The New California Landscape

Maintaining Landscapes for Low Water Use

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October 16, 2015

UCDAVIS
PLANT SCIENCES

University of California
Agriculture and Natural Resources

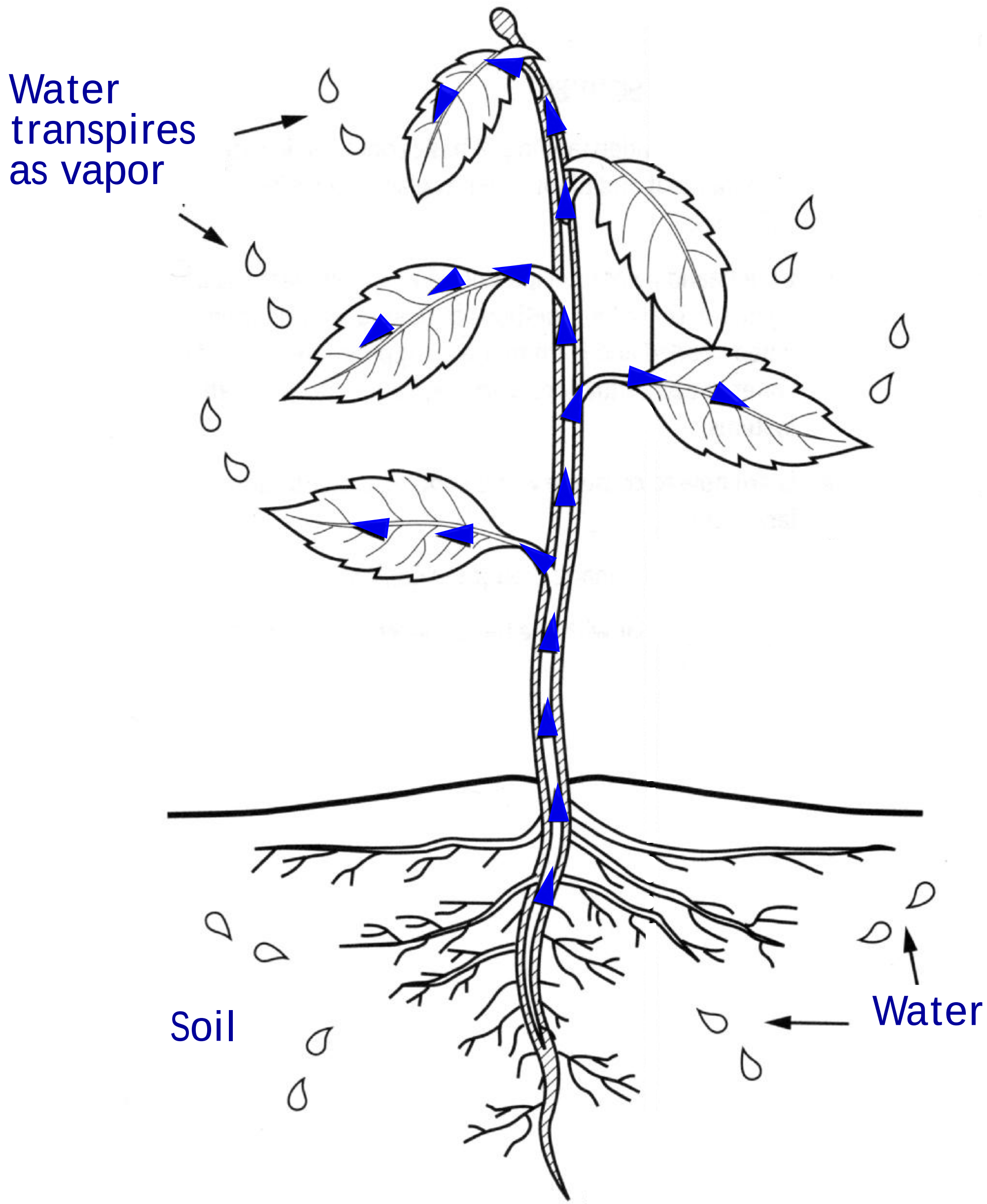
Topics

- Why plants need water
- Irrigation management
  - Assessing system performance
  - Scheduling
  - Smart controllers
- Maintaining plants
  - Turf
  - Trees and shrubs
  - Edibles
- Fire Safe

Topics

- Why plants need water

Soil-Plant-Atmosphere continuum



Graphic: California Master Gardener Handbook, 2002

Why do plants need water?
How does water move from the soil, up a plant, and into the air?

