# Deficit Irrigation of Alfalfa as a Irrigation Water Management Strategy

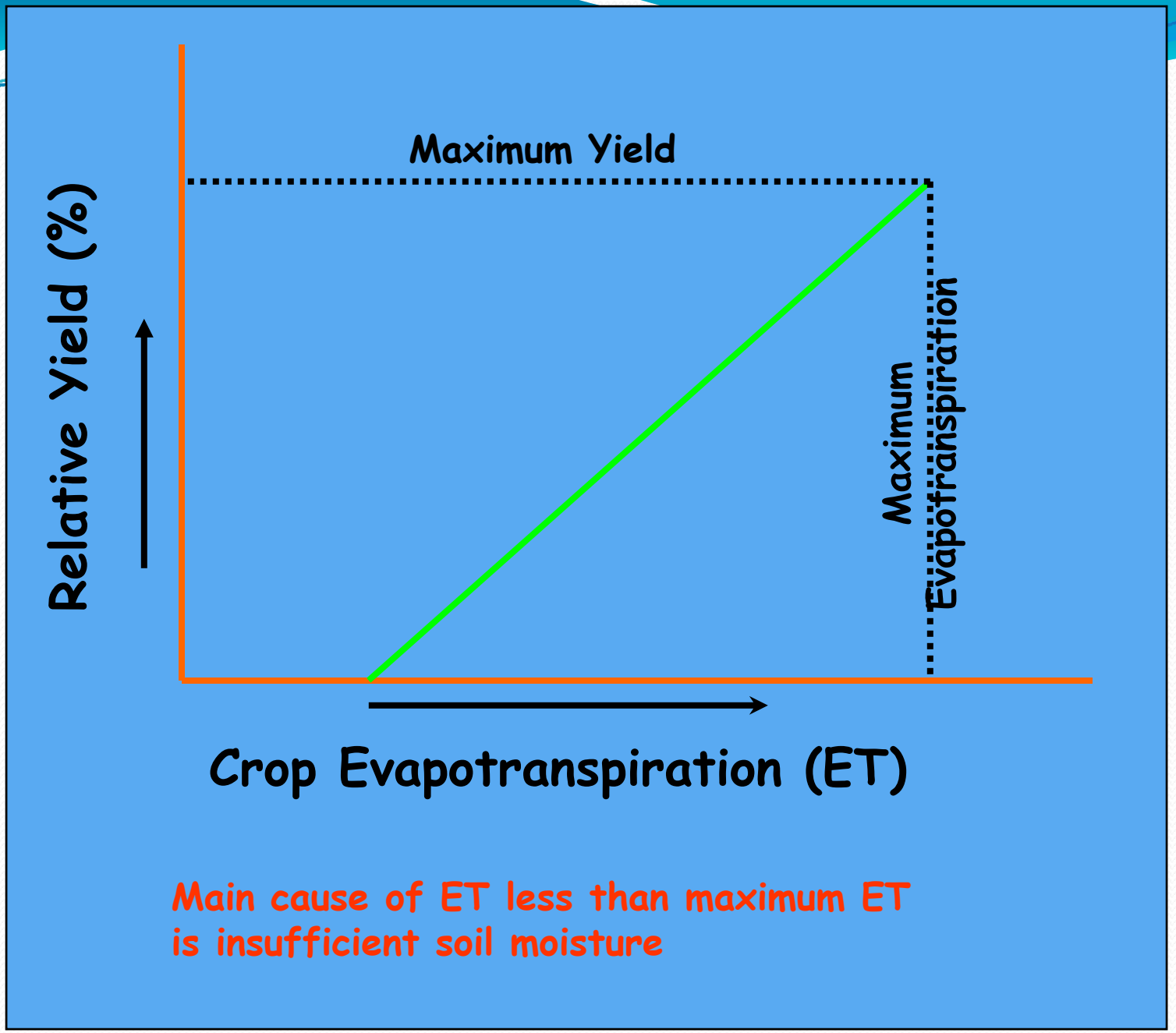
**Blaine Hanson**
**Dept. of Land, Air and Water Resources**
**University of California, Davis**

