



# **Thirty Plus years of Irrigation Technology Transfer in California**

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**INOVAGRI**  
International Meeting

&



**IV WINOTEC**  
International Workshop  
Technological Innovations  
in Irrigation

# **Irrigation Technology Transfer**

## **(1980-2012)**

**2,500 farmer survey**

**Less than 0.5% ever used ET**

**Faber and Snyder (1990)**

**2012 estimate**

**30 to 40% of farmers use ET**

**Department of Water Resources**

**Why the big adoption of technology?**

# ET Information

1.  $ET_0$  Map
2. CIMIS
3. Spatial CIMIS
4. FRET

**Reasons for Adoption**

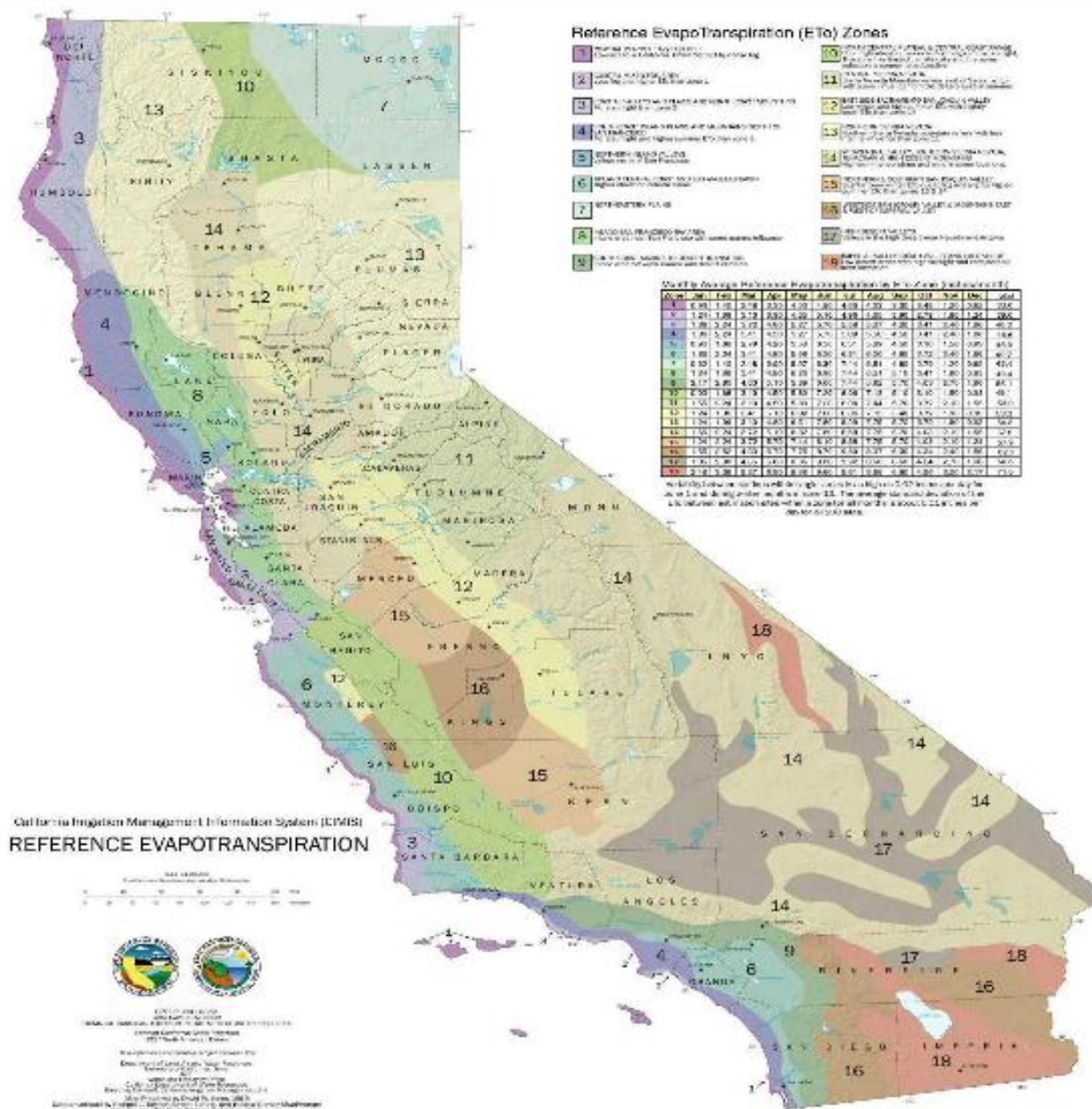
Spatial Overview  
Spatial Model

- ETo Map
- Solar Radiation Map
- Station Location Map
- ETo Zones Map

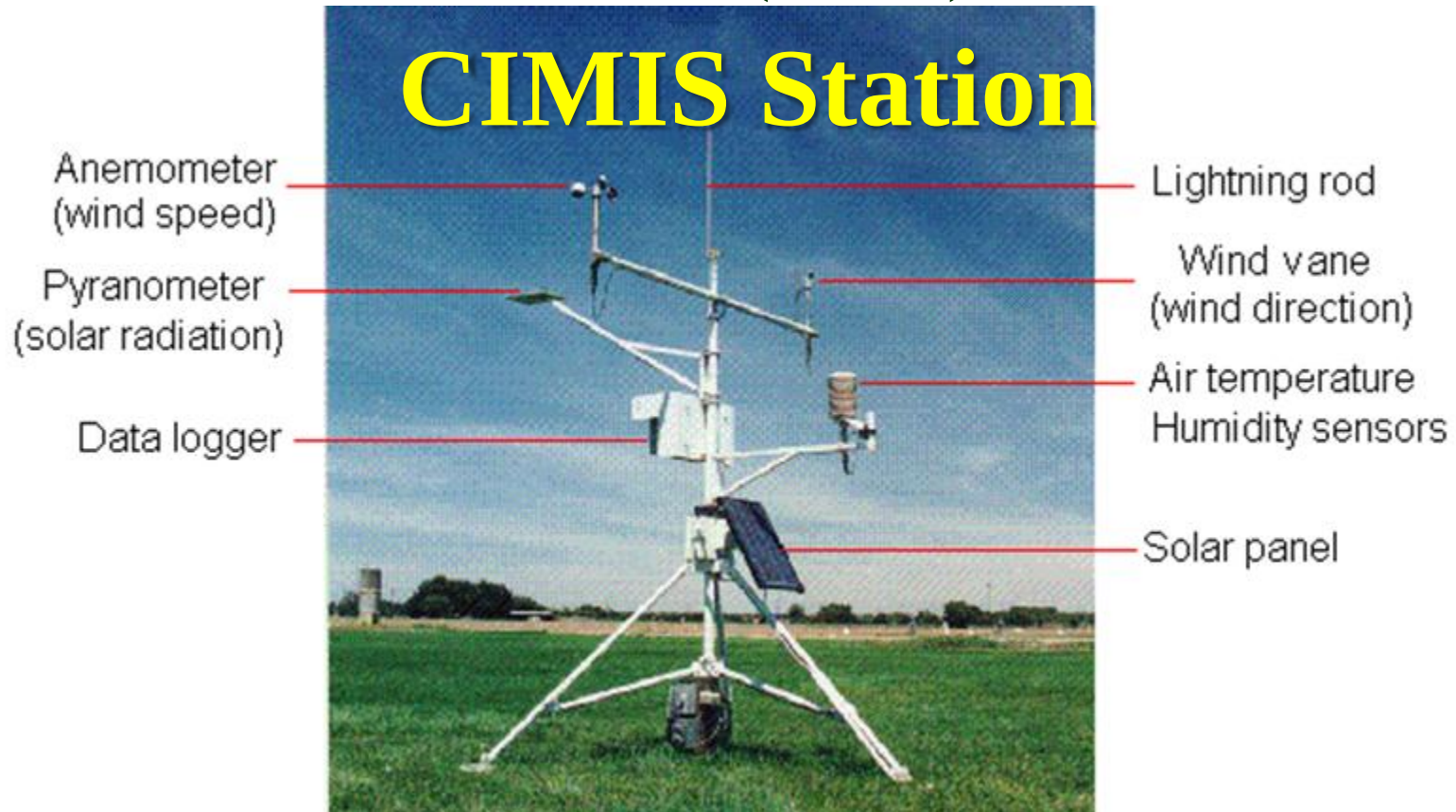
- Logon
- Map Reports
- Map Reports Help

The EToZones Map was created by ....

## 1. ET<sub>0</sub> Map



# Reference ET (ETo) Network



- **137 Active Weather Stations**
- **Main Agricultural Regions**
- **Main Urban Areas**

**R.L. Snyder, E. Fereres , W.O. Pruitt, D. Henderson,  
J. Hatfield, T.C. Hsiao, W.W. Wallender, A. Dong**

# **Benefits from CIMIS**

- 1. Water savings**
- 2. Reduced runoff**
- 3. Higher yield and quality**
- 4. Healthier landscape**
- 5. Improved water quality**
- 6. Increased energy efficiency**
- 7. Weather data set**

# **CIMIS cost/benefit study**

- 1. 10%-20% less applied water**
- 2. 23% growers increased crop yield**
- 3. 28% growers increased crop quality.**
- 4. Operation cost \$850,000/year**
- 5. Farmer profits \$64,200,000/year**