The concept of water potential

Water moves down an energy gradient

Potential energy components of water in substrates

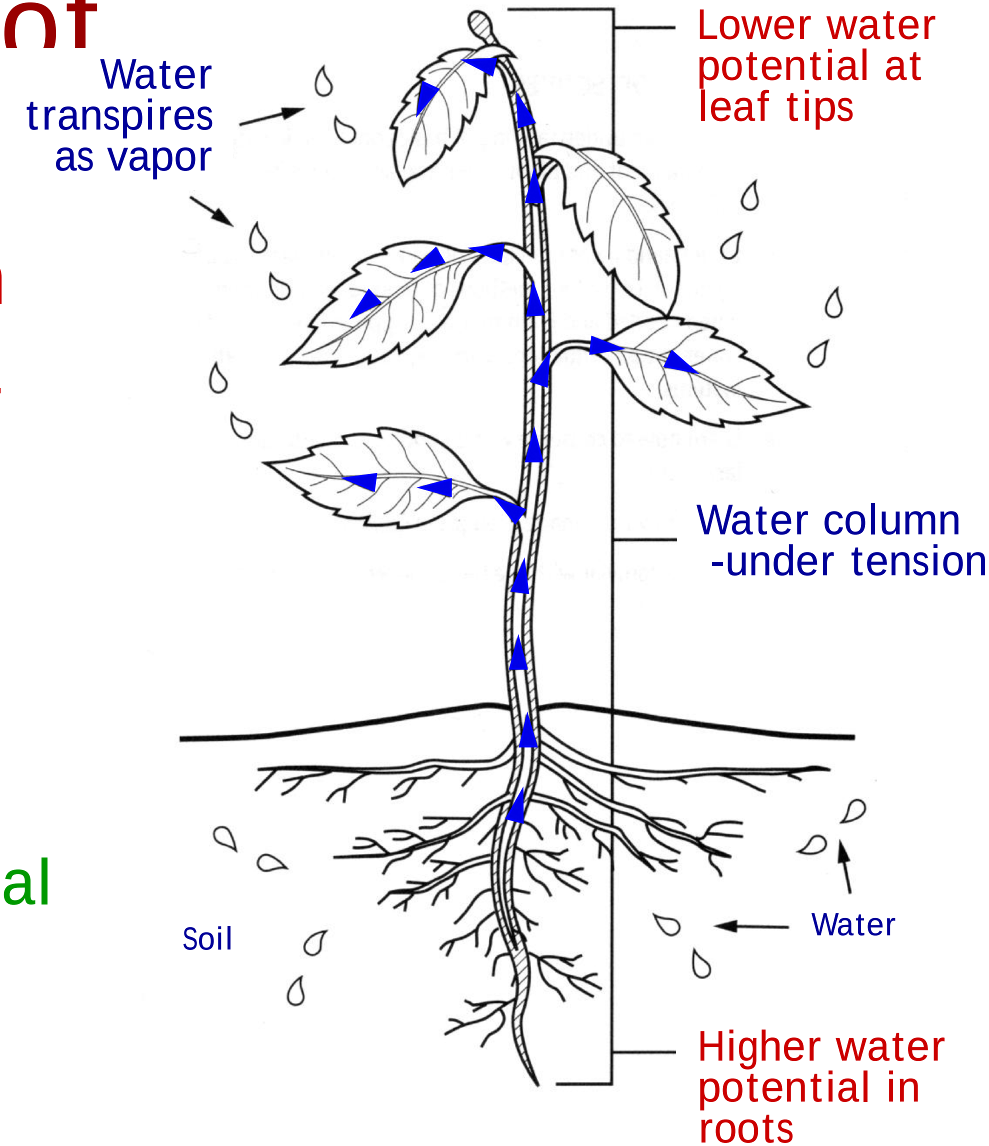
- Matric potential
- Gravimetric potential
- Solute potential

The concept of

Water moves down an energy gradient

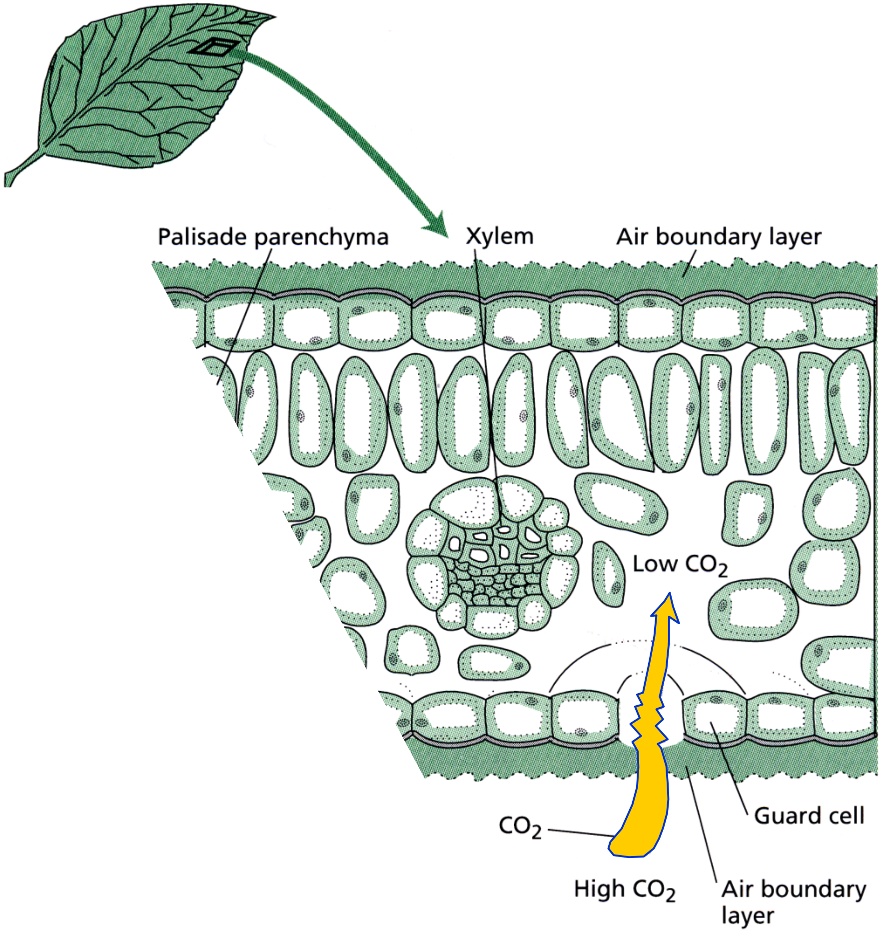
Potential energy components of water in substrates

- Matric potential
- Gravimetric potential
- Solute potential



Graphic: California Master Gardener Handbook, 2002

Plant Water Relations



- CO_2 is necessary for photosynthesis
- Water is lost as CO_2 is taken into the leaves

Graphic adapted from: Taiz & Zeiger, Plant Physiology, 2nd ed, 1998

Topics

- Why plants need water
- Irrigation management
  - Assessing system performance

The Need To Measure

"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind."

Lord Kelvin

"If it can't be expressed in figures, it is not science; it is opinion."

Robert Heinlein

Conducting An Irrigation Audit

Assessing system performance

1. Inspect the site
2. Tune up the irrigation system
3. Test the system (collect data)
4. Calculate performance
5. Interpret the information

Credit: Irrigation Association
Landscape Irrigation Auditor
certification program

Conducting An Irrigation Audit

Assessing system performance

1. Inspect the site
   a) Meter
   b) Main shut-off valve
   c) Controller
   d) Valves

Credit: Irrigation Association
Landscape Irrigation Auditor
certification program

Conducting An Irrigation Audit

Assessing system performance

1. Inspect the site
   a) Zones
      a) Drip: in-line, point-source, flow rates, micro spray
      b) Overhead: fan, multi-stream rotor, gear drive rotor
      c) Manufacturer & model, quantity
      d) Site characteristics
   b) Pressure: static vs dynamic

Credit: Irrigation Association
Landscape Irrigation Auditor
certification program

