Scheduling Irrigation
How Much and When

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Resilient Landscaping
Sanger, CA
October 15, 2015
Learning Objectives

• How to calculate a schedule
  - Irrigation system factors
  - Why is soil important in scheduling?
  - Climate
  - Landscape factors

• Understanding other factors that influence irrigation management

• Is drip better?
Irrigation Objectives

- Provide water to plants
  - only when it is needed
  - only the amount that will be used
  - only where it can be used

Photo: L. Oki
Irrigation System Objectives

- Delivery
- Control
Irrigation System Objectives

• Delivery
  - Place water where it can be used
  - Uniformly or in the desired pattern
  - Apply water so the soil can absorb it
Irrigation System Objectives

- Delivery
- Control
  - When
    - Start irrigation
  - How much
    - Stop irrigation
- Focus on timer controllers
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients
  - Climate (Water Use Rates)
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity (0.65)
  - Precipitation rate
    - How fast water is applied
Precipitation Rate

- Calculating PR
  - Average of all ($Avg_T$), mL
  - Catch can throat area ($C$), sq.in
    - This is 16.6 sq. in. for the ones used
  - Valve on duration ($T$), minutes
    - Let’s set this at 4 minutes

$$PR = \frac{Avg_T}{C \times T} \times 3.66$$
Developing An Irrigation Schedule

• Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
    • Plant available water
# Soil Texture

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Infiltration Rate (in/hr)</th>
<th>Plant Avail Water (cm/cm)*</th>
<th>Irrig to Wet to Depth (in)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand / fine sand</td>
<td>1.5</td>
<td>0.05</td>
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<tr>
<td>loamy sand</td>
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</tr>
<tr>
<td>Moderately Coarse sandy loam</td>
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<tr>
<td>Medium loam</td>
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<td>silty loam</td>
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<tr>
<td>clay</td>
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<td>0.9</td>
</tr>
</tbody>
</table>

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth
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<td>0.8</td>
<td>0.11</td>
<td>0.66</td>
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<tr>
<td>Medium</td>
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<tr>
<td>loam</td>
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<td>0.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Irrig to wet to depth

Desired depth to wet = 12”

Plant avail water = 0.2

Assume 50% dry down

\[
12” \times 0.2 \times 50\% = 1.2”
\]

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth
Run-time, Part 1

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<td>Medium silty loam</td>
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</table>

- Calculating Run-time
  - Lower Boundary (LB)
    - PR = 1.35 in/hr
    - Irrigation to wet to depth = 1.2”
Run-time, Part 2

- Calculating Run-time with DU
  - Upper Boundary (UB)
    - Scheduling multiplier (SM)
      - DU = 0.65
    - Lower boundary (LB) = 53 min.
Developing An Irrigation Schedule

• Things you know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
Developing An Irrigation Schedule

- Things you know
  - Distribution uniformity = 0.65
  - Precipitation rate = 1.35 in/hr
  - Soil texture
    - Lower boundary = 53 min
    - Upper boundary = 67 min

- This is how much to water
- Now we need to know when to irrigate
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients ($K_L$)
Landscape Coefficients

- Information on plant water use
- WUCOLS

www.ucanr.sites/WUCOLS
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients ($K_L$)
  - Climate ($ET_0$)
CIMIS

California Irrigation Management Information System

- Collects weather info
- Estimates plant water use
- More than 120 stations

Water use reports are used with a crop or landscape coefficient to estimate site water use

http://www.cimis.water.ca.gov/cimis/
Climate

- Water use models
  - Based on weather data
  - Requires previous research
  - Crop specific
  - Easy to use
Climate

Water use models

Reference ET ($ET_0$) is reported (CIMIS)
Crop coefficient ($K_c$) is necessary
Determine $ET_{crop} (ET_c)$ to estimate crop water use
so, $ET_c = ET_0 \times K_c$

Example: citrus orchard

$K_c = 0.65$

If $ET_0 = 0.5”$, then

crop water use is 0.325”

(0.325=0.5 x 0.65)
ETo Zones Map

http://www.cimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf
### ETo Zones

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

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**Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
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See the [Cimis Reference Evapotranspiration (ETo) Zones](http://www.cimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf) for more detailed information.
Developing An Irrigation Schedule

• So,
  - We know how much to apply (1.2 in)
  - Replaces ½ of field capacity

• Then,
  - We need to estimate when that amount of water is used
  - We know our plants
  - We have info about the climate
Developing An Irrigation Schedule

- **Landscape and plant coefficients** ($K_L$)
  - For this example, 0.4

- **Climate (Water Use Rates)**
  - For this example, we’ll use October = 4.03 in/month
  - $ET_{day} = 4.03 \text{ in} \div 31 \text{ days} = 0.13 \text{ in/day}$

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- For this example, we’ll use October = 4.03 in/month
  - $ET_{day} = 4.03 \text{ in} \div 31 \text{ days} = 0.13 \text{ in/day}$
Developing An Irrigation Schedule