**Parker et al. (2000)**

# 2011 Irrigation Scheduling Survey

**55% use soil moisture monitoring**

**43% use crop ET (ETc) estimates**

**38% use midday stem water potential**

**Soil Moisture**



**CIMIS**



**Stem Water Potential**



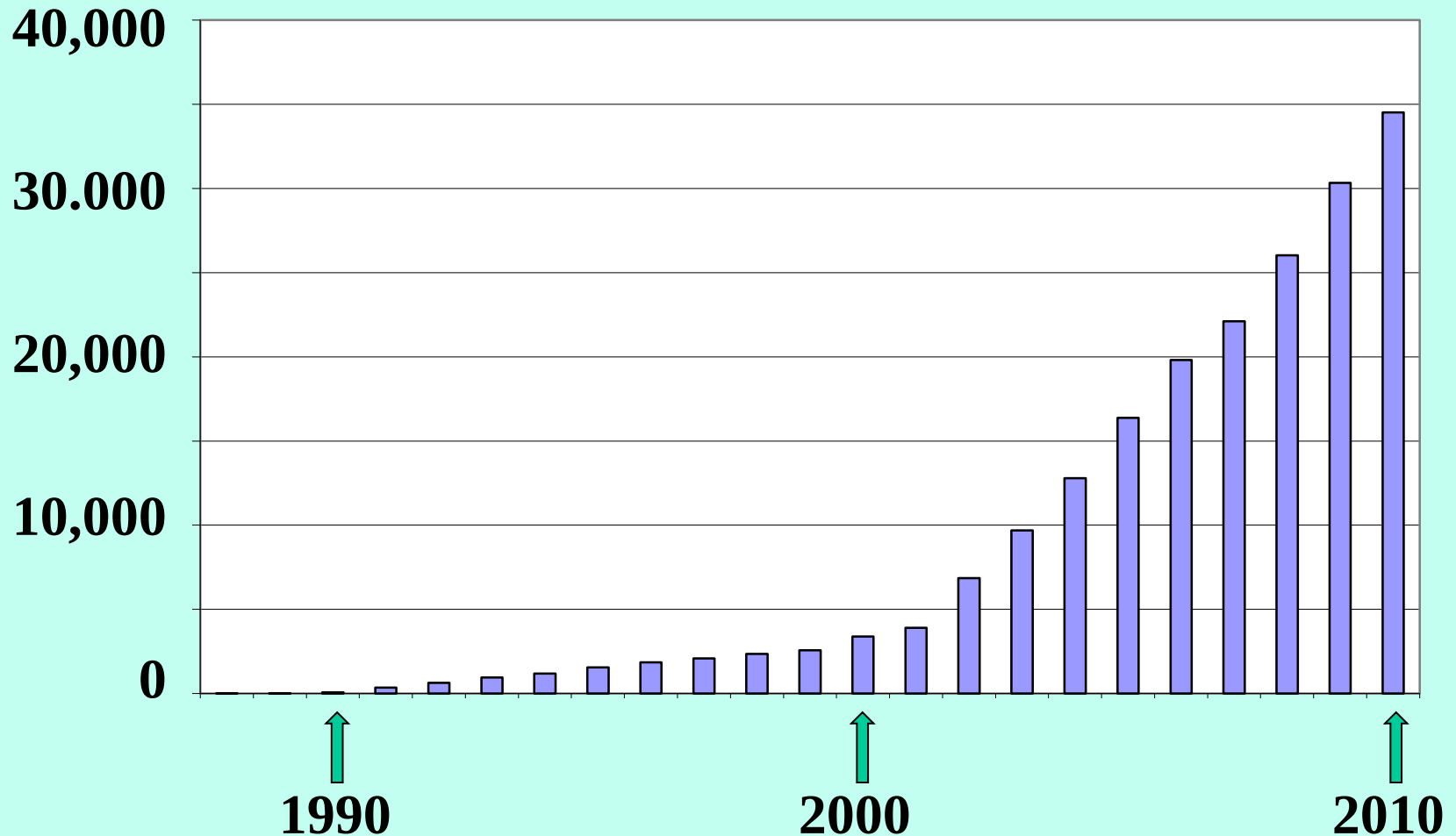
**Almond Board (2011)**

**From: Allan Fulton**

# CIMIS Adoption Indicator

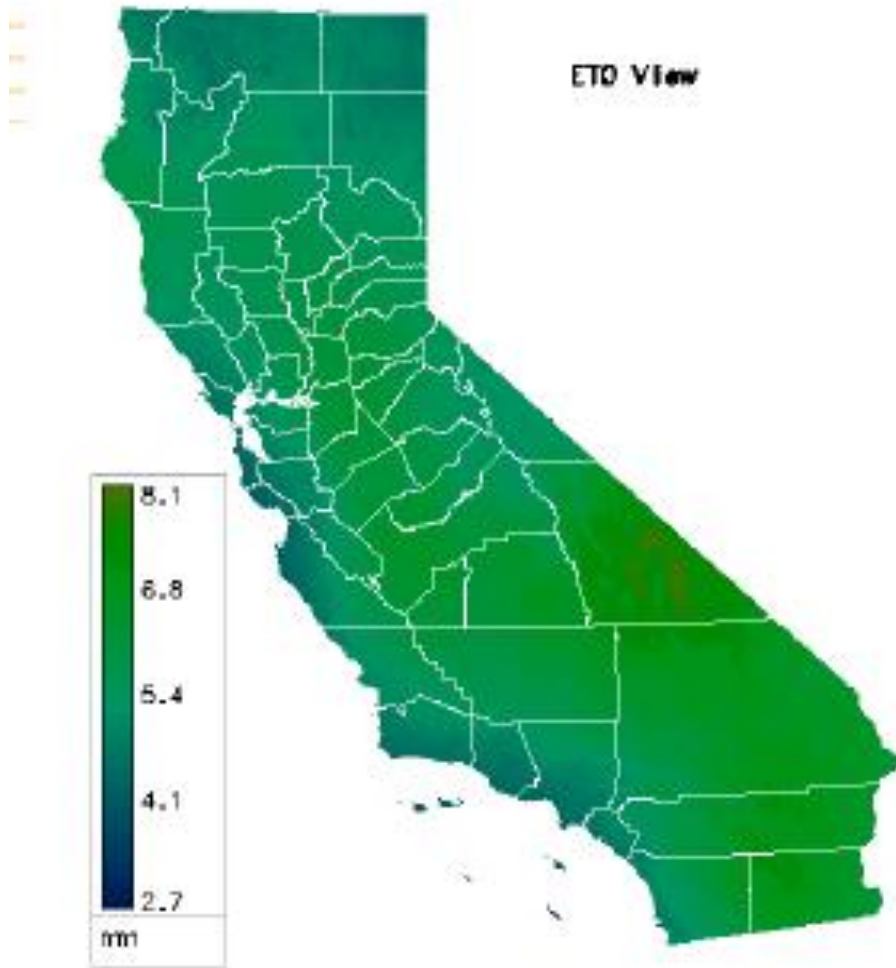
Registered CIMIS Data Users

Users



# Spatial CIMIS

May 19, 2012



ET<sub>0</sub> (2-km grid)

Uses:

**CIMIS**

**Remote sensing**

**Topography**

<http://wwwcimis.water.ca.gov/cimis/cimiSatSpatialCimis.jsp>

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## Forecast Weather Table Interface

Select Weather Format

- ☒ Custom Weather Table  
☐ XML  
☐ Point Forecast Page
- ☐ Point Forecast Matrix  
☐ Hourly Tabular Forecast  
☐ Hourly Weather Graph

Interval in Hours: ☐ 1 ☒ 3 ☐ 6Duration in Days: ☐ 1 ☐ 2 ☒ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Enter a Location or Click on Map Below

Search by address; city,state; latitude/longitude...

Chico CA

Go





Get Local Forecast for:

Enter location ...

Search Help

XML RSS Feeds

Current Hazards

Watches / Warnings

Outlooks

NOAA Watch

Local Outlook

Current Conditions

Observations

Radar

Satellite

Precipitation

Soundings/Profilers

Other Observations

Forecasts

Forecast Discussion

Local Area

Activity Planner

Aviation Weather

Fire Weather

Marine Weather

Severe Weather

Hurricane Center

Weather Tables

Hydrology

Rivers and Lakes

Other Hydro Info

Climate

Local

National

Drought

More...

Climate portal

Weather Safety

Preparedness

Weather Radio

SkyWarn™

StormReady

Weather Spotters

Additional Info

Items of Interest

Other Useful Links

Education Resources

COOP Observer

Our Office

Computer models

Contact Us

Contact Info

No Warnings or Advisories In Effect for this Point.

For warnings and/or advisories in effect for adjacent areas to this point, see <http://www.wrh.noaa.gov/sto>Change Table Font Size [Increase](#) [Decrease](#)

Forecast For Lat/Lon: 39.7380/-121.8480 (Elev. 194 ft)

