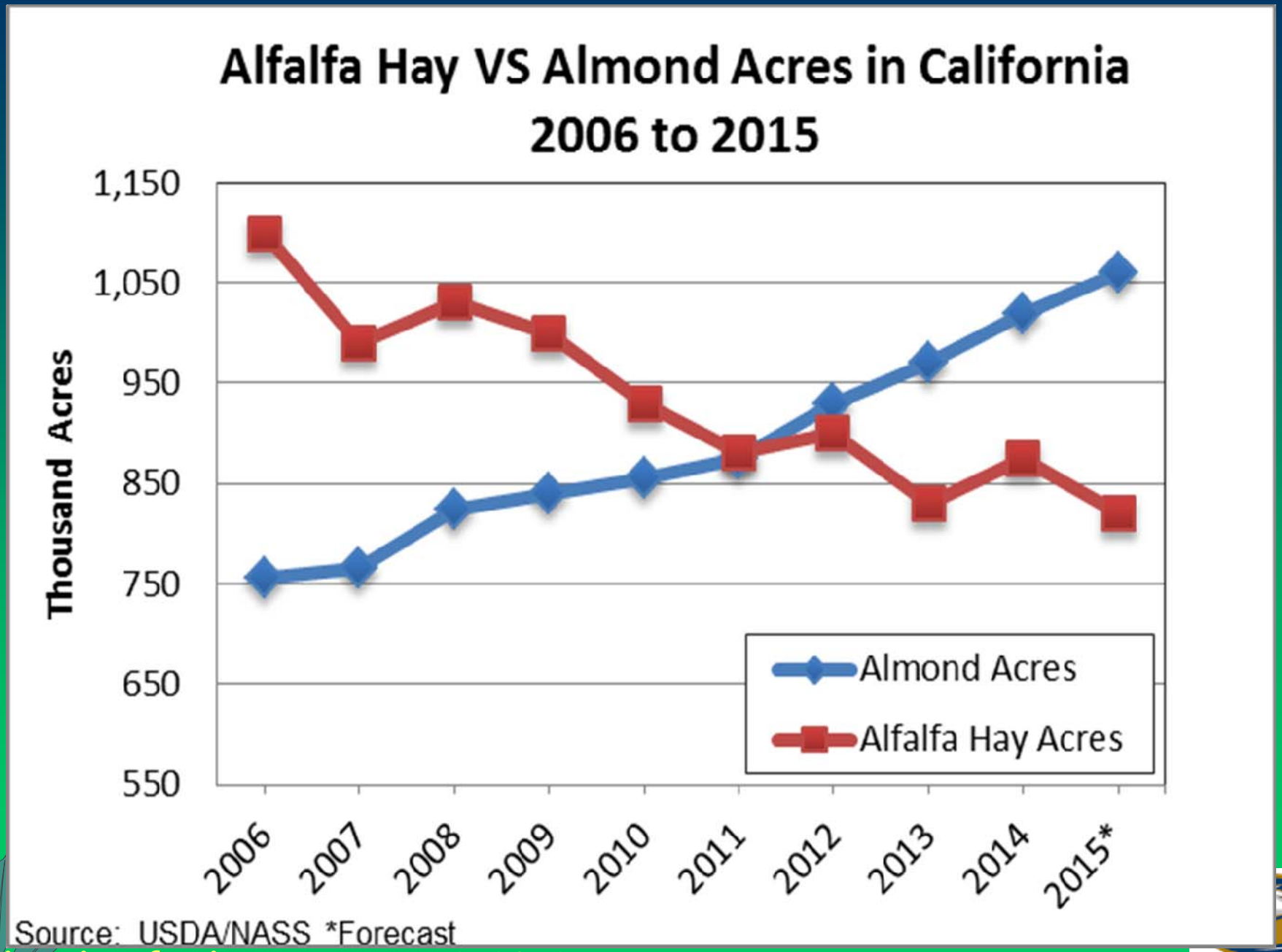


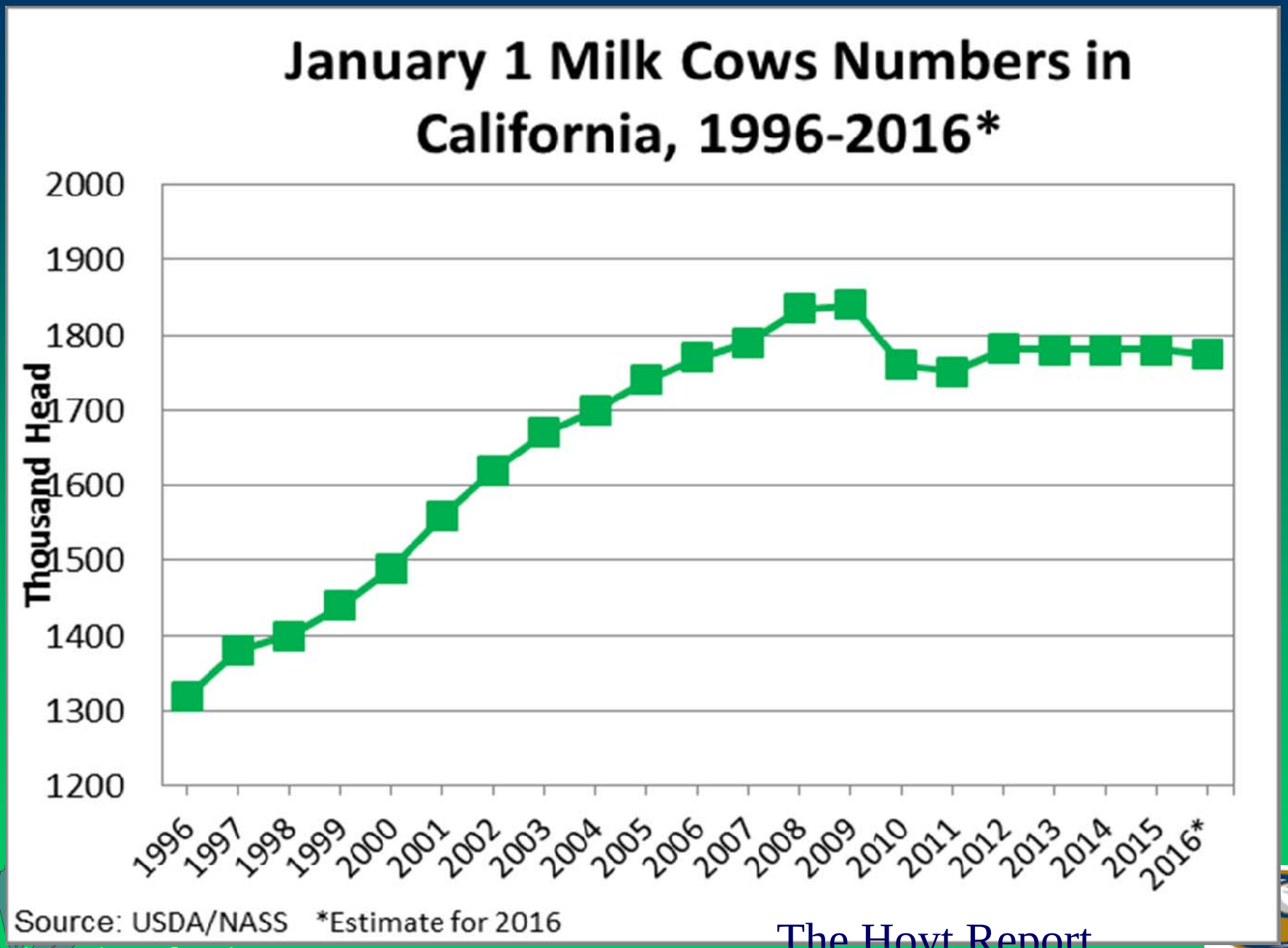
from: Lester Snow, CA Water Foundation

CVP Water Allocations from Bureau of Reclamation



Source: Westlands Water District


Alfalfa Hay VS Almond Acres in California
2006 to 2015
Thousand Acres
1,150
1,050
950
850
750
650
550
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015*
Almond Acres
Alfalfa Hay Acres
Source: USDA/NASS *Forecast


January 1 Milk Cows Numbers in California, 1996-2016*
Thousand Head
2000
1900
1800
1700
1600
1500
1400
1300
1200
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016*
Source: USDA/NASS *Estimate for 2016


Hay Exports from US to China (Ten year trend)
All Hay (tons)
1,200
1,000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Future trends for Alfalfa?

- Dethroned as #1 acreage crop (~2012)
- 'Tug of war' between
  - Restrictions on acreage/production due to competition from other crops, water limitations
  - Strong demand from Western Dairies, Exports, horses, other livestock
- Need for:
  - Higher yields on limited land availability (this is a GLOBAL issue)
  - Lower water use
  - Water transfers
  - 'Sustainable intensification'
- Alfalfa will remain a major crop for many years to come

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California Alfalfa

- ~84% Surface irrigation
- ~14% sprinklers (pivots/wheel lines)
- ~2-3% SDI

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Why an interest in SDI in Alfalfa?