# Other participants

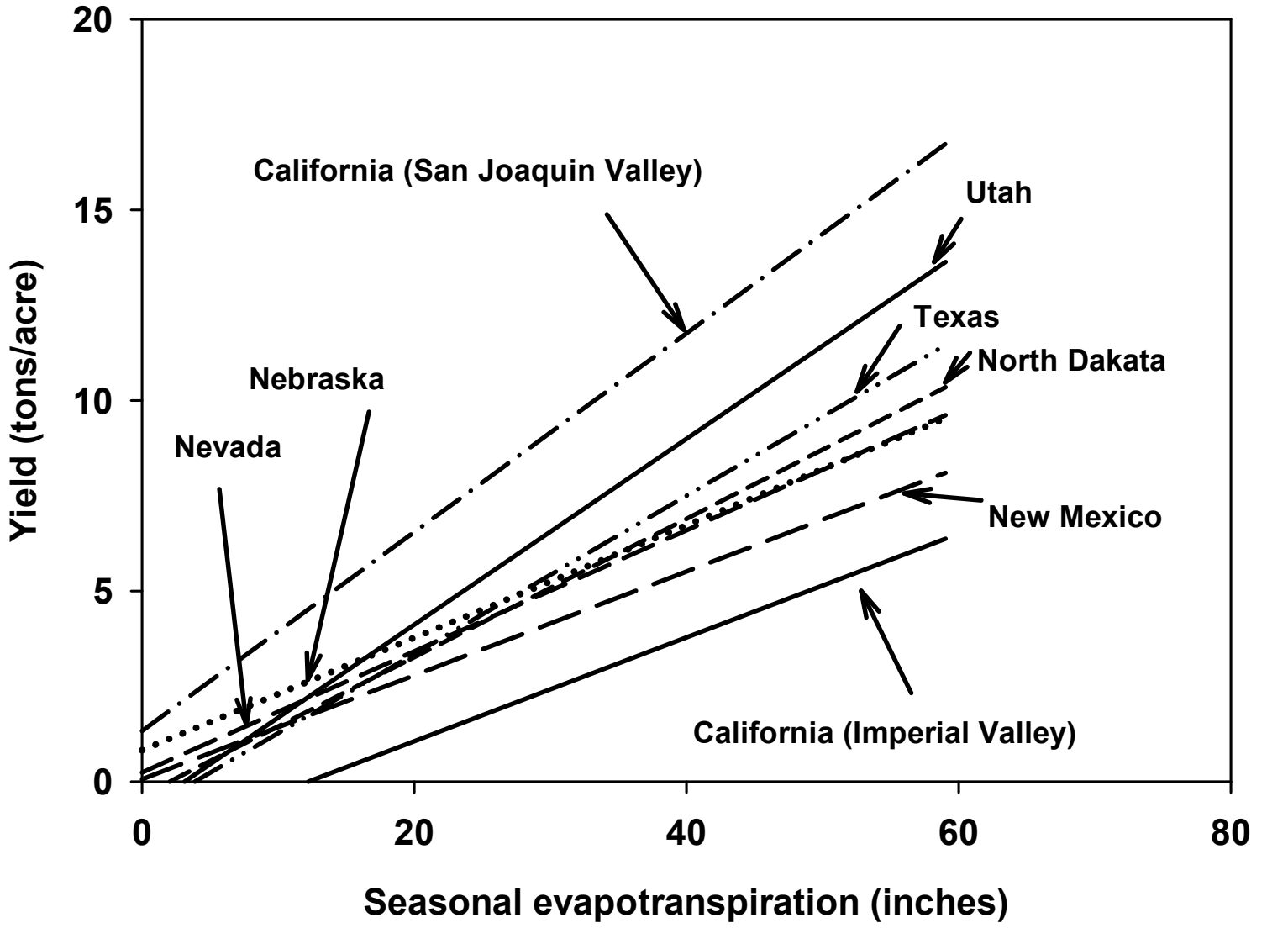
- **Steve Orloff – Farm Advisor, Siskiyou County**
- **Blake Sanden – Farm Advisor, Kern County**
- **Khaled Bali – Farm Advisor, Imperial County**
- **Harry Carlson – Farm Advisor, Siskiyou County**
- **Dan Putnam – UC Davis**

# Definitions

- Evapotranspiration (ET) – crop water use (transpiration & evaporation
- Types of ET
  - Crop ET
  - Reference crop ET (ET of grass) – used by the CIMIS network to estimate the potential crop ET
    - $ET_{crop}$ = Crop coefficient x Reference crop ET




Main cause of ET less than maximum ET is insufficient soil moisture


20
15
10
5
0
Yield (tons/acre)
California (San Joaquin Valley)
Utah
Texas
North Dakata
Nebraska
Nevada
New Mexico
California (Imperial Valley)
0
20
40
60
80
Seasonal evapotranspiration (inches)