3 Miles WSW Chico CA

Custom Weather Forecast Table

|                      | Tue Nov 08                      |        |         |        |        |        |         |        | Wed Nov 09                      |        |         |        |        |        |         |        | Thu Nov 10                      |        |         |        |        |        |         |        | Fri<br>Nov<br>11         |
|----------------------|---------------------------------|--------|---------|--------|--------|--------|---------|--------|---------------------------------|--------|---------|--------|--------|--------|---------|--------|---------------------------------|--------|---------|--------|--------|--------|---------|--------|--------------------------|
| Weather              | Patchy Frost and Fog            |        |         |        |        |        |         |        | Patchy Fog                      |        |         |        |        |        |         |        | Patchy Fog                      |        |         |        |        |        |         |        | Slight<br>Chance<br>Rain |
| Daily-Temp           | High <b>59</b><br>Low <b>36</b> |        |         |        |        |        |         |        | High <b>62</b><br>Low <b>38</b> |        |         |        |        |        |         |        | High <b>66</b><br>Low <b>40</b> |        |         |        |        |        |         |        | Low<br><b>43</b>         |
| Chance of<br>Precip  | 0%                              | 0%     | 0%      | 0%     | 0%     | 0%     | 0%      | 0%     | 0%                              | 0%     | 0%      | 0%     | 0%     | 0%     | 0%      | 0%     | 5%                              | 10%    | 20%     |        |        |        |         |        |                          |
| Precip<br>12-hr      | 0.00"                           | 0.00"  | 0.00"   | 0.00"  | 0.00"  | 0.00"  | 0.00"   | 0.00"  | 0.00"                           | 0.00"  | 0.00"   | 0.00"  | 0.00"  | 0.00"  | 0.00"   | 0.00"  | 0.00"                           | 0.00"  | 0.00"   |        |        |        |         |        |                          |
| Snow Total           | 0"                              |        |         |        |        |        |         |        | 0"                              |        |         |        |        |        |         |        | 0"                              |        |         |        |        |        |         |        | 0"                       |
| FRET                 | 0.05"                           |        |         |        |        |        |         |        | 0.05"                           |        |         |        |        |        |         |        | 0.06"                           |        |         |        |        |        |         |        | "                        |
| 3-Hour<br>Temp       | 4am 37                          | 7am 36 | 10am 51 | 1pm 56 | 4pm 55 | 7pm 48 | 10pm 44 | 1am 41 | 4am 40                          | 7am 39 | 10am 54 | 1pm 61 | 4pm 60 | 7pm 51 | 10pm 46 | 1am 44 | 4am 42                          | 7am 41 | 10am 56 | 1pm 64 | 4pm 65 | 7pm 53 | 10pm 49 | 1am 47 |                          |
| Cloudiness           | 11%                             | 11%    | 24%     | 24%    | 24%    | 24%    | 30%     | 30%    | 28%                             | 28%    | 35%     | 35%    | 32%    | 32%    | 32%     | 44%    | 44%                             | 53%    | 53%     | 58%    | 58%    | 62%    | 62%     |        |                          |
| Dewpoint             | 33                              | 34     | 42      | 39     | 41     | 40     | 38      | 36     | 36                              | 36     | 40      | 39     | 34     | 39     | 38      | 37     | 37                              | 38     | 38      | 37     | 34     | 40     | 41      | 40     |                          |
| Relative<br>Humidity | 84%                             | 90%    | 71%     | 52%    | 58%    | 75%    | 79%     | 81%    | 85%                             | 89%    | 60%     | 44%    | 38%    | 65%    | 72%     | 76%    | 83%                             | 88%    | 50%     | 37%    | 31%    | 60%    | 73%     | 77%    |                          |
| Wind                 | NE                              | N      | W       | W      | W      | NE     | NE      | NE     | NE                              | N      | W       | S      | SE     | N      | N       | N      | N                               | N      | SE      | SE     | S      | S      | NE      | NE     |                          |
| Snow<br>Level (ft)   | 2                               | 2      | 2       | 3      | 2      | 1      | 2       | 2      | 2                               | 3      | 2       | 2      | 3      | 1      | 3       | 3      | 3                               | 3      | 3       | 3      | 1      | 1      | 7       | 7      |                          |
|                      | 540                             | 254    | 0254    | 0254   | 0270   | 2870   | 2870    | 2870   | 2873                            | 3987   | 3987    | 3987   | 3987   | 8927   | 8927    | 8927   | 7383                            | 7383   | 7383    | 7383   | 6768   | 6768   | 6768    | 6768   |                          |

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Reload Table



Print Version

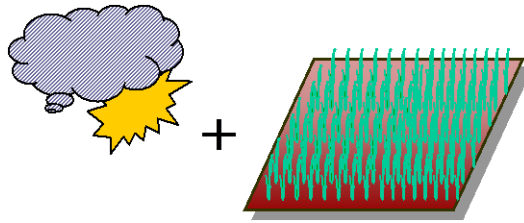
Enter a Location or Click on Map Below

Search by address; city, state; latitude/longitude...