- Possibility of Higher Yields
- Experience with other crops
- Higher Hay price
- The Water Squeeze

Drip Irrigated Alfalfa
Fresno County, CA

Drip Irrigated Alfalfa – Seeley, CA

UC SDI Studies:

- "Case Studies" of grower's experiences across a range of environments (18-20)
  - Documenting successes/failures
  - Costs/benefits
- Controlled Studies on UC Facilities:
  - SDI compared with Flood
  - Variety interactions (with AZ, NMSU)
  - Deficit Irrigation with drip
  - Spacing Studies, understanding optimum irrigation management
  - Gopher Management

Key Recommendations

To consider SDI in alfalfa:

- Must improve yields over surface irrigation to justify cost
- Must understand source of water, water quality, delivery
- Must be prepared for higher level of management

Sample Costs for SDI
(compared with surface irrigation)

Item	Partial Budget ($/a)	Annualized Costs ($/a)
Drip Tape (40”) – 6 yr.	$450 (400-500)	75
Drip Tape Installation– 6 yr.	$200 (100-300)	33.33
Irrig. Infrastructure (valves/pipes, pump) -15 yr.	$1400 (800-1800)	93.33
Water Cost (-8% SDI)	-$42 (+10% to -20%)	-$42
Energy Cost (vs. surface)	$118	$118
Labor Irrig. Management	-$66	-$66
Labor for Rodent mgt. & repair	$75	$75
Remove Driplines—6 yr.	100 (80-120)	16.67
Total Sample costs	$2,050 initial + $185/yr	302.50/year

Note: Actual costs may be higher or lower than these amounts

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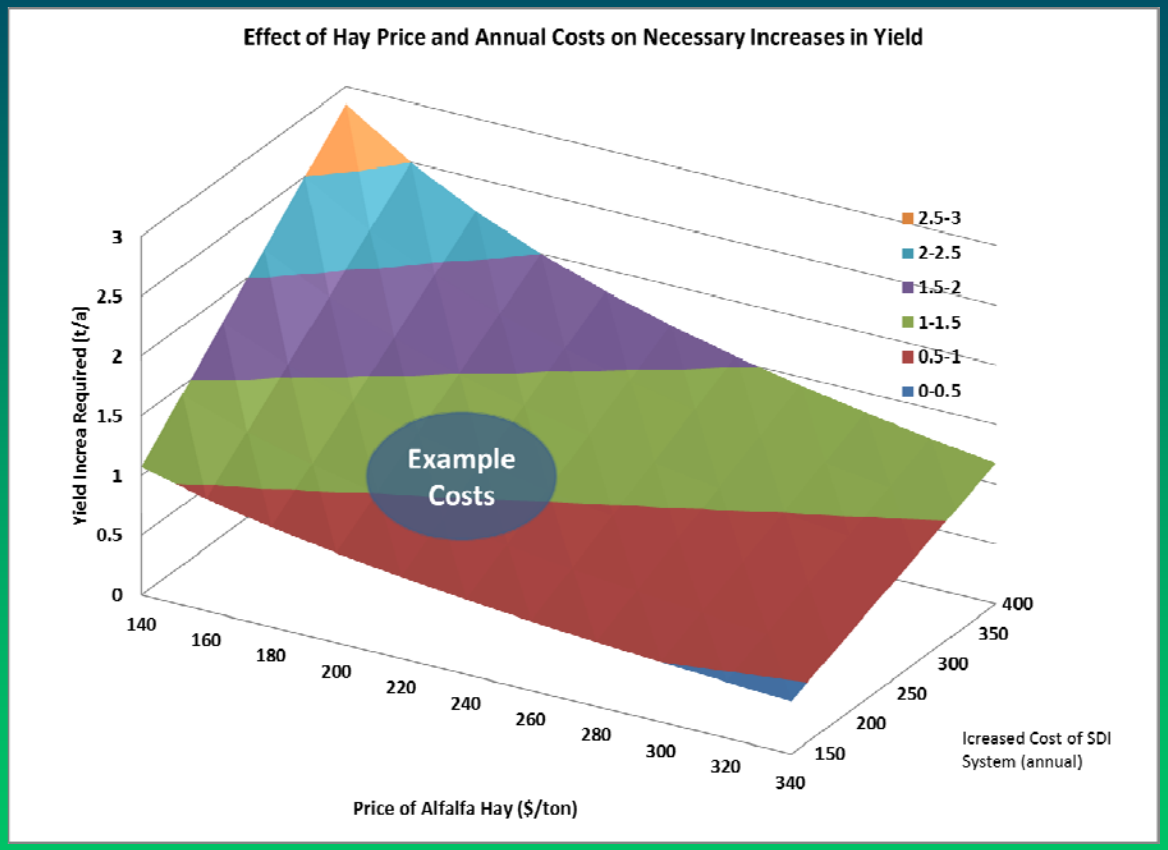
What is needed to Justify SDI?

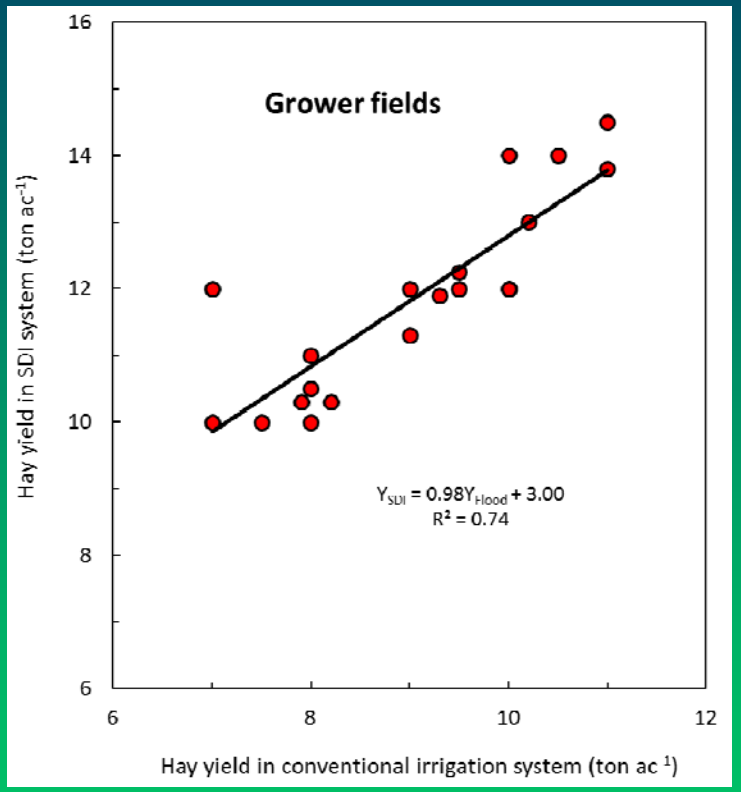
(Fixed costs)



- Assumptions: 15 yrs. infrastructure (pumps, filters, etc.)
- 6 years drip lines
- Does not consider support by NRCS or state agencies or rotation value

Are these yield improvements possible?

- Yield Increases appear real
- Confirmed by controlled studies (Lamm et al. 2012, UC studies)
- Growers report approximately 3.1 t/a improvement over flood.
- 20-35% range
- Why is that?