# Irrigation water management of alfalfa

- First spring irrigation – irrigate when the soil moisture tension approaches a recommended value
- Subsequent irrigations – controlled by cutting schedules
  - First irrigation between cuttings – after bales are removed
  - Last irrigation between cuttings – sufficient drying time before next cutting
- Options – 1, 2, or 3 irrigations between harvests
- Monitor soil moisture tension to determine if number of irrigations is adequate

# Why deficit irrigation?

- Transfers from agriculture by DWR and other water agencies to provide water for urban and environmental uses in drought years
- DWR program - fallowing of agricultural land
  - No yield
  - ET of fallow field = 0
  - Amount transferred = ET of crop not planted
- Deficit irrigation of alfalfa (over 1 million acres; long crop season; about 5.3 million acre feet of water)
  - Reduced yield
  - ET > 0
  - DWR approach - ET difference between fully irrigated and deficit irrigation alfalfa

# Why (continued)?

- Limited water supplies
  - Options
    - Fully irrigate a reduced acreage. Acreage reduction depends on amount of available irrigation water
    - Apply smaller amounts of water per irrigation throughout the crop season
    - Mid-summer deficit irrigation
  - Mid-summer deficit irrigation
    - No irrigation during July, August, and September (?)
    - Maintains high yields of early harvests
    - Deficit irrigation during period of lower yields

# Mid-summer deficit irrigation project - objectives

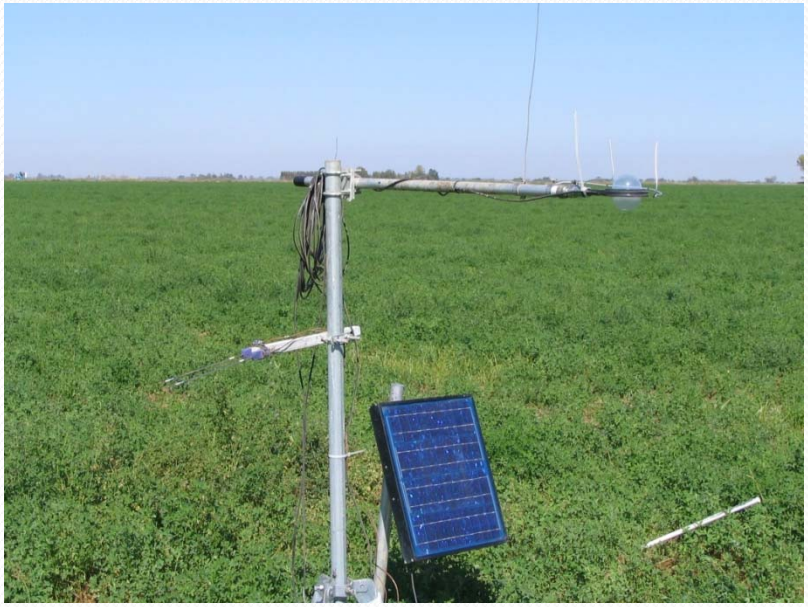
- Determine the ET of fully-irrigated and mid-summer deficit-irrigated (no irrigation) of alfalfa
- Determine the effect of mid-summer deficit irrigation alfalfa yield
- Determine any carry-over yield effects into the following year