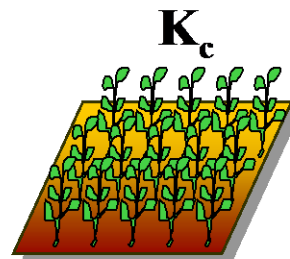
Go



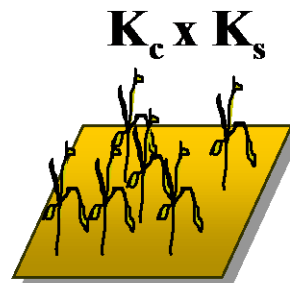
# Actual Crop ET ( $ET_a$ )



$ET_o$   **$ET_o$  from weather**



$ET_o \times K_c = ET_c$   **$ET_c = ET_o \times K_c$**



$ET_o \times K_c \times K_s = ET_a$   **$ET_a = ET_c \times K_s$**

$K_c$  factors could change with climate

# Crop Evapotranspiration

$$ET_c = ET_0 \times K_c$$



## Measurement

Eddy covariance

Surface renewal

Lysimeter

## $K_c$ Improvements

Soil

Climate

Topography

# Lysimeter (Peach Orchard)



# Energy Balance

$$LE = R_n - G - H$$

**LE – Latent Heat Flux**

**$R_n$  – Net Radiation**

**G – Ground Heat Flux**

**H – Sensible Heat Flux**

$$ET_a = \frac{LE}{2.45 \text{ MJ kg}^{-1}}$$

$$K_a = K_c \times K_s = \frac{ET_a}{ET_o}$$

# **Sensible Heat Flux**

## **Surface Renewal**

## **Eddy Covariance**



# Water Balance Scheduling

$$\Delta W = I + P + C - R - D - ET_a$$

$\Delta W$  - change in soil water content

$I$  - irrigation application

$P$  - precipitation (fog and dew)

$C$  - capillary (water table)

$R$  - runoff

$D$  - deep percolation

$ET_a$  - actual evapotranspiration

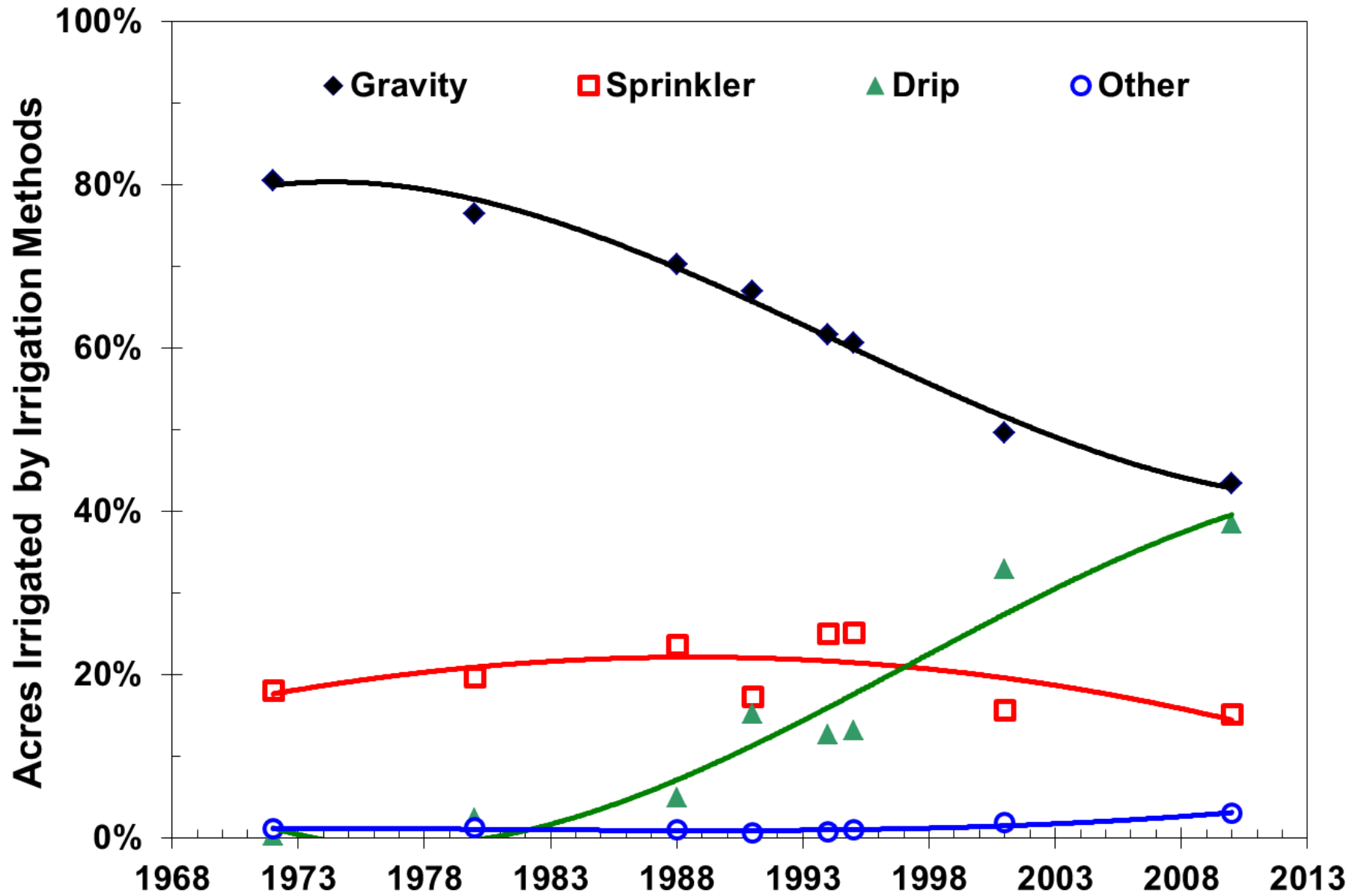
Problems: Fog, Dew, Light Rain, and Water Tables