Conducting An Irrigation Audit

Assessing system performance

2. Tune up the irrigation system
   - Repair, replace, update

- Rebates
  - Rotary stream sprinklers, drip systems, smart controllers, conversions
  - www.ccuh.ucdavis.edu/public/drought/map

Topics

- Why plants need water
- Irrigation management
  - Assessing system performance
  - Scheduling
    - 3 methods

Developing An Irrigation Schedule

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

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
    - How evenly water is applied
    - Applies to overhead and drip
    - Catch can test

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
    - Catch can test
      - Calculate average volume collected (Avg_T)
      - Sort the volumes
      - Calculate the average of the lowest ¼ (Avg_{LQ})
      - $DU = Avg_{LQ} \div Avg_T$
      - Should be AT LEAST 0.7
      - If less than 0.7, repairs or modifications are needed

12:30

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
    - How fast water is applied

$$PR = \frac{Avg_T}{C \times T} \times 3.66$$

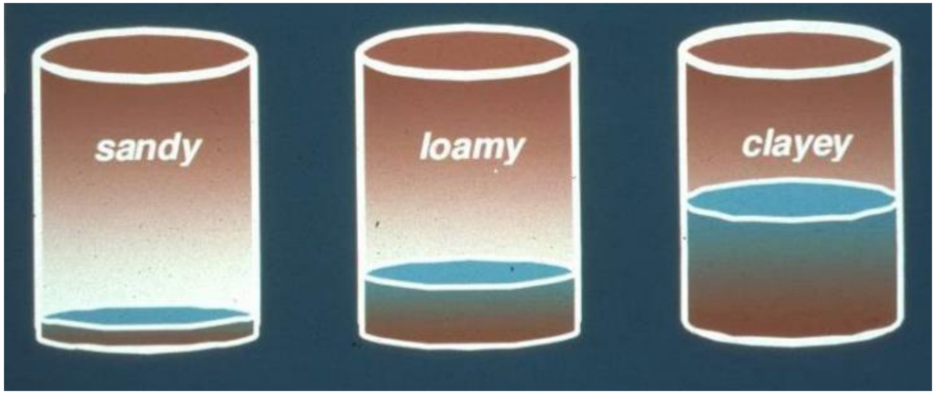
Avg_T = Average of all catch can volumes (mL)
C = Throat area of catch can (sq. in.)
T = Run time (min.)

Developing An Irrigation Schedule

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

Soil Texture & Irrigation

Water Holding Capacity

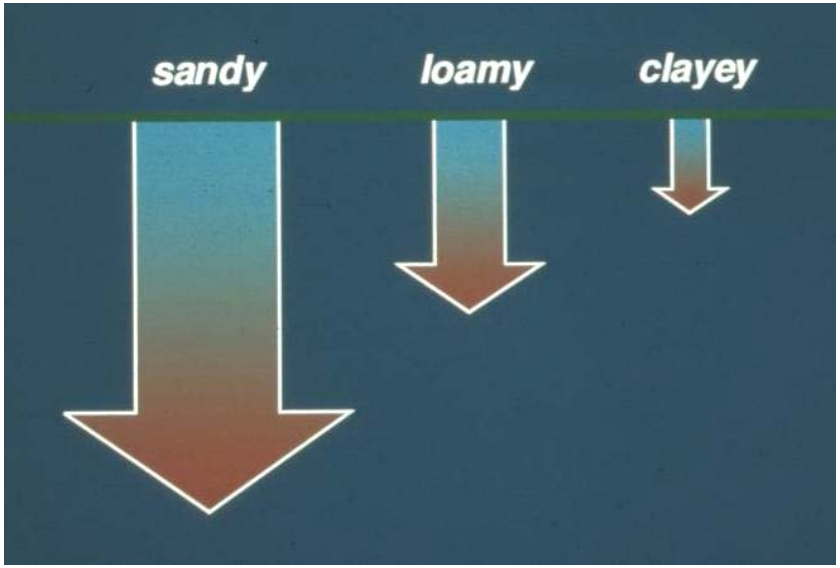


Sandy soils hold less water than clays.

Soil Texture & Irrigation

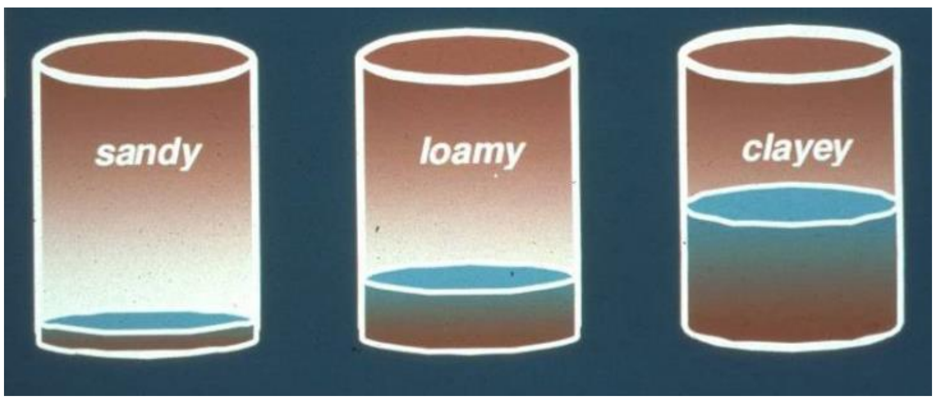
Permeability

Tightly textured, fine soils like clays have slow infiltration rates.