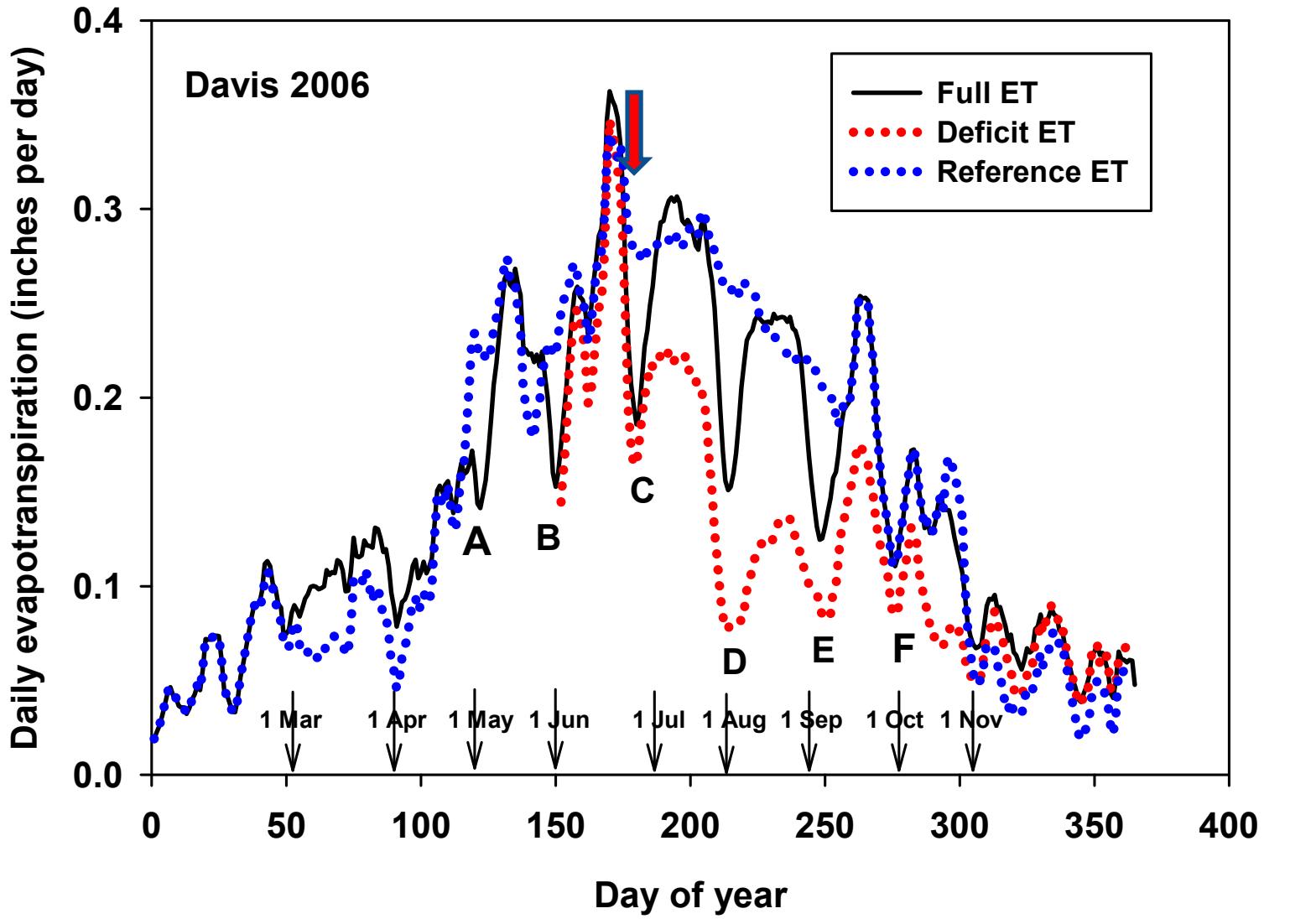
# Method

- Sites (commercial fields except Tulelake)
  - Imperial Valley
  - Kern County (near Buttonwillow)
  - Yolo County (near Davis)
  - Tulelake (near Klamath Falls, OR)
  - Scott Valley (near Yreka)
- Experimental approach
  - Most of the field was fully irrigated; mid-summer termination of irrigation on part of the field
- ET measurements – meteorological methods (eddy covariance and surface renewal)