Key Recommendations

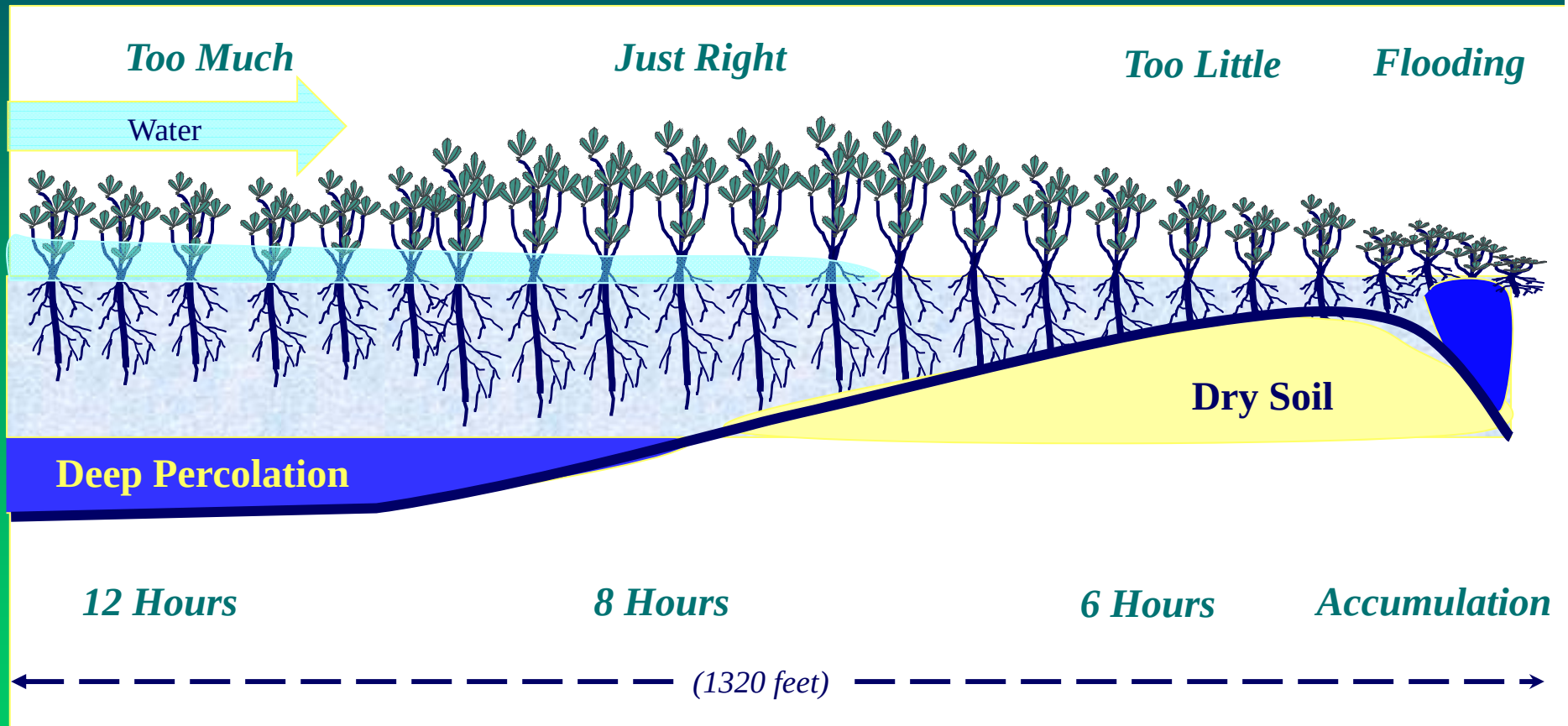
Why would we expect improved yields in SDI vs. surface?

- 1. Superior Distribution Uniformity (in Space)
  - Less difference between top and bottom of field
  - Well known problems with surface systems

Innate Problems with Flood Irrigation

(Distribution uniformity can be poor due to soil infiltration rate, flow, and set duration)

In a 12 hour irrigation set:

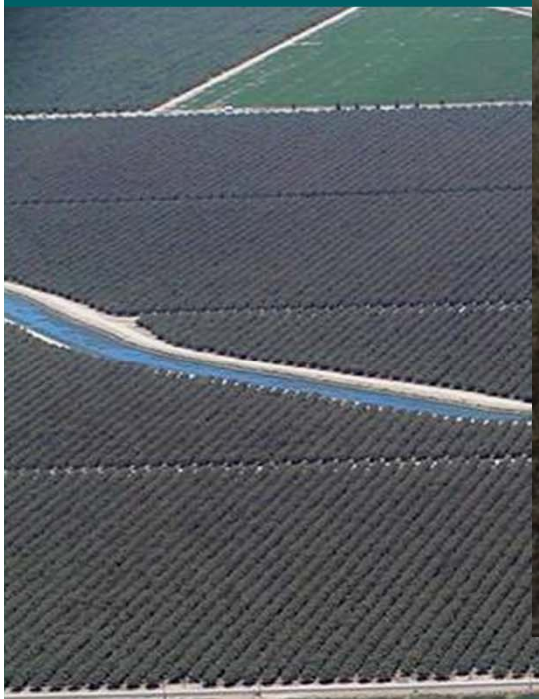


Standing Water

(the enemy of alfalfa)

University of Arizona-August 12, 2016

Tail –End Damage

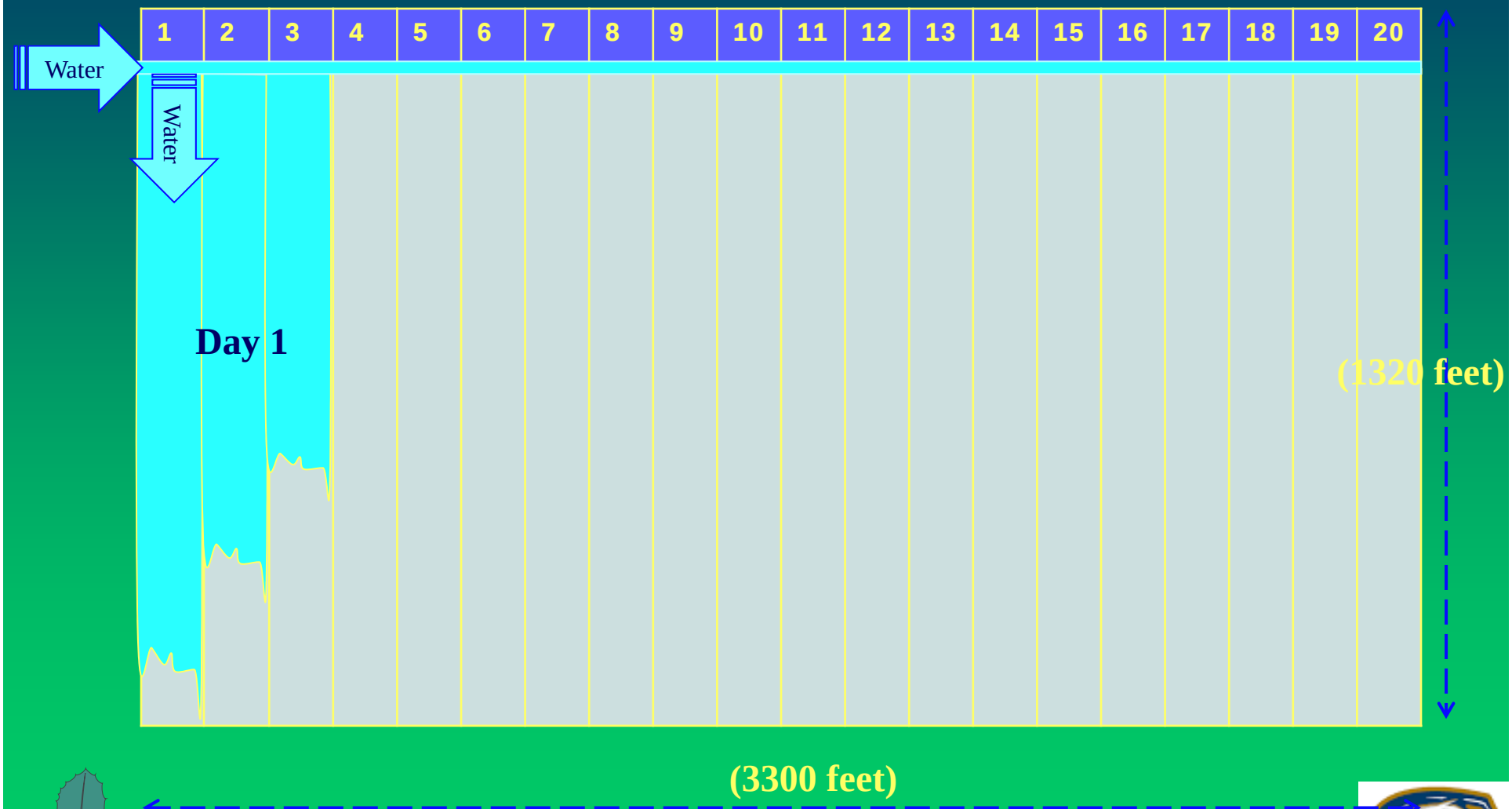


Weeds intrude in damaged areas

Why would we expect improved yields in SDI vs. surface?