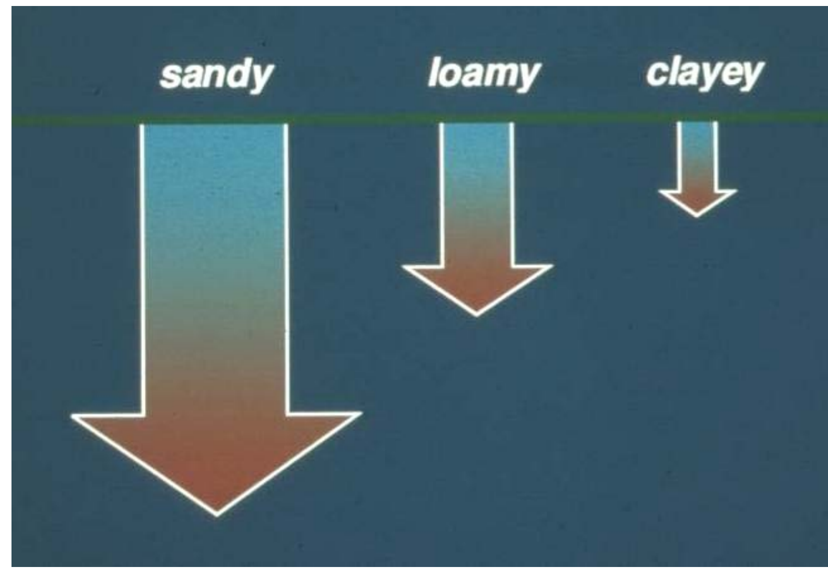


Soil Texture & Irrigation

Water Holding Capacity (volume)



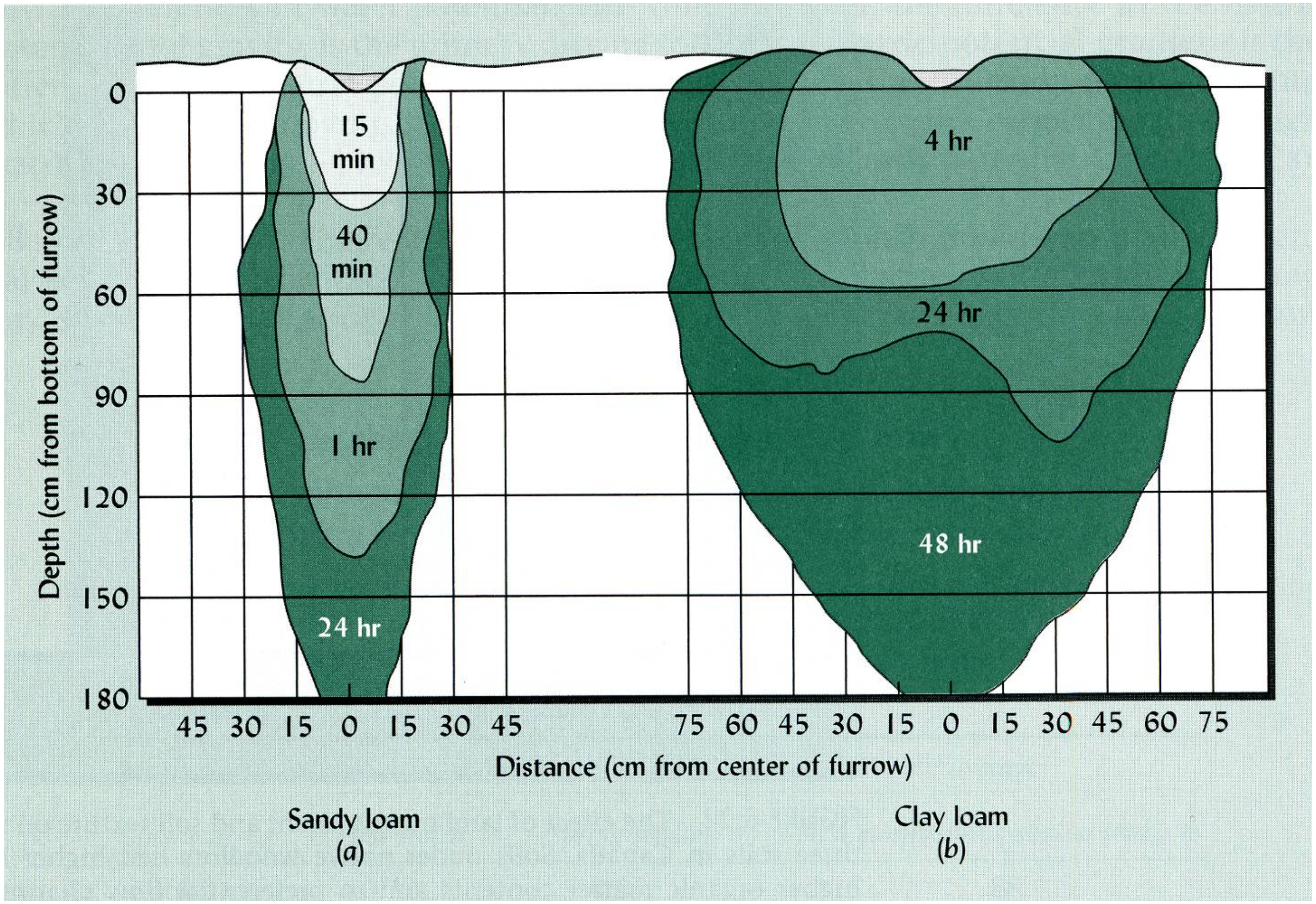
Permeability (rate)



Sandy: Apply small amounts frequently

Clay: Apply larger amounts slowly, less often

Soil Texture and Irrigation



Graphic: Brady & Weil, The Nature and Properties of Soils, 2002

Soil Texture

Soil Texture		Plant Avail Water (cm/cm)*
Coarse	sand / fine sand	0.05
	loamy sand	0.07
Moderately Coarse	sandy loam	0.11
Medium	loam	0.16
	silty loam	0.2
	silt	0.2
Moderately Fine	sandy clay loam	0.15
	clay loam	0.16
	silty clay loam	0.18
Fine	sandy clay	0.12
	silty clay	0.14
	clay	0.15

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Soil Texture

Soil Texture		Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**
Coarse	sand / fine sand	0.05	0.3
	loamy sand	0.07	0.42
Moderately Coarse	sandy loam	0.11	0.66
Medium	loam	0.16	0.96
	silty loam	0.2	1.2
	silt	0.2	1.2
Moderately Fine	sandy clay loam	0.15	0.9
	clay loam	0.16	0.96
	silty clay loam	0.18	1.08
Fine	sandy clay	0.12	0.72
	silty clay	0.14	0.84
	clay	0.15	0.9

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Soil Texture

Soil Texture		Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**
Coarse	sand / fine sand	0.05	0.3
	loamy sand	0.07	0.42
Moderately Coarse	sandy loam	0.11	0.66
Medium	loam	0.16	0.96
	silty loam	0.2	1.2
	silt	0.2	1.2

Irrig to wet to depth

= 12” × 0.2 × 50% = 1.2”

Desired depth to wet = 12”

Plant avail water = 0.2, so 12” × 0.2= 2.4”