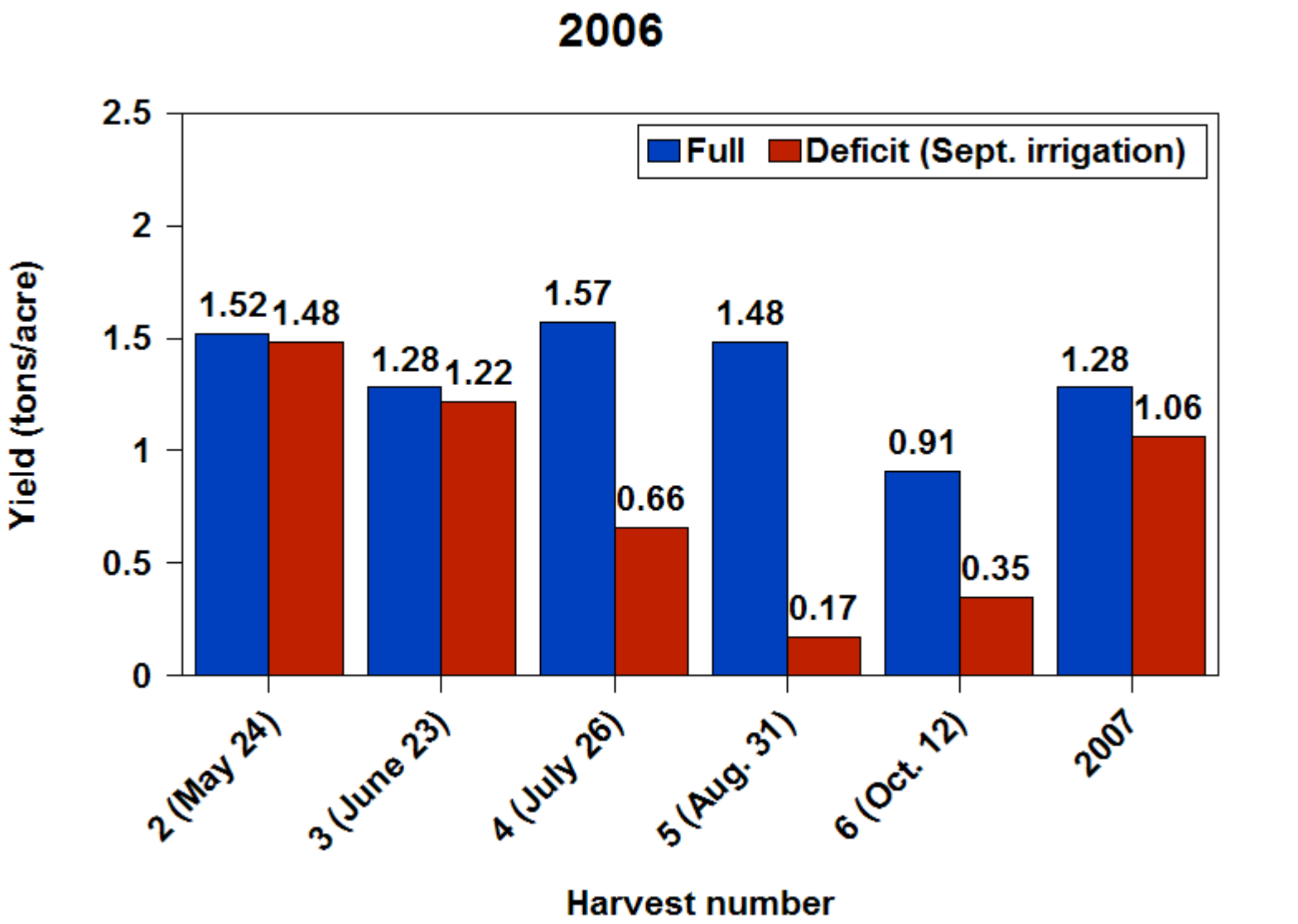
## Eddy covariance

## Surface renewal

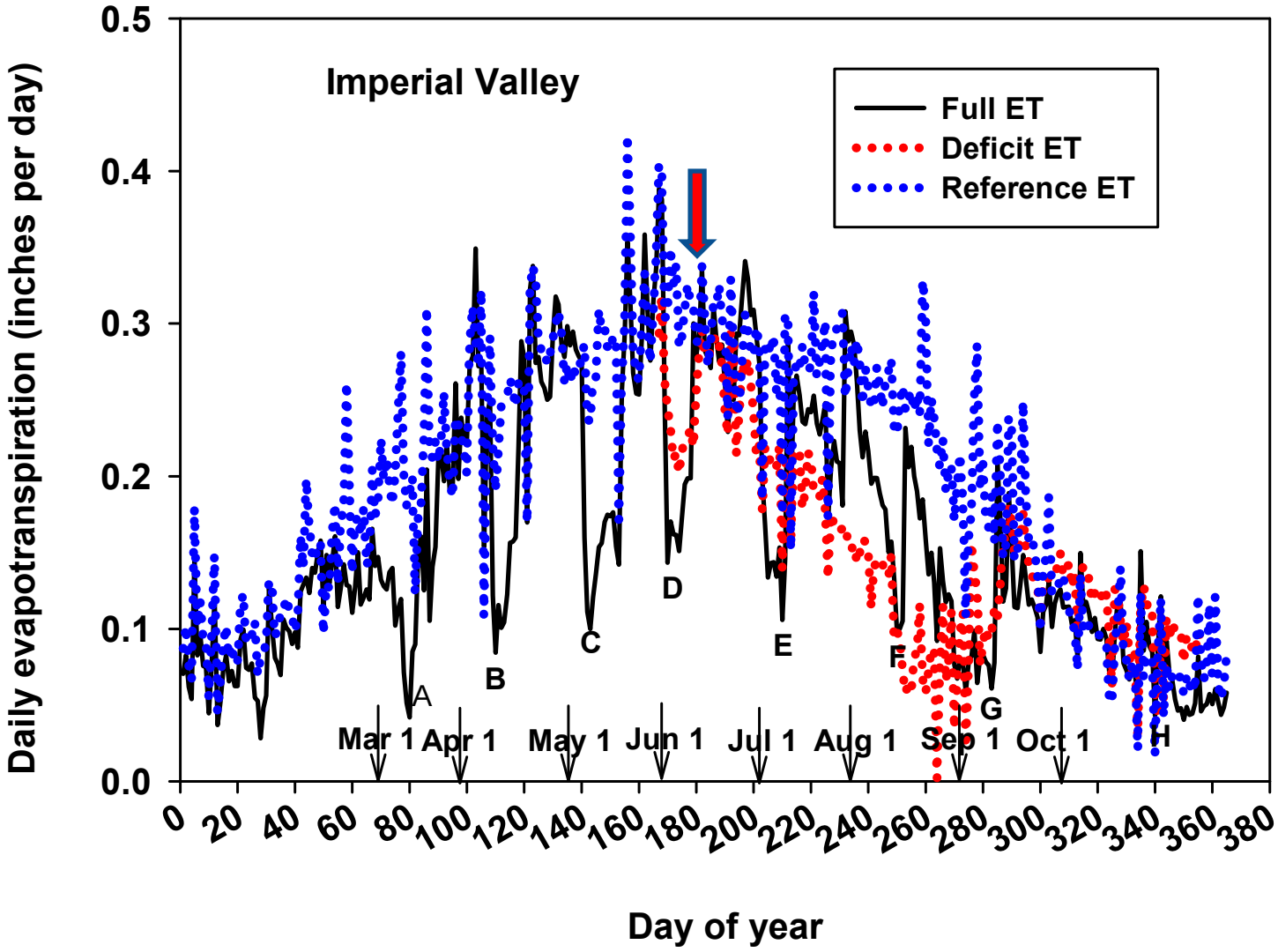


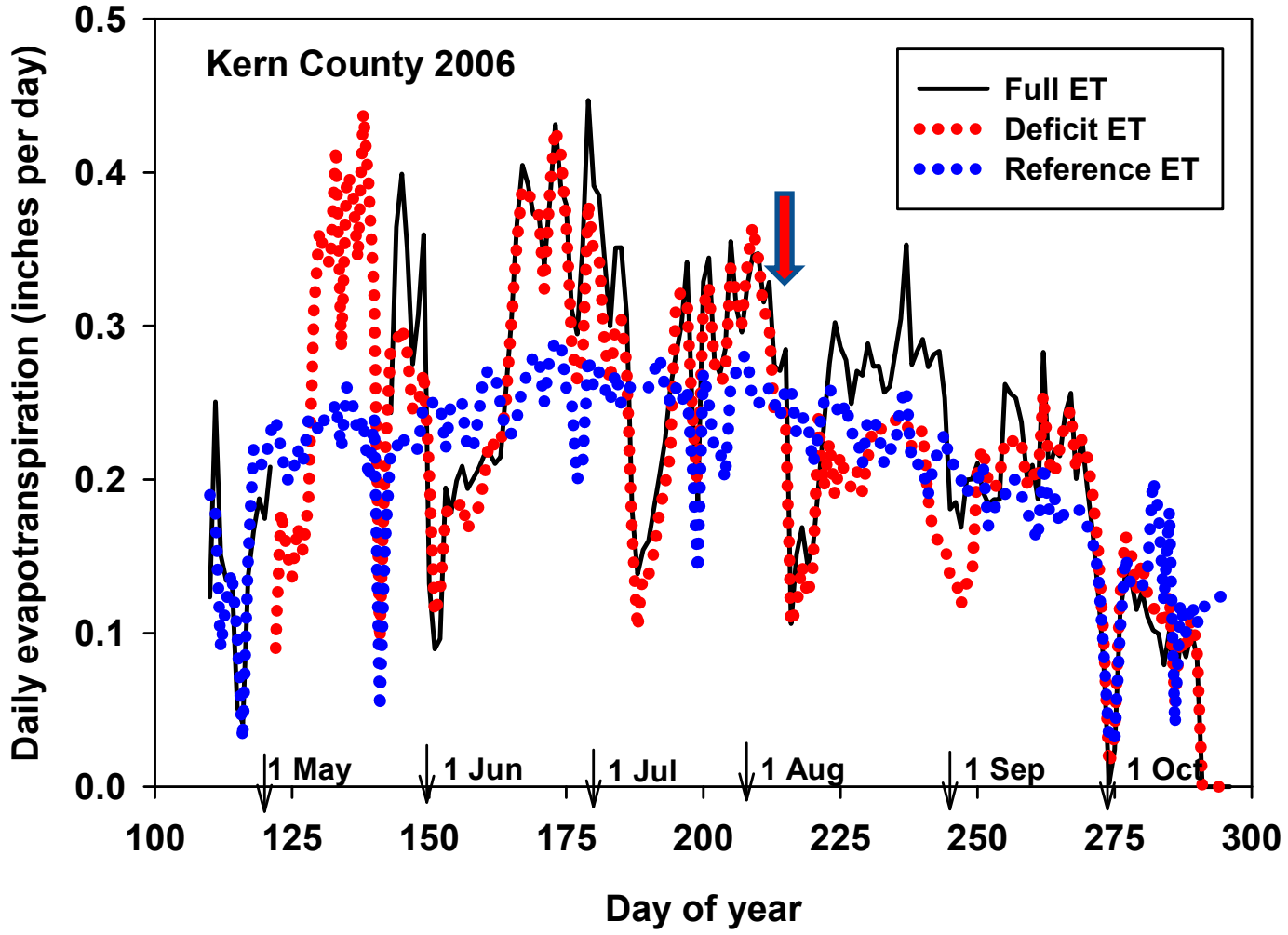

Davis 2006
Full ET
Deficit ET
Reference ET
Daily evapotranspiration (inches per day)
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
F
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
0
50
100
150
200
250
300
350
400
Day of year

# Yield




**Deficit irrigation started at the end of June**


Imperial Valley
Full ET
Deficit ET
Reference ET