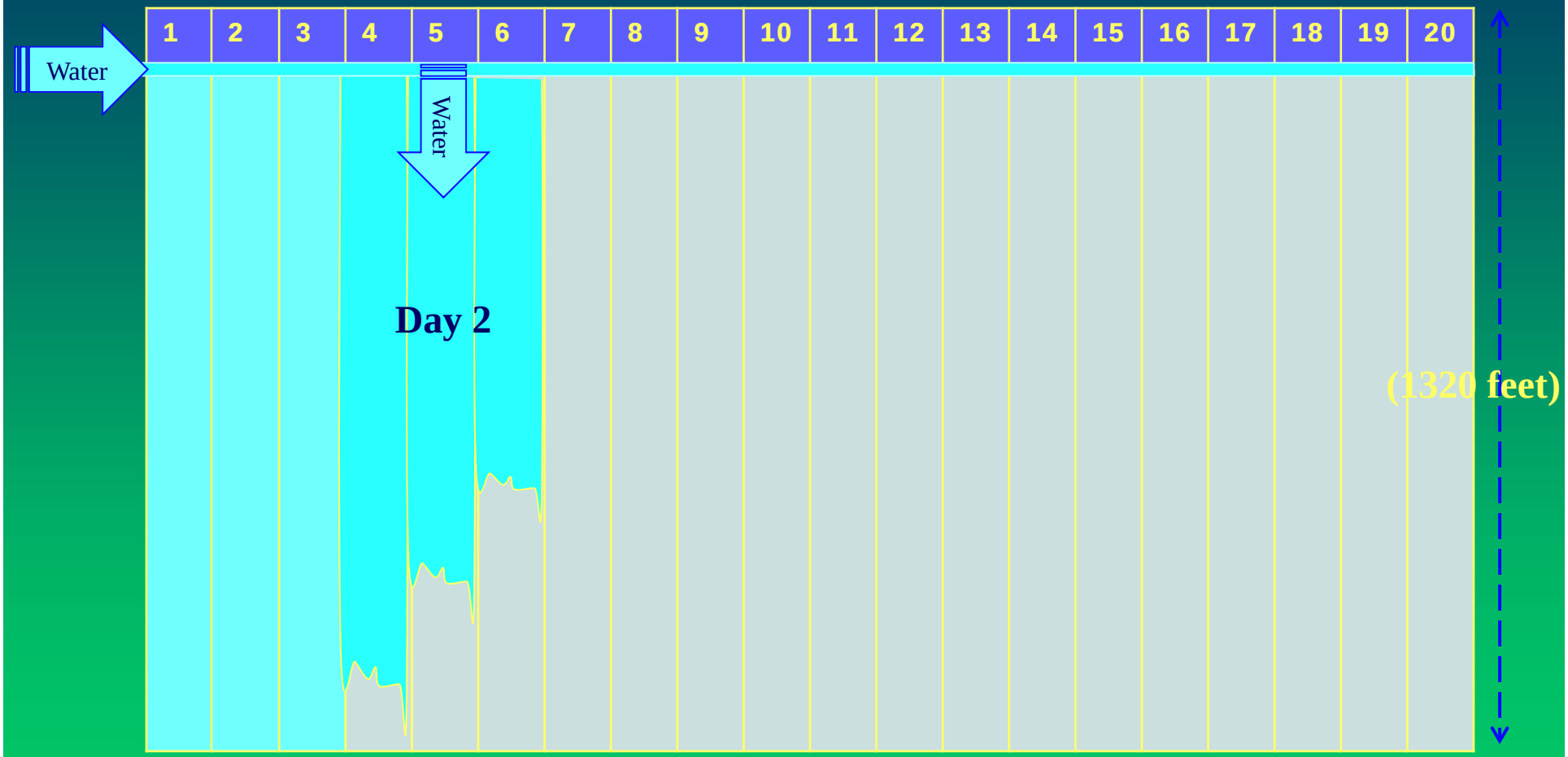
- **2. Distribution Uniformity (in Time)**
  - Ability to 'charge' a field within hours, not days
  - Most Flood-irrigated (and some sprinkle irrigated) fields require 4-12 days to irrigate, depending upon flow available.

Innate Problems with Flood Irrigation



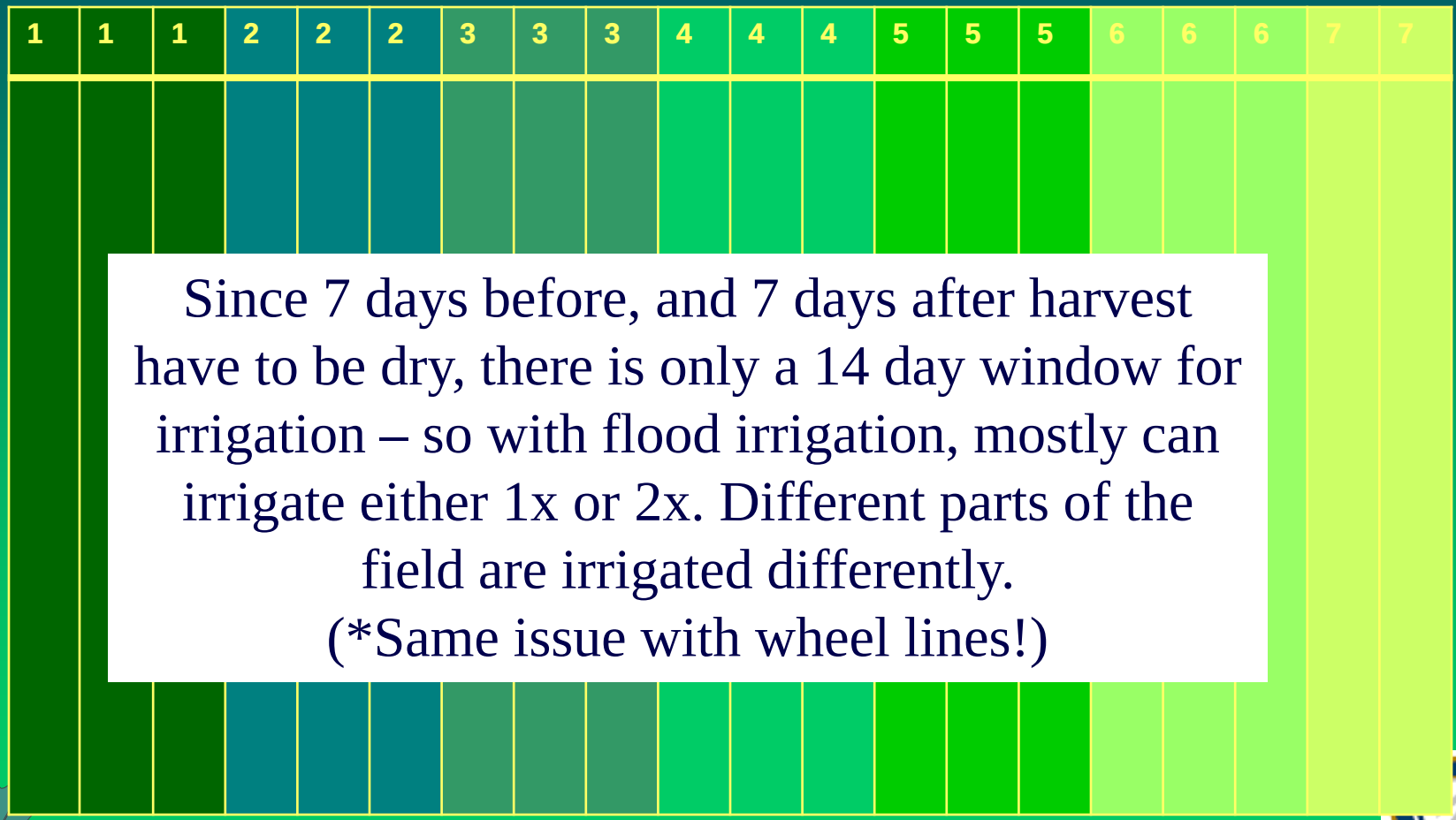
Innate Problems with Flood Irrigation

Check number:



Innate Problems with Flood Irrigation

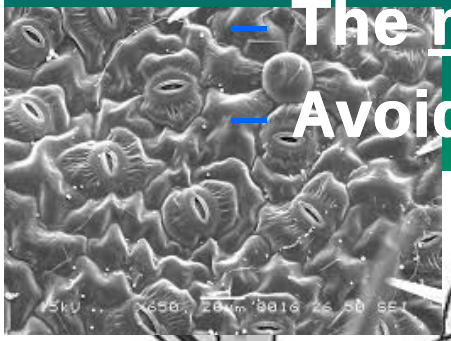
In a 28 day growth cycle, some parts of the field get water 7-8 days later.



Since 7 days before, and 7 days after harvest have to be dry, there is only a 14 day window for irrigation – so with flood irrigation, mostly can irrigate either 1x or 2x. Different parts of the field are irrigated differently.
(*Same issue with wheel lines!)

Why Increased Yields with SDI?