Assume 50% dry down (1/2 of the water is used), then 1.2”

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Soil Texture

Soil Texture		Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**	Infiltration Rate (in/hr)
Coarse	sand / fine sand	0.05	0.3	1.5
	loamy sand	0.07	0.42	1
Moderately Coarse	sandy loam	0.11	0.66	0.8
Medium	loam	0.16	0.96	0.4
	silty loam	0.2	1.2	0.25
	silt	0.2	1.2	0.3
Moderately Fine	sandy clay loam	0.15	0.9	0.1
	clay loam	0.16	0.96	0.07
	silty clay loam	0.18	1.08	0.05
Fine	sandy clay	0.12	0.72	0.08
	silty clay	0.14	0.84	0.05
	clay	0.15	0.9	0.05

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Run-time

Soil Texture		Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**	Infiltration Rate (in/hr)
Medium	silty loam	0.2	1.2	0.25

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

Run-time

- 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 = silty loam
    - 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

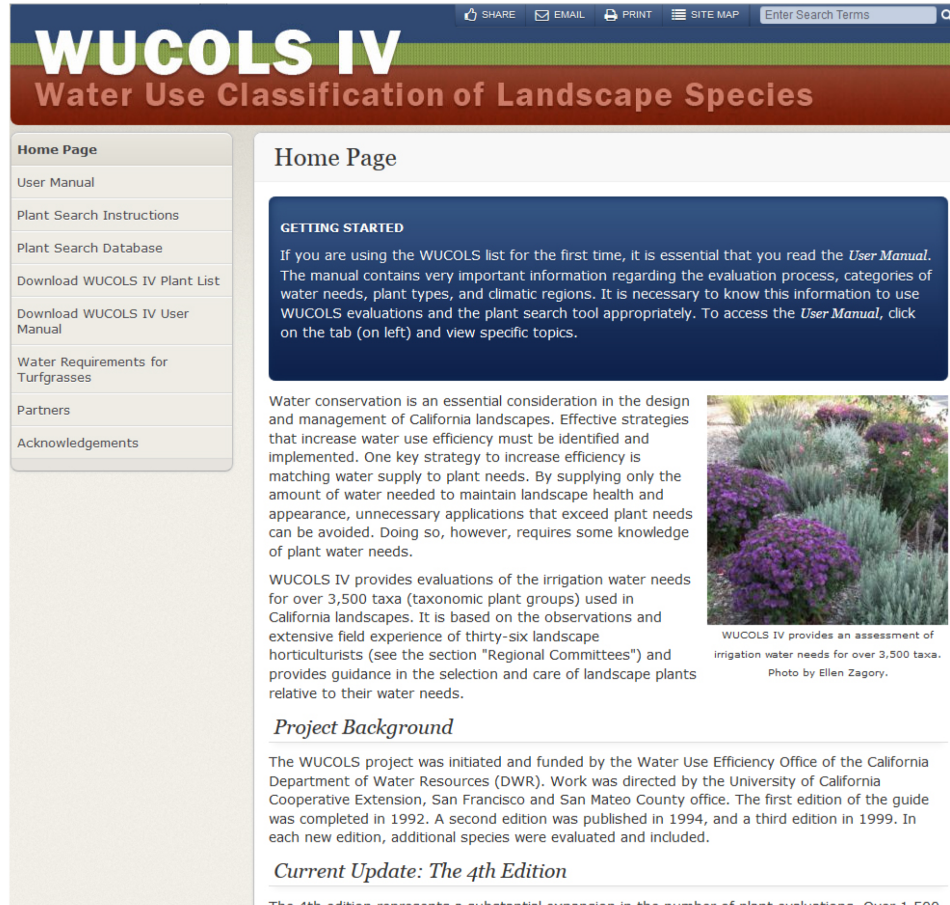
- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients (K_L)

12:45

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

C alifornia
I rrigation
M anagement
I nformation
S ystem

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://wwwcimis.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, $ET_c = ET_0 \times K_c$

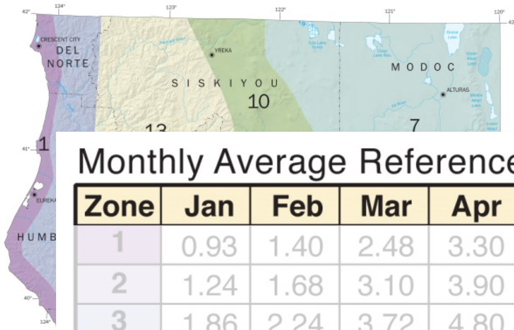
Example: citrus orchard

$K_c = 0.65$

If $ET_0 = 0.5$", then

crop water use is 0.325"

(0.325=0.5 x 0.65)



Reference EvapoTranspiration (ETo) Zones

1 COASTAL PLAINS HEAVY FOG BELT
Lowest ETo in California. Characterized by dense fog

2 COASTAL MIXED FOG AREA
Less fog and higher ETo than zone 1

3 COASTAL VALLEYS AND PLAINS AND NORTH COAST MOUNTAINS
More sunlight than zone 2

10 NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE
Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective

11 CENTRAL SIERRA NEVADA
Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer

12 EAST SIDE SACRAMENTO-SAN JOAQUIN VALLEY
Low winter and high summer ETo with slightly lower ETo than zone 14

ETo Zones

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

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	32.9
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.3
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.1
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.4
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	**1.55**	**2.24**	**3.72**	**5.10**	**6.82**	**7.80**	**8.68**	**7.75**	**5.70**	**4.03**	**2.10**	**1.55**	**57.0**
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity 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.