Daily evapotranspiration (inches per day)
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Mar 1
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
A
B
C
D
E
F
G
H
Day of year


Kern County 2006
Full ET
Deficit ET
Reference ET
Daily evapotranspiration (inches per day)
0.5
0.4
0.3
0.2
0.1
0.0
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
100
125
150
175
200
225
250
275
300
Day of year

# Seasonal ET

| Site | Measured Seasonal ET (inches) | Historical Seasonal ET (inches) |
|---|---|---|
| Imperial Valley | 58.2 | 76 |
| Kern County | 53.0 (12 Oct) | 49 |
| Davis | 59.8<br>49.5– 2005<br>54.2 – 2006 | 49 |
| Scott Valley | 39.0 | 33 |
| Tulelake | 41.1 | 33 |

# ET differences

| Site | ET difference (inches) | Fully –irrigated ET during deficit irrigation period (inches) |
|---|---|---|
| Imperial Valley | 2.4 | 18.6 |
| Kern County | 1.4<br>2.9 – 2006 | 8.5 - 2006 |
| Davis | 7.8<br>9.4 – 2005<br>8.8 – 2006 | 21.5<br>15.9 – 2005<br>16.8 – 2006 |
| Scott Valley | 2.2 | 11.4 |
| Tulelake | 0.2 | 28.3 |