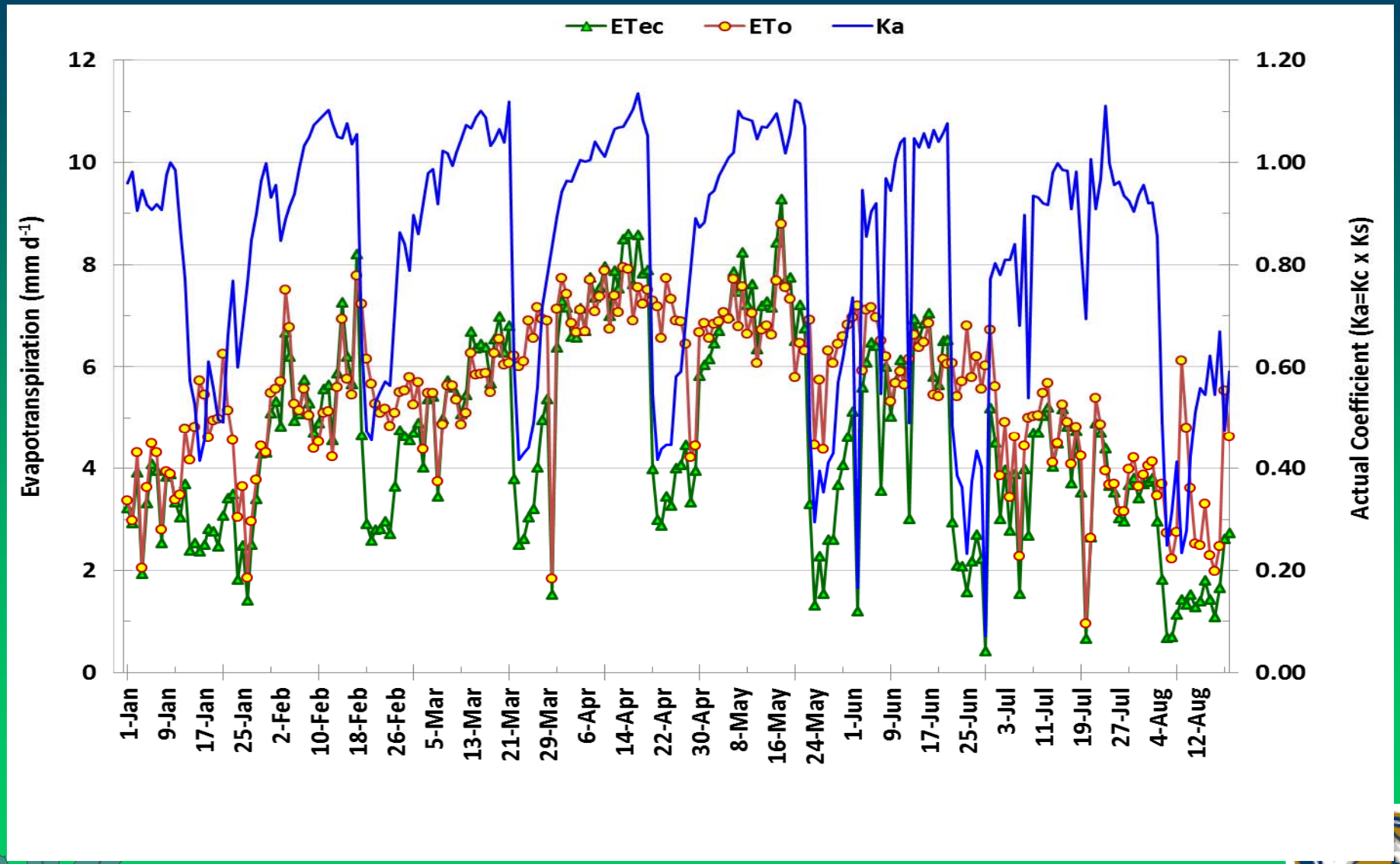
- **3. Ability to Maintain Turgor**
- **Avoid temporary droughts**
  - **The moment turgor is lost, growth ceases**
  - **Avoid wetting-drying patterns (flood/drying)**



Why Increased Yields?

- **4. Manipulating Irrigation Schedules to match ET**
  - Essentially any schedule desired
  - Can irrigate every day
  - Many hours, few hours
  - Maintaining turgor
  - Irrigating close to harvests (during??)

ET – Davis, CA



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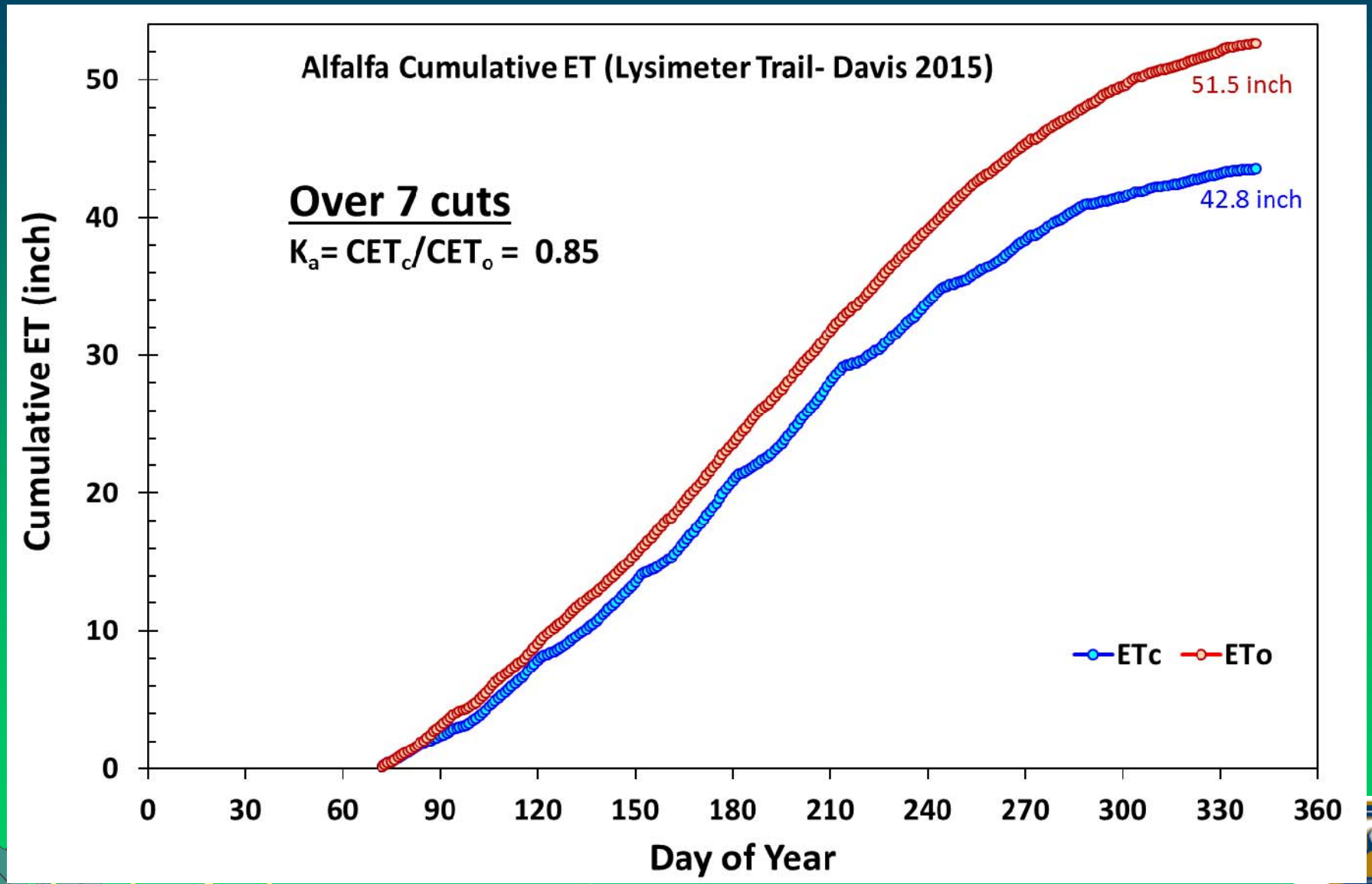
Davis Data - ET