California
REFERENCE EVAPOTRANSPIRATION

Lambert Conformal Conic Projection

http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf

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)

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

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0

October = 4.03 in/month

- ET_{day} = 4.03 in ÷ 31 days = 0.13 in/day

Developing An Irrigation Schedule

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

$$ET_L = 0.13 \times 0.4 = 0.07 \text{ in/day}$$

Developing An Irrigation Schedule

ET_0 = 0.13
× K_L = 0.4
= ET_L = 0.07

Irrig = 1.2

October

Day	Total ET_L
1	0.07
2	0.14
3	0.21
4	0.28
5	0.35
6	0.42
7	0.49
8	0.56
9	0.63
10	0.70

Developing An Irrigation Schedule

ET_0 = 0.13
$\times K_L$ = 0.4
= ET_L = 0.07

Irrig = 1.2

October

Day	Total ET_L	Day	Total ET_L
1	0.07	11	0.77
2	0.14	12	0.84
3	0.21	13	0.91
4	0.28	14	0.98
5	0.35	15	1.05
6	0.42	16	1.12
7	0.49	17	1.19
8	0.56	18	1.26
9	0.63	19	0.32
10	0.70	20	0.40

1.19
+ 0.07 (ET_L)
= 1.26

Developing An Irrigation Schedule

ET_0 = 0.13
$\times K_L$ = 0.4
$= ET_L$ = 0.07

Irrig = 1.2

October

Day	Total ET_L	Day	Total ET_L
1	0.07	11	0.77
2	0.14	12	0.84
3	0.21	13	0.91
4	0.28	14	0.98
5	0.35	15	1.05
6	0.42	16	1.12
7	0.49	17	1.19
8	0.56	18	0.06
9	0.63	19	0.13
10	0.70	20	0.20

1.19
+ 0.07 (ET_L)
= 1.26
- 1.20 (Irrig)
= 0.06

Developing An Irrigation Schedule

ET_0 = 0.13
× K_L = 0.4
= ET_L = 0.07

Irrig = 1.2

October

Day	Total ET_l	Day	Total ET_l	Day	Total ET_l
1	0.07	11	0.77	21	0.27
2	0.14	12	0.84	22	0.34
3	0.21	13	0.91	23	0.41
4	0.28	14	0.98	24	0.48
5	0.35	15	1.05	25	0.55
6	0.42	16	1.12	26	0.62
7	0.49	17	1.19	27	0.69
8	0.56	18	0.06	28	0.76
9	0.63	19	0.13	29	0.83
10	0.70	20	0.20	30	0.90

Developing An Irrigation Schedule

ET_0 = 0.13
× K_L = 0.4
= ET_L = 0.07

Irrig = 1.2

October

Day	Total ET_L
1	0.07
2	0.14
3	0.21
4	0.28
5	0.35
6	0.42
7	0.49
8	0.56
9	0.63
10	0.70

- For more accuracy
  - Use actual instead of historical data
  - Obtain daily ET_0 from CIMIS
  - Calculate & accumulate actual ET_L

Developing An Irrigation Schedule

- Determine when to irrigate
  - Irrigation application = 1.2 in
  - ET_L = 0.07 in/day
- Method 1
  - Accumulate ET_L daily
  - When accumulated total reaches 1.2 in
  - Irrigate!
- Method 2
  - 1.2 in ÷ 0.07 in/day = 17.1 days
  - Irrigate every 17 days

Developing An Irrigation Schedule

- Method 3
  - ccuh.ucdavis.edu
    “irrigation scheduling worksheet”
  - Conduct catch can test
  - Enter catch can volumes and other information
    - Depth to wet, designated days
  - Calculates:
    - DU, PR
    - Run time (duration and cycles)
    - Annual irrigation calendar

1:00

Topics

- Why plants need water
- Irrigation management
  - Assessing system performance
  - Scheduling
  - Smart controllers

Smart Controllers

- What they do
  - "automatically" adjust irrigation to "plant water needs"
  - Information needed: See previous sections irrigation scheduling
    - Irrigation system specifics
    - Plant mix
    - Slope
    - **Weather**

Smart Controllers

- How they adjust
  - Not all controllers are “good”
- Programs are adjusted in two ways:
  1. Modify run times, fixed schedule
  2. Modify schedule, fixed run times

Topics

- Why plants need water
- Irrigation management
  - Assessing system performance
  - Scheduling
  - Smart controllers
- Maintaining plants
  - Turf
  - Trees and shrubs
  - Edibles

Turf

Turf

Trees
What's the problem?

- Planted in or adjacent to turf
- Improper tree selection
- Poor irrigation management
- Shallow roots

A Common Sight in 2014

Recognize water stress

- Incipient
  – Color change to bluish or grayish green
- Temporary
  – Flagging, wilting
- Permanent wilting
  – Desiccation, drying
  – Nonrecoverable