• How fast is our landscape using water?
  - \( ET_L = ET_{\text{day}} \times K_L \)
  - \( ET_{\text{day}} = 0.13 \text{ in/day} \)
  - \( K_L = 0.4 \)

\[ ET_L = 0.13 \times 0.4 = 0.07 \text{ in/day} \]
Developing An Irrigation Schedule

- Determine when to irrigate
  - Irrigation application = 1.2 in
  - $ET_L = 0.07$ in/day
- Accumulate $ET_L$ daily
- When accumulated total reaches 1.2 in
- Irrigate!
## Developing An Irrigation Schedule

### October

<table>
<thead>
<tr>
<th>Day</th>
<th>Total ET&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Day</th>
<th>Total ET&lt;sub&gt;i&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.07</td>
<td>11</td>
<td>0.77</td>
</tr>
<tr>
<td>2</td>
<td>0.14</td>
<td>12</td>
<td>0.84</td>
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<td>4</td>
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<td>15</td>
<td>1.05</td>
</tr>
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<tr>
<td>10</td>
<td>0.70</td>
<td>20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

- **ET<sub>day</sub>** = 0.13
- **K<sub>L</sub>** = 0.4
- **ET<sub>L</sub>** = 0.07
- **Irrig** = 1.2

\[
\begin{align*}
ET_{\text{day}} &= 0.13 \\
K_L &= 0.4 \\
ET_{L} &= 0.07 \\
Irrig &= 1.2 \\
\end{align*}
\]

\[
\begin{align*}
1.19 + 0.07 (ET_{L}) &= 1.26 \\
- 1.20 (Irrig) &= 0.06
\end{align*}
\]
# Developing An Irrigation Schedule

**October**

<table>
<thead>
<tr>
<th>Day</th>
<th>Total ET$_i$</th>
<th>Day</th>
<th>Total ET$_i$</th>
<th>Day</th>
<th>Total ET$_i$</th>
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<tbody>
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<td>0.07</td>
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<td>0.27</td>
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<tr>
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<td>17</td>
<td>1.19</td>
<td>27</td>
<td>0.69</td>
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<tr>
<td>8</td>
<td>0.56</td>
<td>18</td>
<td>0.06</td>
<td>28</td>
<td>0.76</td>
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<tr>
<td>9</td>
<td>0.63</td>
<td>19</td>
<td>0.13</td>
<td>29</td>
<td>0.83</td>
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<tr>
<td>10</td>
<td>0.70</td>
<td>20</td>
<td>0.20</td>
<td>30</td>
<td>0.90</td>
</tr>
</tbody>
</table>

\[ \text{ET}_\text{day} = 0.13 \]
\[ K_L = 0.4 \]
\[ \text{ET}_L = 0.07 \]
\[ \text{Irrig} = 1.2 \]
Developing An Irrigation Schedule

- For more accuracy
  - Use actual daily ET
  - Obtain from CIMIS
  - Calculate & accumulate actual rather than historical ET_L

<table>
<thead>
<tr>
<th>Day</th>
<th>Total ET_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.07</td>
</tr>
<tr>
<td>2</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>0.21</td>
</tr>
<tr>
<td>4</td>
<td>0.28</td>
</tr>
<tr>
<td>5</td>
<td>0.35</td>
</tr>
<tr>
<td>6</td>
<td>0.42</td>
</tr>
<tr>
<td>7</td>
<td>0.49</td>
</tr>
<tr>
<td>8</td>
<td>0.56</td>
</tr>
<tr>
<td>9</td>
<td>0.63</td>
</tr>
<tr>
<td>10</td>
<td>0.70</td>
</tr>
</tbody>
</table>

ET_{day} = 0.13  
K_L = 0.4  
ET_L = 0.07  
Irrig = 1.2
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients ($K_L$)
  - Climate ($ET_0$)
More Things to Consider

• Adjust controllers monthly
  - Program for monthly changes in $\text{ET}_{\text{day}}$

• Interval vs. duration
  - Increase interval between irrigations
  - DO NOT reduce run times
  - Affects wetting depth
Precipitation Rates

- Precipitation rate
  - How fast water is applied
- Infiltration rates
  - How fast water enters soil

Precipitation > Infiltration = RUNOFF
Precipitation Rates

- Note interval when runoff occurs
- Example:
  - Duration to runoff is 6 minutes
  - Upper boundary is 30 minutes
  - 6 minute duration, 5 times
  - “Cycle-Soak” or “Pulsing”

Precipitation > Infiltration = RUNOFF
Delivery Method

- Upgrade sprinklers if possible
- At three study sites upgrades resulted in DU increases of 21%, 24%, and 18%