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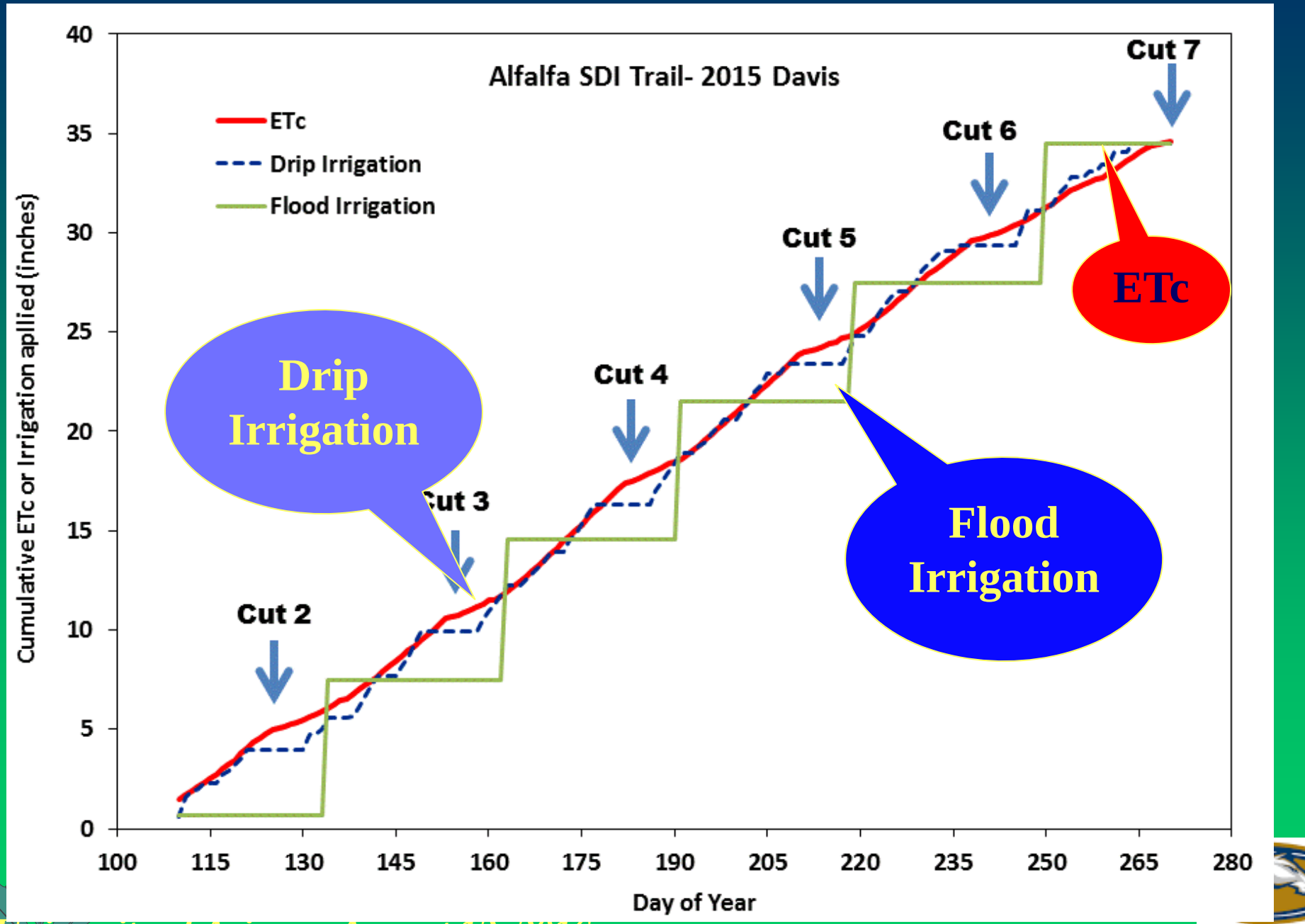
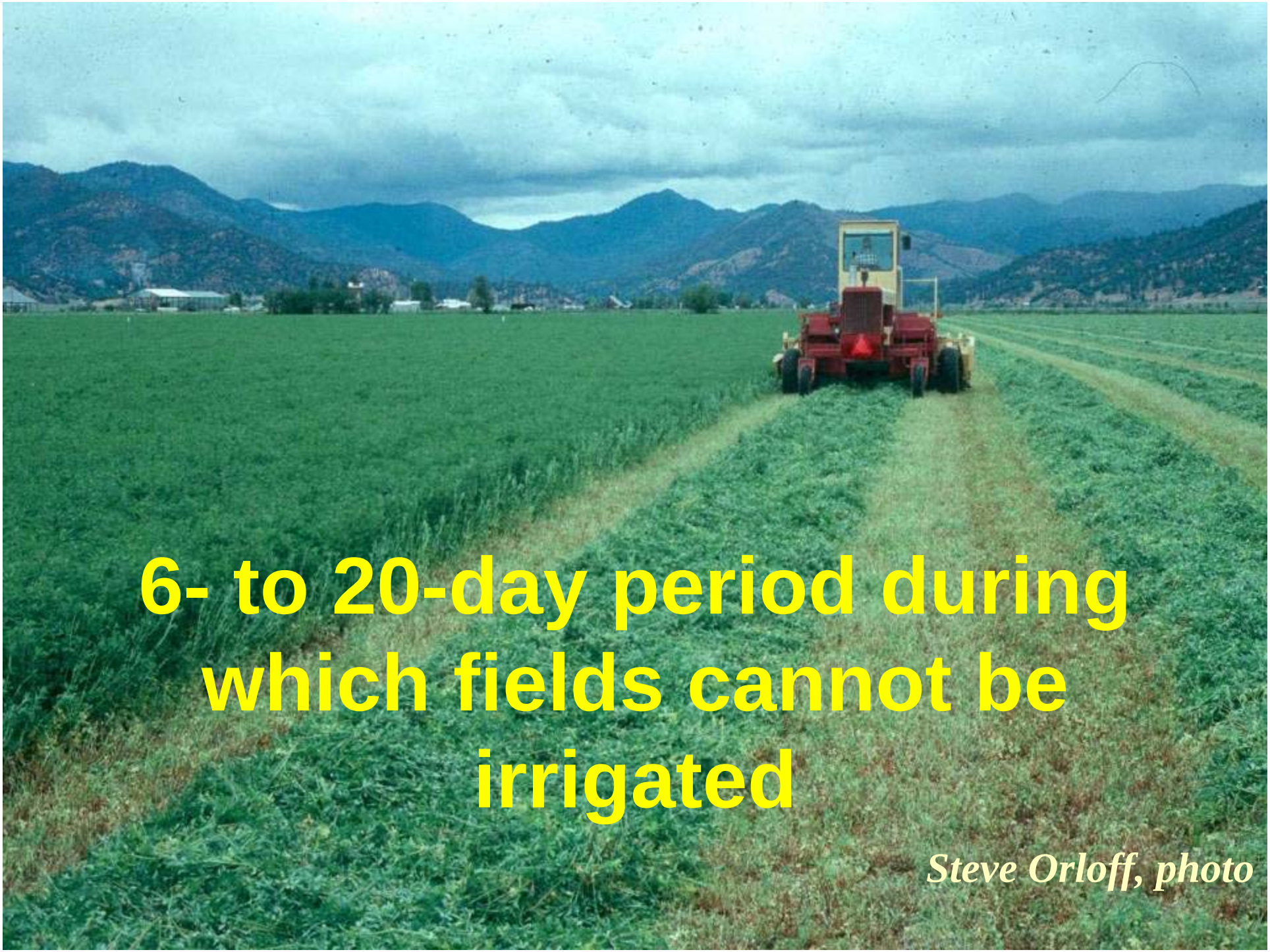

Alfalfa SDI Trail- 2015 Davis
ETc
Drip Irrigation
Flood Irrigation
Cumulative ETc or Irrigation apllied (inches)
Day of Year
Cut 2
Cut 3
Cut 4
Cut 5
Cut 6
Cut 7
Drip Irrigation
Flood Irrigation
ETc
0
5
10
15
20
25
30
35
40
100
115
130
145
160
175
190
205
220
235
250
265
280