Secondary effects

- Susceptibility to:
  - Insects

    e.g., Borers
    - ambrosia beetles
    - longhorned eucalyptus borers

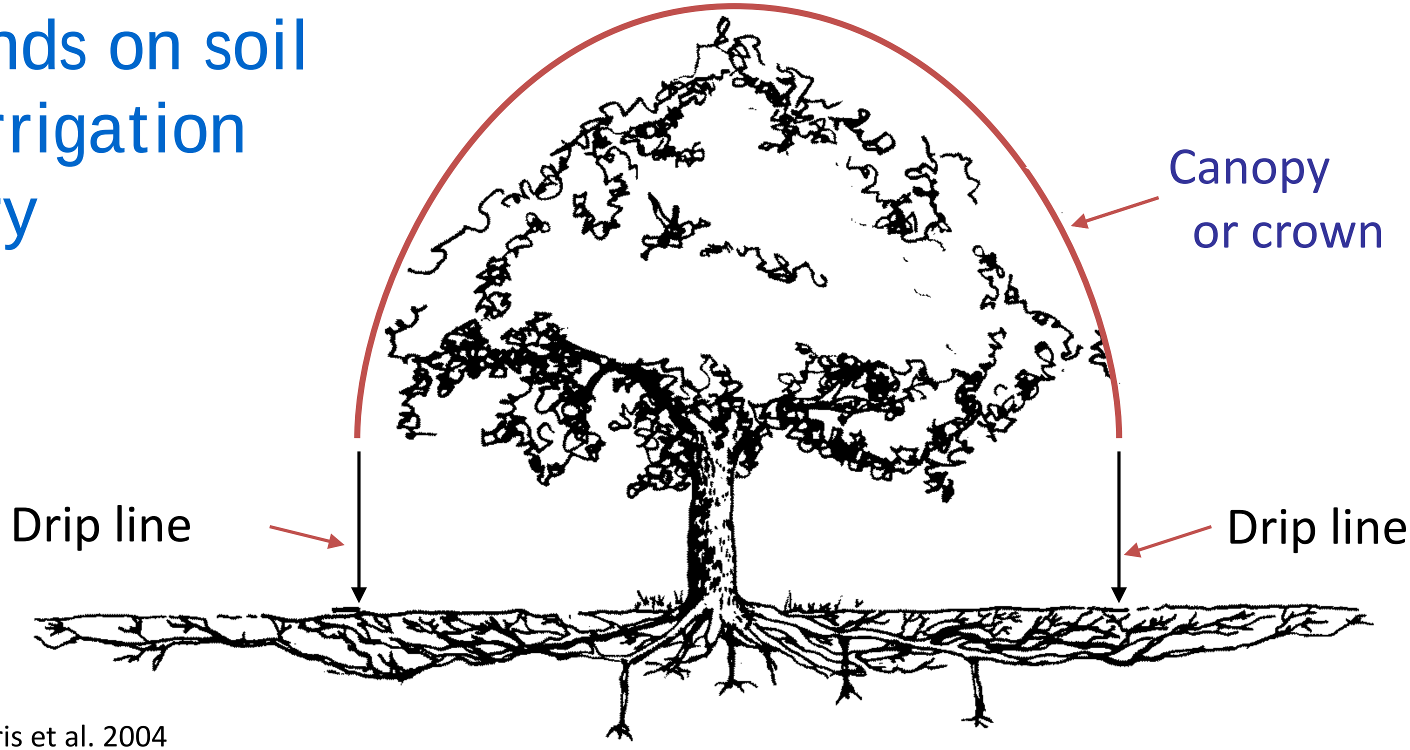
  - Diseases

    e.g., Root rots
    - *Phytophthora*

    and Oak root fungus
    - *Armillaria*

Tree roots

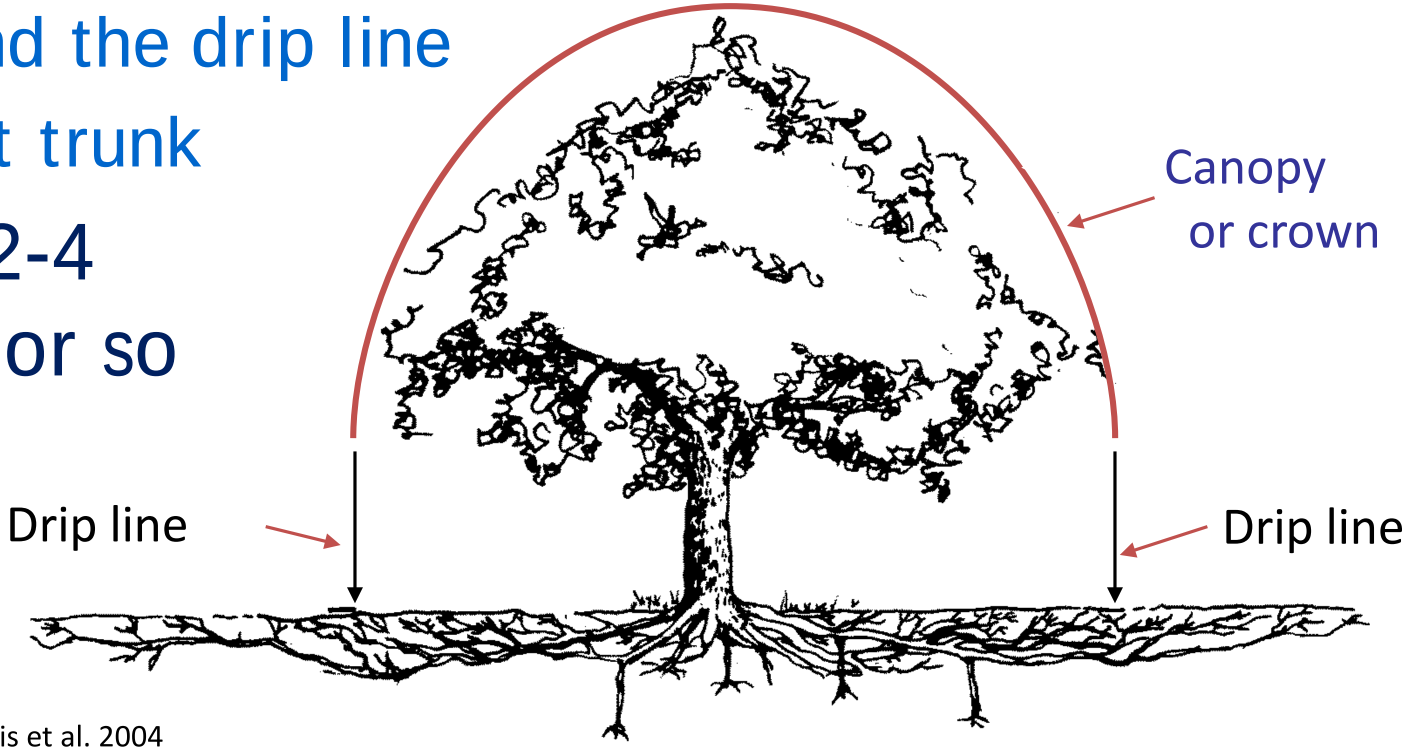
- Relationship to canopy
- May be deep
  - Depends on soil and irrigation history



Graphic adapted from Harris et al. 2004

Where to Irrigate

- Deep to 2 -3 feet
- Beneath the canopy
  - Beyond the drip line
  - Not at trunk
- Every 2-4 weeks or so



Graphic adapted from Harris et al. 2004

Mature Gingko Tree

Considered Deep Rooted

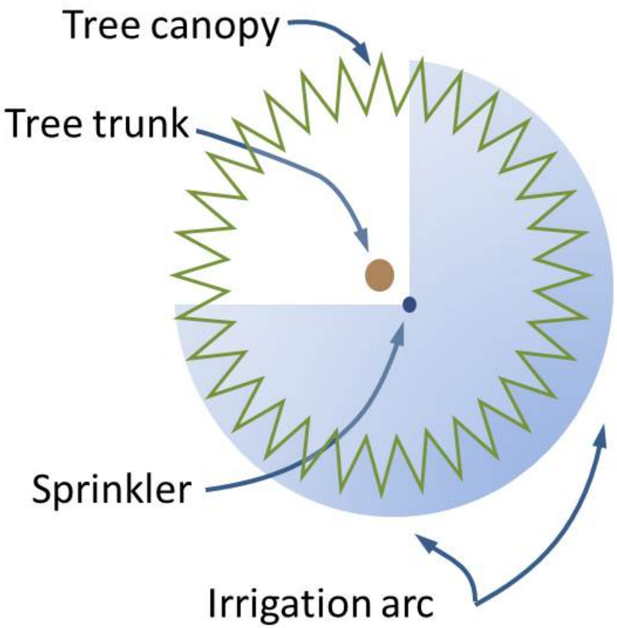
Tree Ring Irrigation Contraption

Loren Oki and Dave Fujino

- Input info for 1' spacing:
  - Canopy radius, soil type, no. of 100' drip lengths
- Calculates irrig. run time to wet soil to 36" deep
- http://ccuh.ucdavis.edu/
  - Search: CCUH TRIC
- ~$100 for parts