# **New Technology**

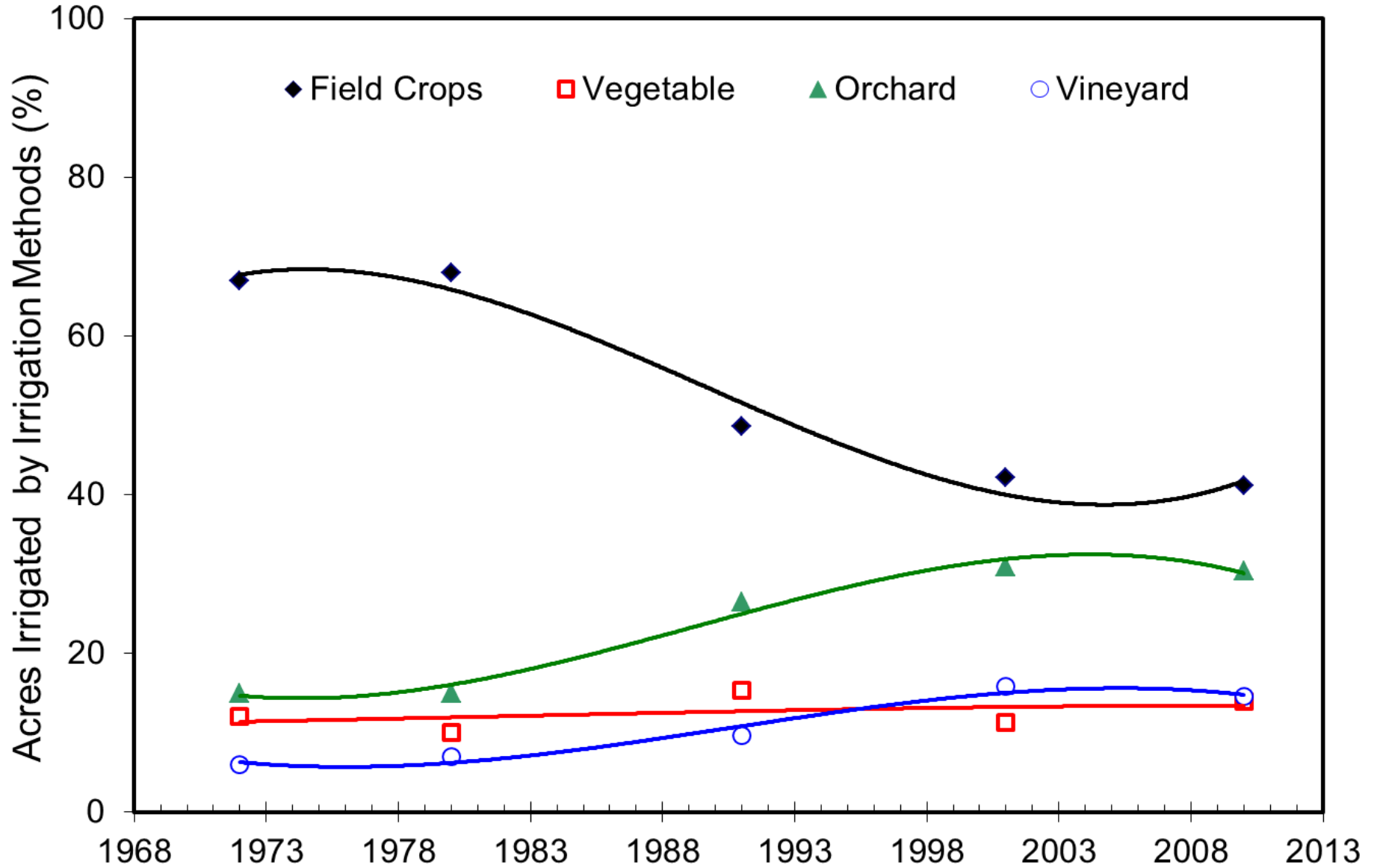
- 1. Irrigation Systems**
- 2. Crop changes**
- 3. Regulated Deficit**
- 4. Soil Monitoring**