6- to 20-day period during which fields cannot be irrigated
Steve Orloff, photo

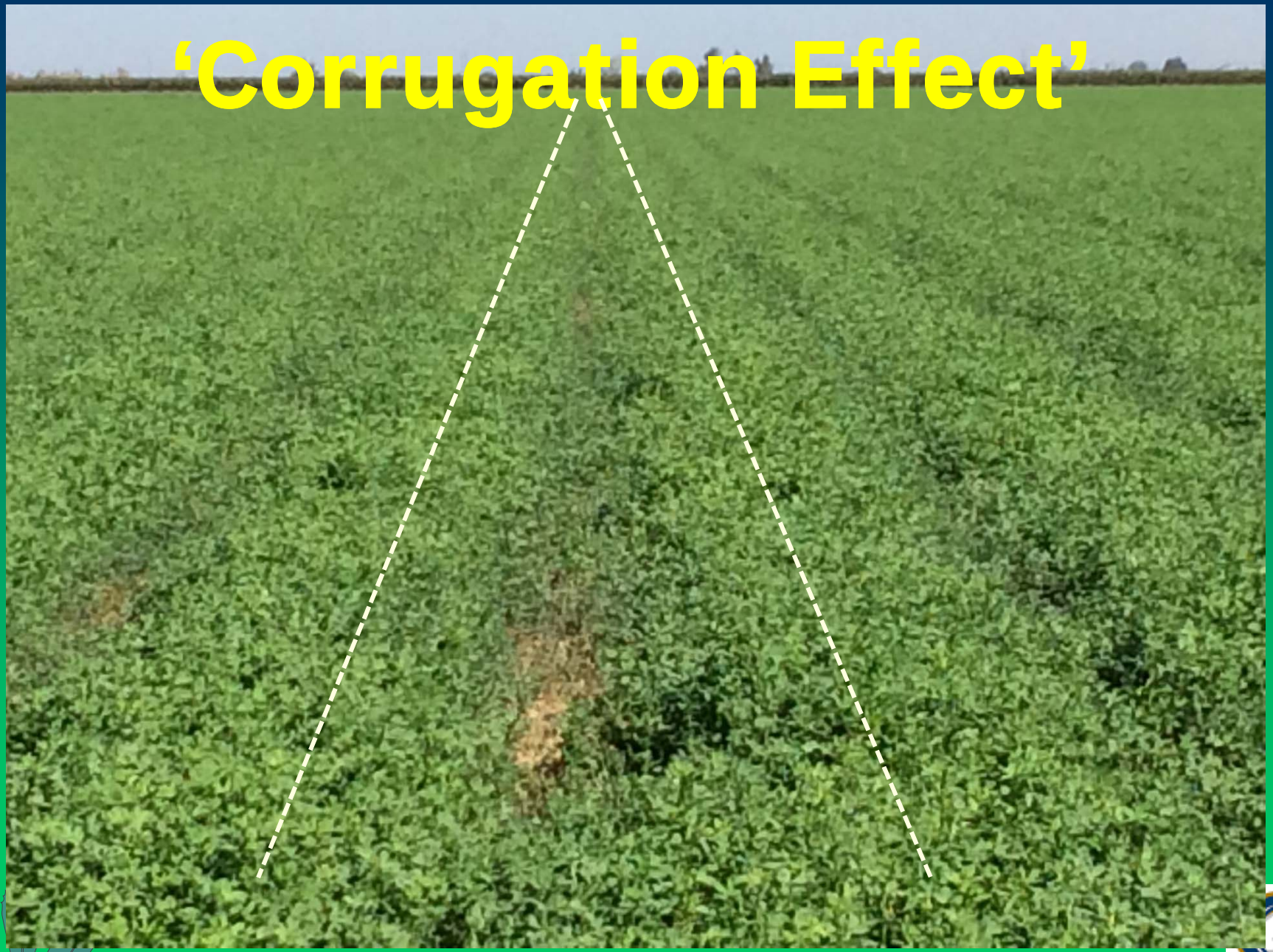
Can a system follow ET?

- Is it restricted in terms of applying small amounts?
- Can it recharge the profile?

Distribution Uniformity was not perfect in SDI fields:

- In many fields, a ‘corrugation’ effect was seen, in spite of improved yields
- Perhaps 10-20% yield hit?
- Likely a spacing issue-soil type dependent
- More to learn on lateral spacing/flow rates

‘Corrugation Effect’



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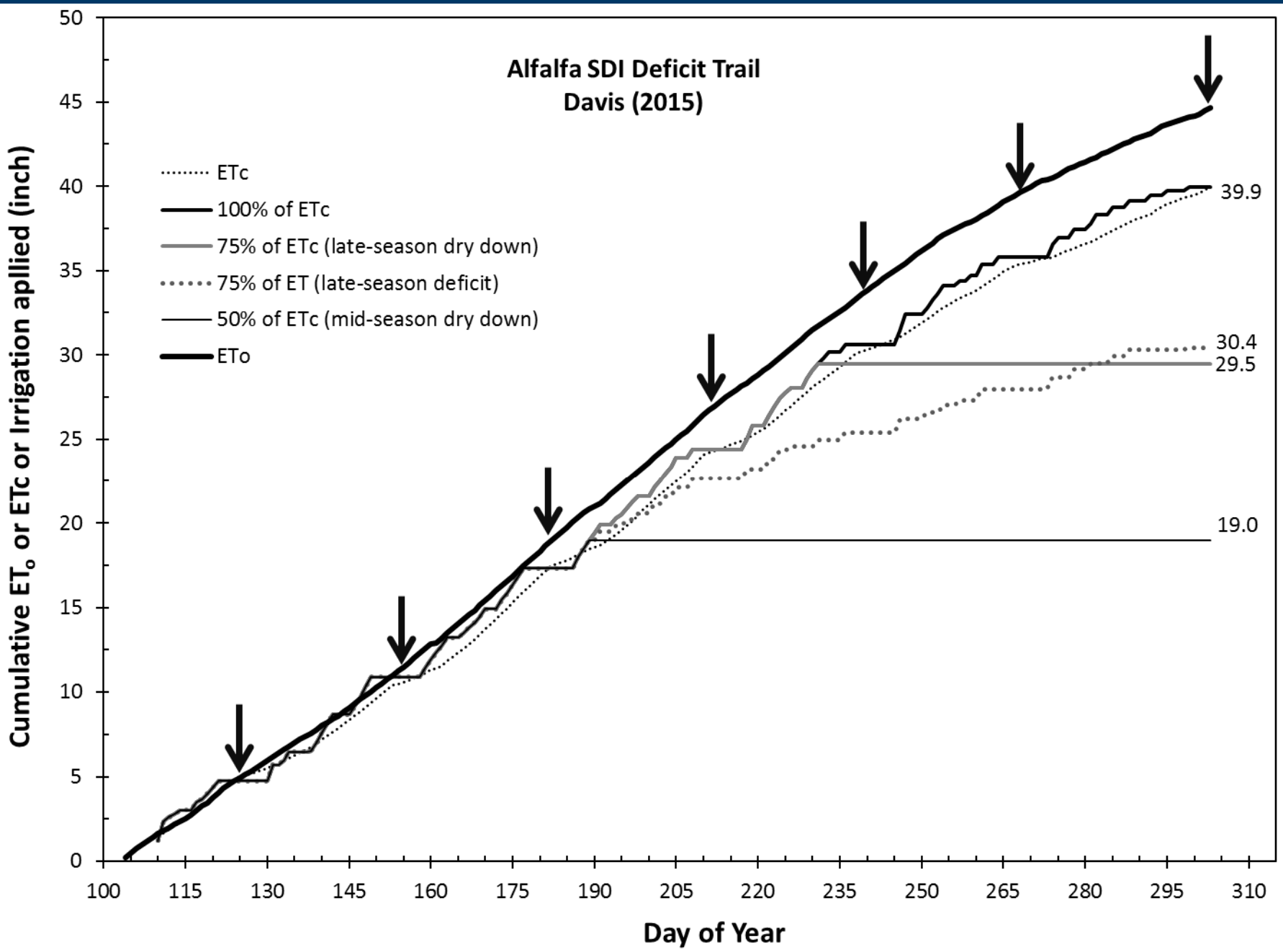
Key Recommendations

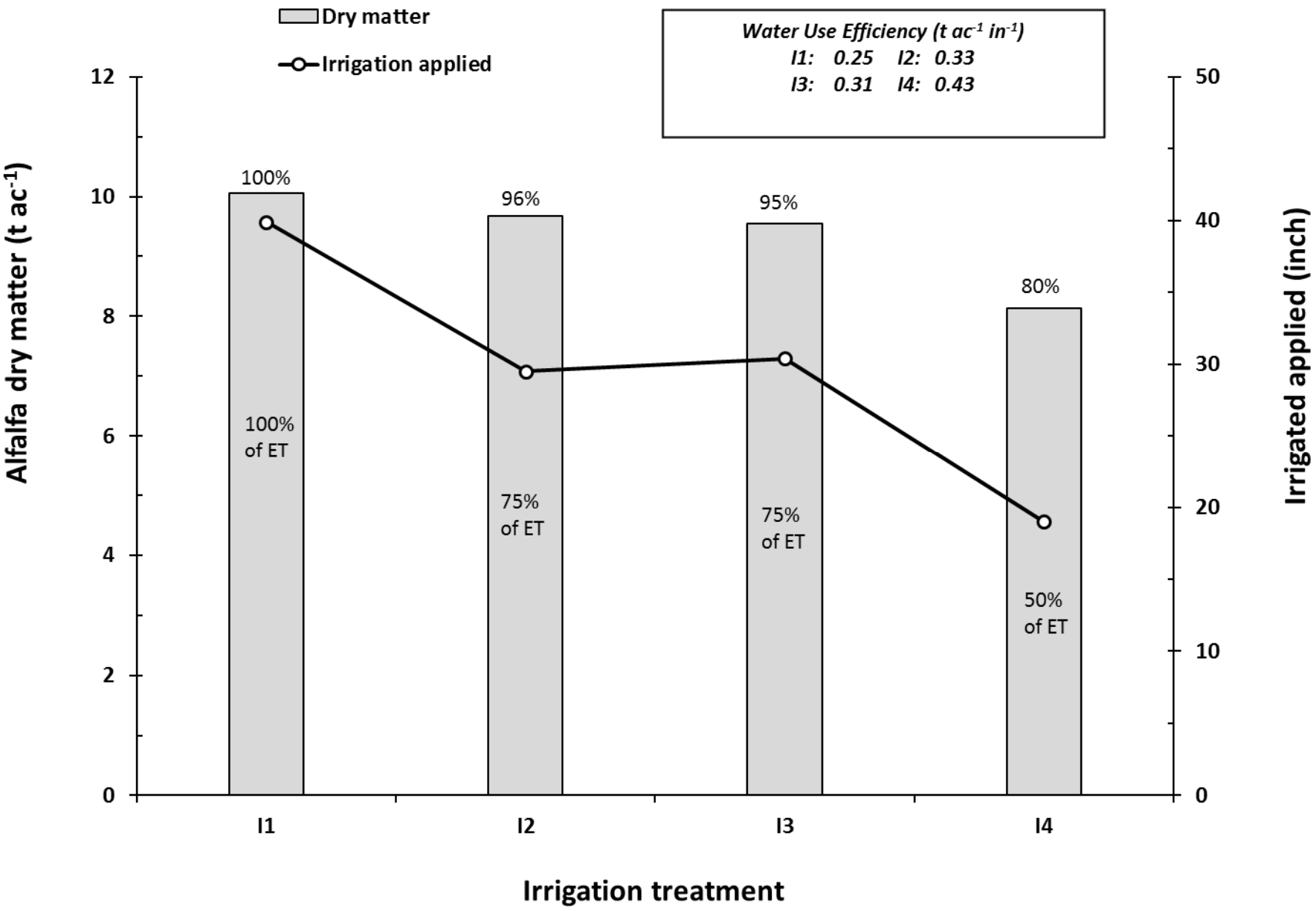
What we've learned:

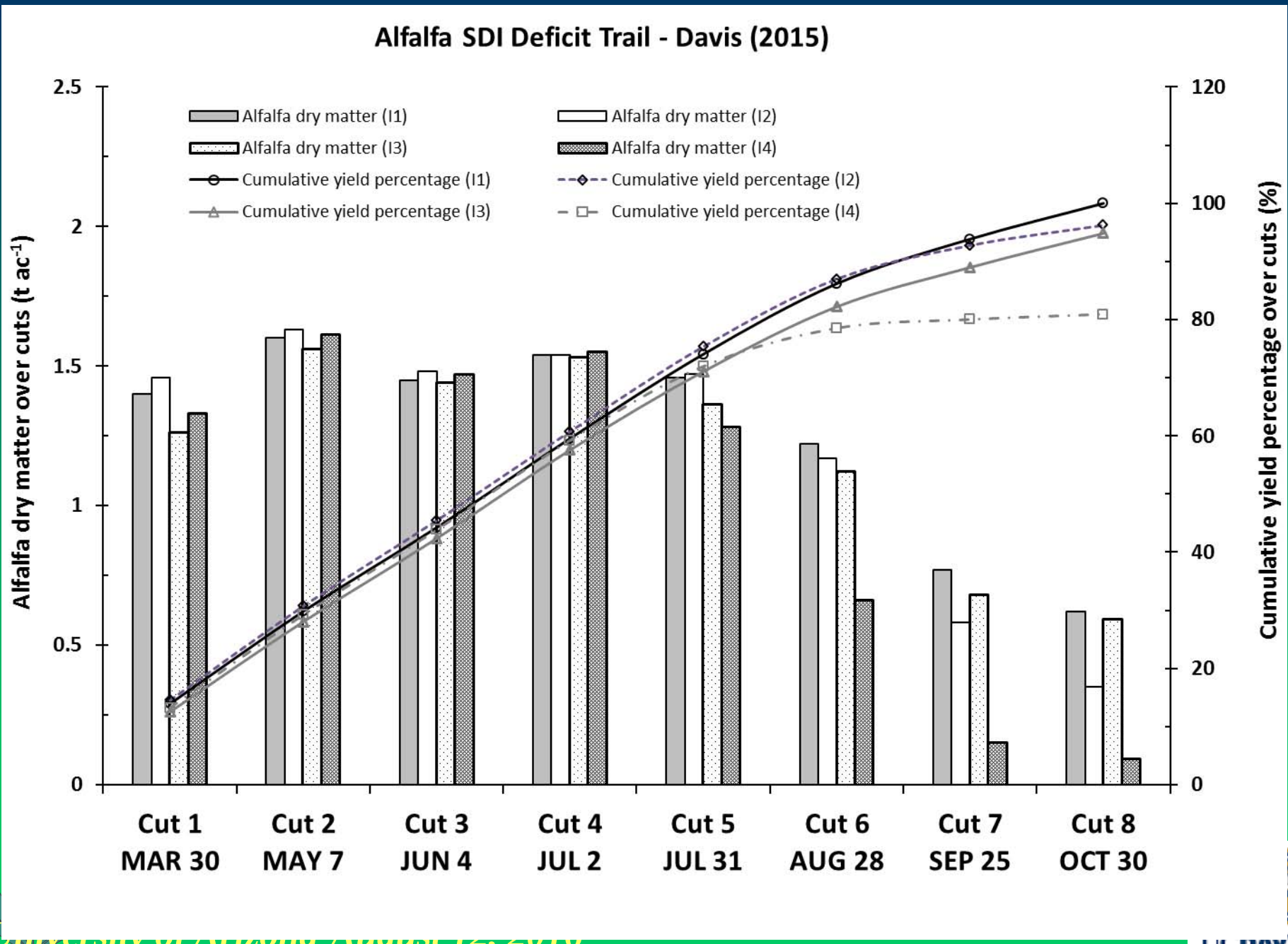
- Rodents are perhaps THE major challenge for SDI in alfalfa

Leak Discovery Method


Variety X Water Deficits under drip Irrigation
-El Centro & Davis


Alfalfa SDI Deficit Trail
Davis (2015)
ETc
100% of ETc
75% of ETc (late-season dry down)
75% of ET (late-season deficit)
50% of ETc (mid-season dry down)
ETo
39.9
30.4
29.5
19.0
Cumulative ETo or ETc or Irrigation apllied (inch)
Day of Year
0
5
10
15
20
25
30
35
40
45
50
100
115
130
145
160
175
190
205
220
235
250
265
280
295
310


Dry matter
Irrigation applied
Water Use Efficiency (t ac-1 in-1)
I1: 0.25 I2: 0.33
I3: 0.31 I4: 0.43
Alfalfa dry matter (t ac-1)
Irrigated applied (inch)
100%
96%
95%
80%
100% of ET
75% of ET
75% of ET
50% of ET
I1
I2
I3
I4
Irrigation treatment


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

SDI - A Balance Sheet

Consideration	SDI	Flood	Notes
Water Use per Acre	(+)	(-)	Generally favors SDI, although will depend upon soil type and efficiency of flood system.
Water Use per unit prod.(ton)	(+)	(-)	Clearly favors SDI given innate advantages in water application.
Energy Use per acre	(-)	(+)	Gravity-fed systems are almost always superior in energy flux per unit area
Energy Use per unit prod. (ton)	(+)	(-)	Improving yield is likely to lower energy use per unit production, depends upon extent
GHG per unit production	(+)	(-)	Not fully known but likely to be lower in SDI, due to higher yields and lower direct emissions
Irrigation Mgt.	(+)	(-)	Clear advantages to SDI, if managed correctly
Refill profile	(-)	(+)	Flood irrigation is likely superior
Germination	(-)	(+)	Sprinklers are preferred, flood works, SDI no
Salinity	(-)	(+)	Salinity may be an issue with SDI-mitigated
Wildlife	(-)	(+)	Favors flood but can be mitigated

SDI - A Balance Sheet

Consideration	SDI	Flood	Notes
Yield	(+)	(-)	Mechanisms for yield increases appear genuine
Stand Longevity	(+)	(-)	Evidence for superior stand longevity
Controlling Fertilizers	(+)	(-)	Delivery directly to root system, prevention of losses (N, P).
Weed Intrusion	(+)	(-)	Evidence for less weed pressure due to dry surfaces and less stand decline
Surface runoff (pesticides etc.)	(+)	(-)	SDI eliminates surface runoff which protects surface water quality
Oxygen to Root system	(+)	(-)	On many heavy soils likely better O2 to roots
Labor	(+)	(-)	Labor savings in SDI irrigations, but greater management for repairs, gophers are needed
Rodent Management	(-)	(+)	Rodents are a problem in all systems, but flood irrigation keeps populations in check.
Flexibility with Deficit Irrigation	(+)	(+)	Both systems can be deficit irrigated. May improve yields under SDI, but higher costs.

Summary

- SDI Not appropriate for all farms-must have yield potential and higher level of management
- Variation in price is an economic limitation
- Improved yields (9-15 t/a range) 2-3 tons/a improvement in CV and desert regions
- Possibility of improved stand longevity, less weeds, Labor savings
- Water benefits, ability to do deficit irrigation
- Yield per unit water, energy, greenhouse gas
- Sustained effort required to solve problems:
  - *Rodent management*
  - *Scheduling/spacing*
  - *Water quality*

Questions?

Web Resources for SDI & Alfalfa

http://alfalfa.ucdavis.edu