Rotary **S**ystem **I**rrigation **C**ontraption

Loren Oki and Dave Fujino

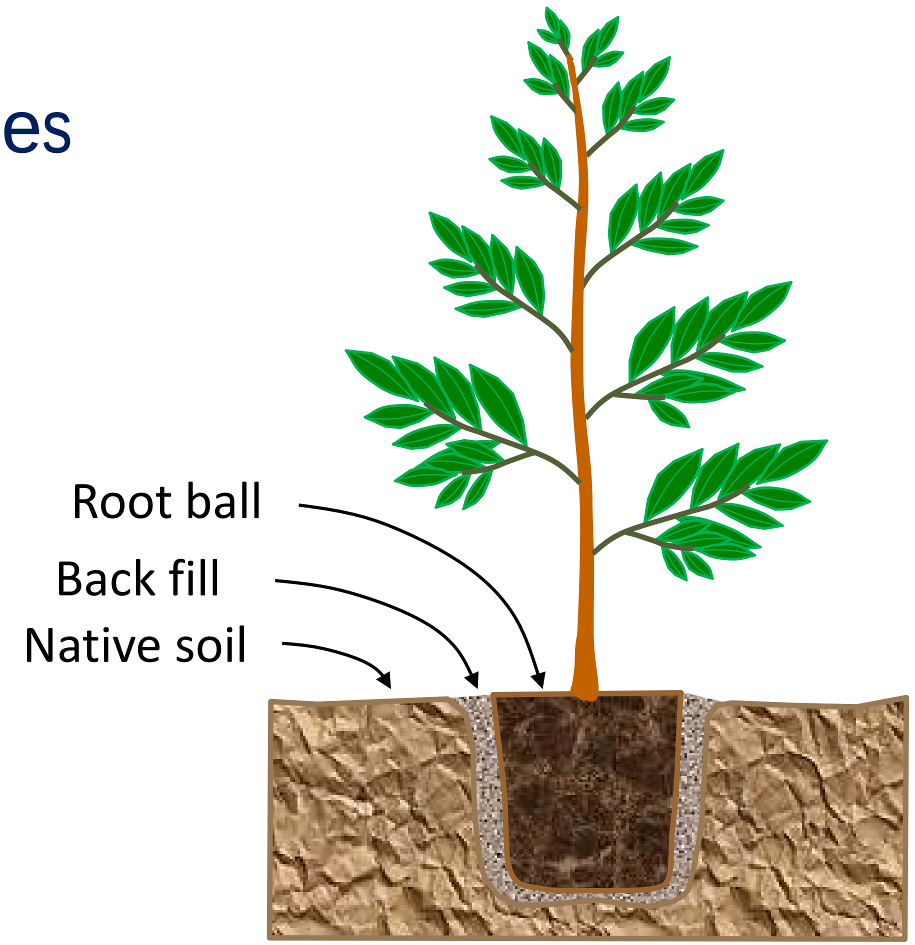


- Low cost ~$20
- Runtime depends on soil type
- http://ccuh.ucdavis.edu/
  – Search: CCUH RSIC

1:20

Tree roots

- Recently planted trees
  - Roots are mostly within the container soil ball
  - Roots may be just entering the native soil
  - Will take several years to fully establish



Topics

- Why plants need water
- Irrigation management
  - Assessing system performance
  - Scheduling
  - Smart controllers
- Maintaining plants
  - Turf
  - Trees and shrubs
  - Edibles

Edibles

- Use the same principles as for landscapes
  - Be aware that “production” is usually associated with higher water use
  - To maximize production, minimize water stress
    - Maintain soil moisture to avoid water stress
    - Productivity is related to photosynthesis
      - Photosynthesis is dependent on CO_2
      - CO_2 enters through stomates
      - Stomates close with water stress

Topics

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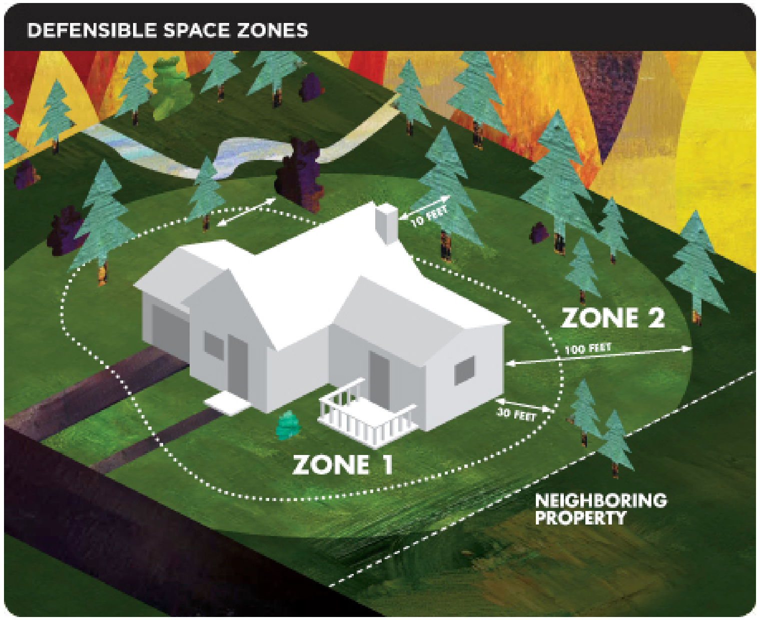
- Fire Safe

Fire Safe

- ucanr.edu/sites/SAFELandscapes
- **CalFire** (fire.ca.gov)
- readyforwildfire.org



Topics

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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
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Photo: L.Oki