**Reasons for Adoption**

# Irrigation Method



# Cropping Trends



# Regulated Deficit Irrigation Increased Yield and Quality

## Stem Water Potential



## Reasons for Adoption

# Soil Monitoring

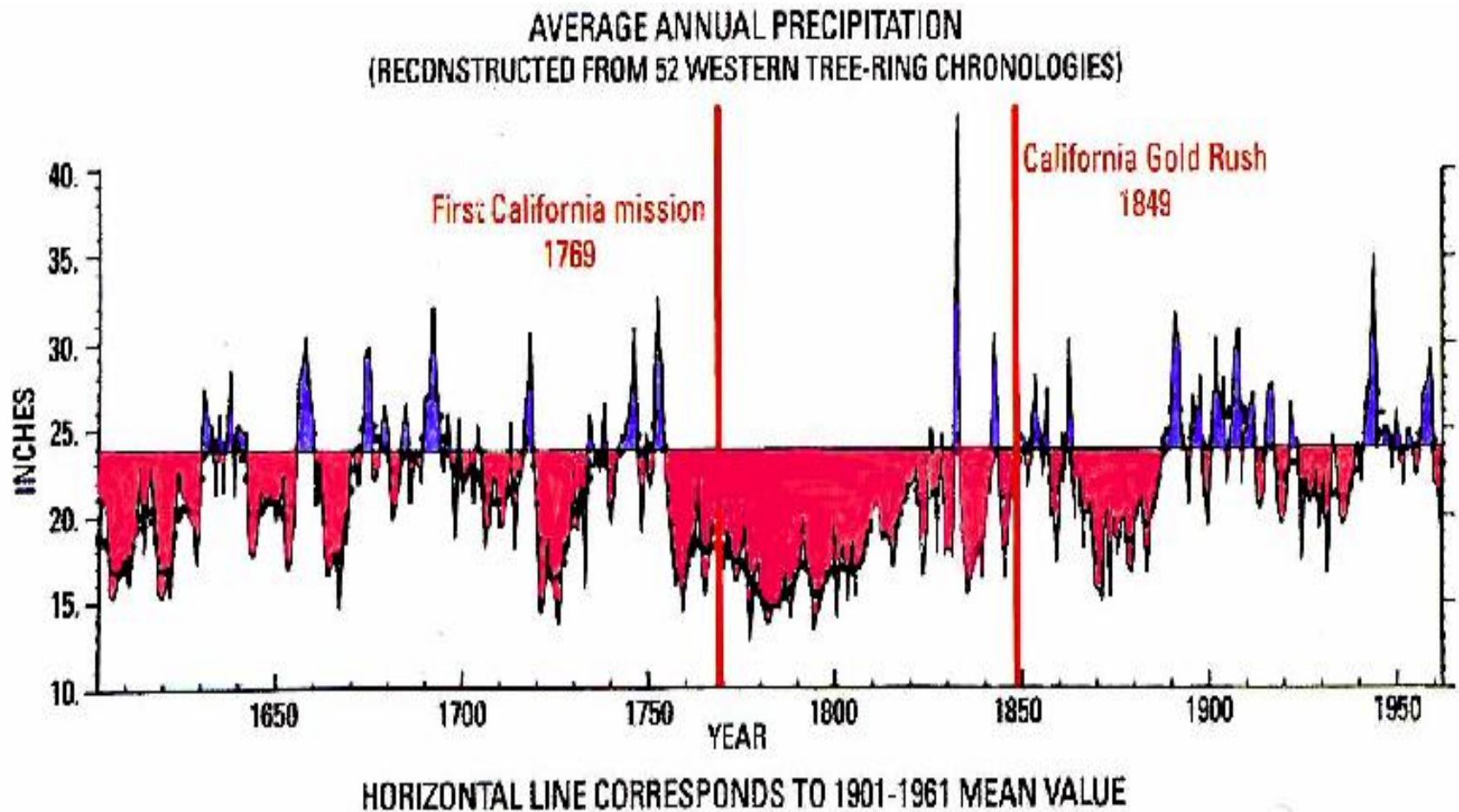


# **Economics**

- 1. Local costs**
- 2. Labor costs**
- 3. Energy costs**
- 4. Yield and Quality**

**Reasons for Adoption**

# Drought (1988-1992)



## Reasons for Adoption

# **Education**

- 1. Education Level**
- 2. Consultants**
- 3. Farm Advisors**

**Reasons for Adoption**

# **Farm Size**

- 1. Large – Agronomists**
- 2. Medium - Consultants**
- 3. Small – UC Extension**

**Reasons for Adoption**

# **Scheduling Requirements**

**Application Rate**

**Distribution Uniformity**

**$\Delta$ Soil Water Content**

**Soil Water Monitoring**

**ET & Water Balance**

**Plant Water Status**

# **Scheduling Requirements**

**What is Needed?**

**$\Delta$  Soil Water**

**Mobile Labs**

**Training**

**The End**

**Thanks!**

**Richard L. Snyder**

**<http://biomet.ucdavis.edu>**