Photo: B. Baker
Time of Day

• Why early in the day?
  - Lower temperatures
  - Less wind
Deep irrigation

• Deep irrigation
  Fills a larger volume of soil to provide water to plants

• Use a soil probe to check wetting depth

Photo: B. Baker
### Drip Irrigation

- **Can it save water?**
- **Does it save water?**

<table>
<thead>
<tr>
<th>GENERAL GUIDELINES</th>
<th>TURF</th>
<th>SHRUB &amp; GROUNDCOVER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLAY SOIL</strong></td>
<td>0.26 GPH</td>
<td>0.26 GPH</td>
</tr>
<tr>
<td><strong>LOAM SOIL</strong></td>
<td>0.4 GPH</td>
<td>0.4 GPH</td>
</tr>
<tr>
<td><strong>SANDY SOIL</strong></td>
<td>0.6 GPH</td>
<td>0.6 GPH</td>
</tr>
<tr>
<td><strong>COARSE SOIL</strong></td>
<td>0.9 GPH</td>
<td>0.9 GPH</td>
</tr>
<tr>
<td><strong>CLAY SOIL</strong></td>
<td>18”</td>
<td>18”</td>
</tr>
<tr>
<td><strong>LOAM SOIL</strong></td>
<td>18”</td>
<td>18”</td>
</tr>
<tr>
<td><strong>SANDY SOIL</strong></td>
<td>12”</td>
<td>12”</td>
</tr>
<tr>
<td><strong>COARSE SOIL</strong></td>
<td>12”</td>
<td>12”</td>
</tr>
<tr>
<td><strong>EMITTER FLOW</strong></td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>EMITTER SPACING</strong></td>
<td>18”</td>
<td>18”</td>
</tr>
<tr>
<td><strong>LATERAL (ROW) SPACING</strong></td>
<td>18”</td>
<td>18”</td>
</tr>
<tr>
<td><strong>BURIAL DEPTH</strong></td>
<td>Bury evenly throughout the zone from 4” to 6”</td>
<td>On-surface or bury evenly throughout the zone to a maximum of 6”</td>
</tr>
<tr>
<td><strong>APPLICATION RATE (INCHES/HOUR)</strong></td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>APPROXIMATE TIME TO APPLY 1/4” OF WATER (MINUTES)</strong></td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

Following these maximum spacing guidelines, emitter flow selection can be increased if desired by the designer. 0.9 GPH flow rate available for areas requiring higher infiltration rates, such as coarse sandy soils.

Note: 0.4, 0.6 and 0.9 GPH are nominal flow rates. Actual flow rates used in the calculations are 0.42, 0.61 and 0.92 GPH.
Drip Irrigation

- Precipitation rates approach those of overhead
- Proper management is key

<table>
<thead>
<tr>
<th>GENERAL GUIDELINES</th>
<th>TURF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLAY SOIL</td>
</tr>
<tr>
<td>Emitter Flow</td>
<td>0.26 GPH</td>
</tr>
<tr>
<td>Emitter Spacing</td>
<td>18”</td>
</tr>
<tr>
<td>Lateral (Row) Spacing</td>
<td>18” 20” 22”</td>
</tr>
<tr>
<td>Burial Depth</td>
<td></td>
</tr>
<tr>
<td>Application Rate (Inches/Hour)</td>
<td>0.19 0.17 0.15</td>
</tr>
<tr>
<td>Time to Apply 1/4” of Water (Minutes)</td>
<td>80 89 97</td>
</tr>
</tbody>
</table>
Drip Irrigation

- Precipitation rates approach those of overhead
- Proper management is key
Drip Irrigation

- Precipitation rates approach those of overhead.
- Proper management is key.
Even More Things To Consider

- Prioritize plants that receive water
- Know water stress symptoms
- Precondition to enhance survival
- Manage salinity
Managing Irrigation

• It’s a “piece of cake”
  - There are a lot of ingredients needed to make the cake
  - There are several, distinct steps to put the ingredients together properly
  - Each has to be managed as part of a program
  - Changing one affects another

• The short version: “It’s complex”
Managing Irrigation

- Anyone can do a mediocre (or less) job
- Doing it well requires diligence
- We’ve gotten away with “good enough” because water supply wasn’t an issue.
- Now it is an issue.

- The question that will be asked:
  - Are the rewards worth the effort?
Websites

DU, PR, and schedule calculator

ccuh.ucdavis.edu/public/drought/landscape-irrigation-system-evaluation-management
Websites

SoilWeb application

http://casoilresource.lawr.ucdavis.edu/soilweb-apps
Websites

UCD Irrigation Trials

http://ccuh.ucdavis.edu/academia/TrialsOverview2.pdf
Thank you

lroki@ucdavis.edu
Fate of Irrigation Water

- **Surface runoff**
  - Carries pesticides and fertilizer to storm drains.

- **Deep percolation**
  - Water draining below the root zone.
  - Carries soluble pollutants into groundwater.

- **Root Zone**
  - A portion is available for use by plants.

- **Evaporation**
  - From the soil surface or during application.