# Conclusions

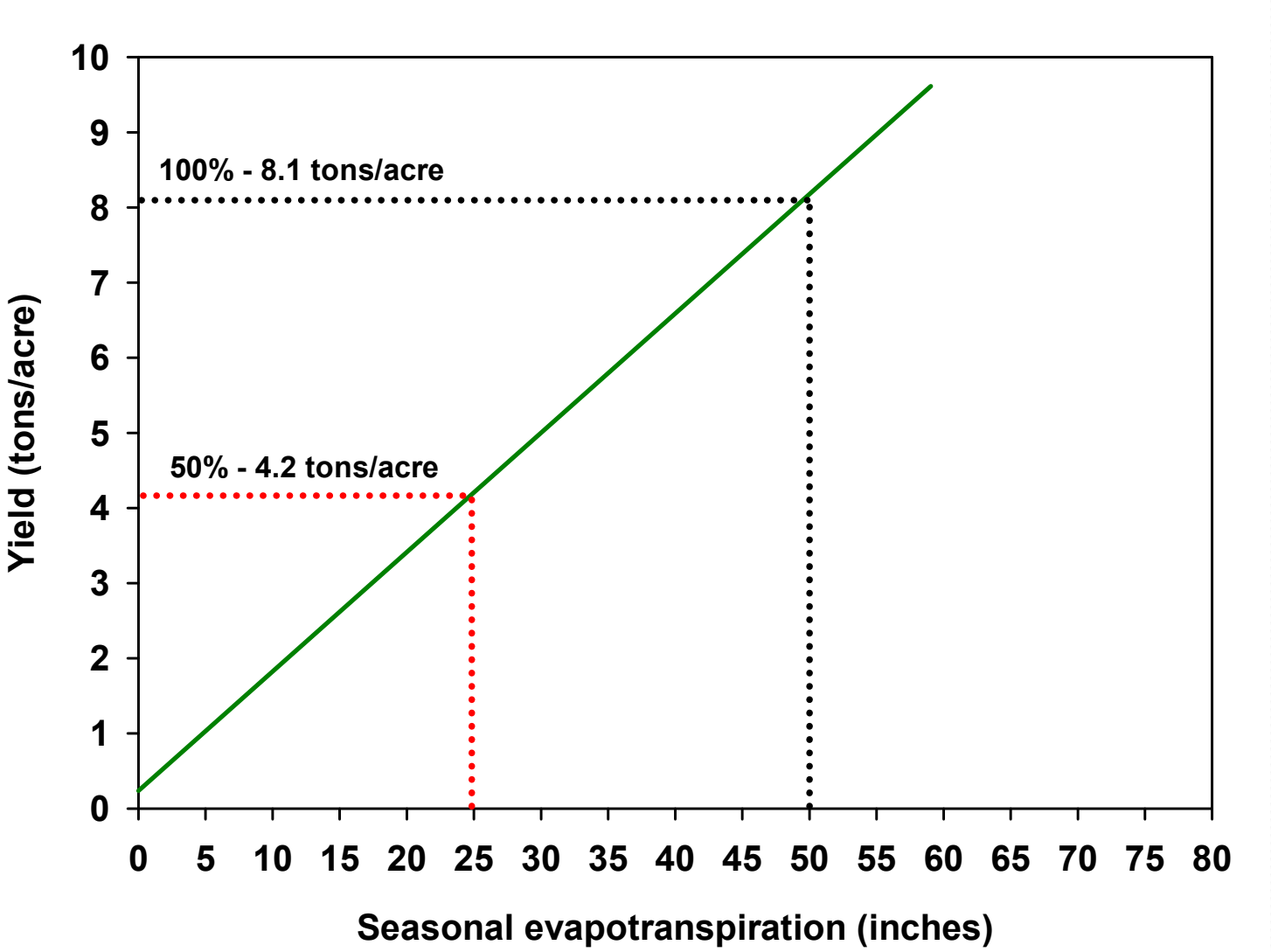
- Mid-summer deficit irrigation reduced both yield and evapotranspiration
- Yield and evapotranspiration reductions were site specific
- Yields of the deficit-irrigated alfalfa recovered the following year except for the Imperial Valley site
- Water transfer amounts based on ET differences is not practical because of the small amounts and the variability between sites
- Water transfer amounts should be based on the ET of full irrigation during the period of deficit irrigation

# Irrigating with a limited water supply

- Fully irrigate a reduced acreage
- Distribute limited water supply throughout the irrigation season
- Mid-summer deficit irrigation

# Example

- Normally irrigate 100 acres
- ET of maximum yield = 50 inches
- Drought condition – 50% of normal allocation (25 inches)
- Crop price = $110/ton
- Strategies
  - Irrigate 50 acres for maximum yield (50 inches)
  - Irrigate 100 acres by applying water throughout the season for seasonal application of 25 inches
  - Mid-summer deficit (no) irrigation


10
9
8
7
6
5
4
3
2
1
0
100% - 8.1 tons/acre
50% - 4.2 tons/acre
Yield (tons/acre)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Seasonal evapotranspiration (inches)

# Economic Analysis

- **Irrigate 50 acres with 50 inches of water (assume no yield from the remaining 50 acres)**
  - **Yield = 8.1 tons/acres**
  - **Total yield = 8.1 tons/acre x 50 acres = 405 tons**
  - **Revenue = $110/ton x 405 tons = $44,550**

- **Irrigate 100 acres with 25 inches of water**
  - **Yield = 4.2 tons/acre**
  - **Total yield = 4.2 tons/acre x 100 acres = 420 tons**
  - **Revenue = $110/ton x 420 tons = $46,200**

**Note: analysis does not consider other costs such as harvest, spraying, etc.**

## Mid-summer deficit irrigation

- 100 acres (full seasonal irrigation yield – 8.53 tons/acres)
- Full irrigation for the first three harvests
- No irrigation for the last three harvests

**Yield by harvest**

1 – 1.66 tons/ac
2 – 1.56 tons/ac
3 – 1.58 tons/ac
4 – 0.66 tons/ac
5 – 0 tons/ac
6 – 0 tons/ac
Total – 5.46 tons/ac

- Total yield = 100 acres x 5.46 tons/ac = 546 tons
- Total revenue = $110/ton x 546 tons = $60,060

# Conclusions

- Mid-summer deficit (no) irrigation offers a potential for higher revenue
- Potential may vary due to site specific conditions

# That's All, Folks