UCCE
Master Gardeners of El Dorado County Present

HEALTHY ENVIRONMENTS

Master Gardener
UNIVERSITY OF CALIFORNIA
COOPERATIVE EXTENSION

University *of* California
Agriculture and Natural Resources

Making a Difference for California

Water Efficient Gardening in the Urban Landscape

Presenter: Stephen Savage

University of California

Agriculture and Natural Resources

California Master Gardener
Cooperative Extension
El Dorado County

Making a Difference For California

The Earth is Not A Toy


Treat It As If Were Your Home


Because...
IT IS !

Course Outline

I. Why Conserve Water
II. Hydrologic Cycle
III. Water Movement in Plants
IV. Managing Irrigation
V. Water Application Methods
VI. Methods That Conserve Water
VII. Measuring Water Loss
VIII. Surviving Drought

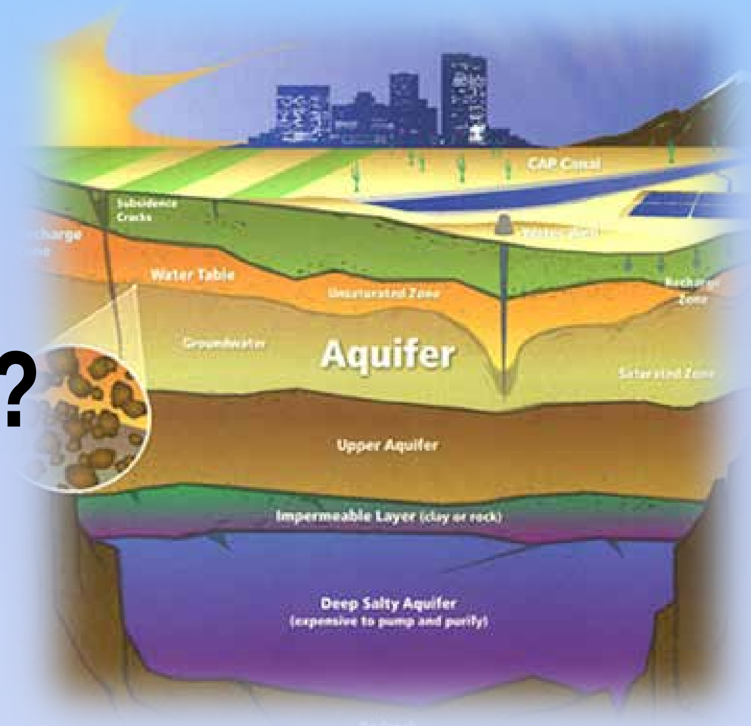
Why Are We Here?

I. Why Conserve Water?

Climate Change- Effect on the Sierra Nevada

Depletion of Our Aquifers - California

Contamination of Aquifers – Foothills, Valley



Climate Change – Effects on Sierra Nevada

Sierra Nevada – 65% of California's water

- Decline in runoff
- Glacial retreat
- Snow pack decreasing
- Rise in snow level
- Peak runoff timing
- off–storage capacity

From: sierranevadaalliance.org

Aquifers

Levels falling

Over drafted

Year round creeks and rivers drying

Increased pumping to supplement decreased runoff

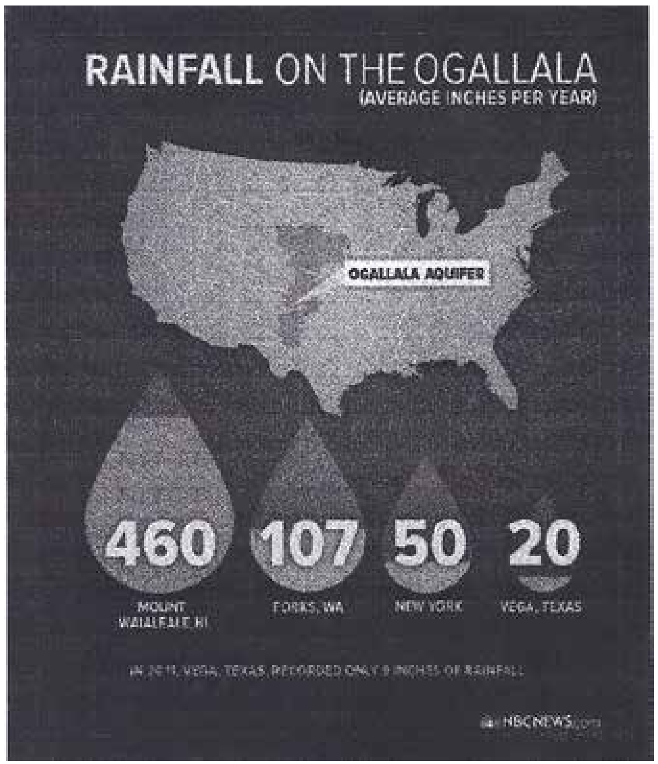
Aquifers depleted

Contamination of Aquifers

- **Nitrates**
- **Salts**

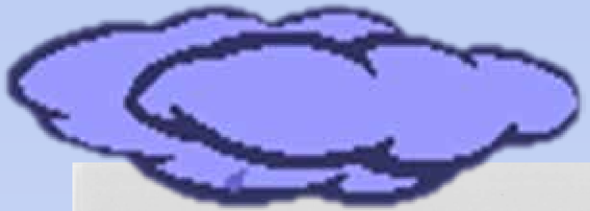
From: groundwater.udcavis.edu/files/136273.pdf

The Biggest Aquifer Disaster of All
The Ogallala



- Covers 175,000 miles ^{2}
- Created ten million years ago
- In many places it is not recharged by rainfall
- Pumping at current rates will deplete South end in 7 – 10 years, North end possibly 20 years
- When it collapses, it can not be recharged; when its gone, its gone!
- No pumping restrictions in Texas. You can Pump it dry if you want to.

II. Hydrologic Cycle



- Precipitation
- Condensation
- Evaporation
- Transpiration
- Surface/ subsurface runoff
- Percolation
- Capillary Action

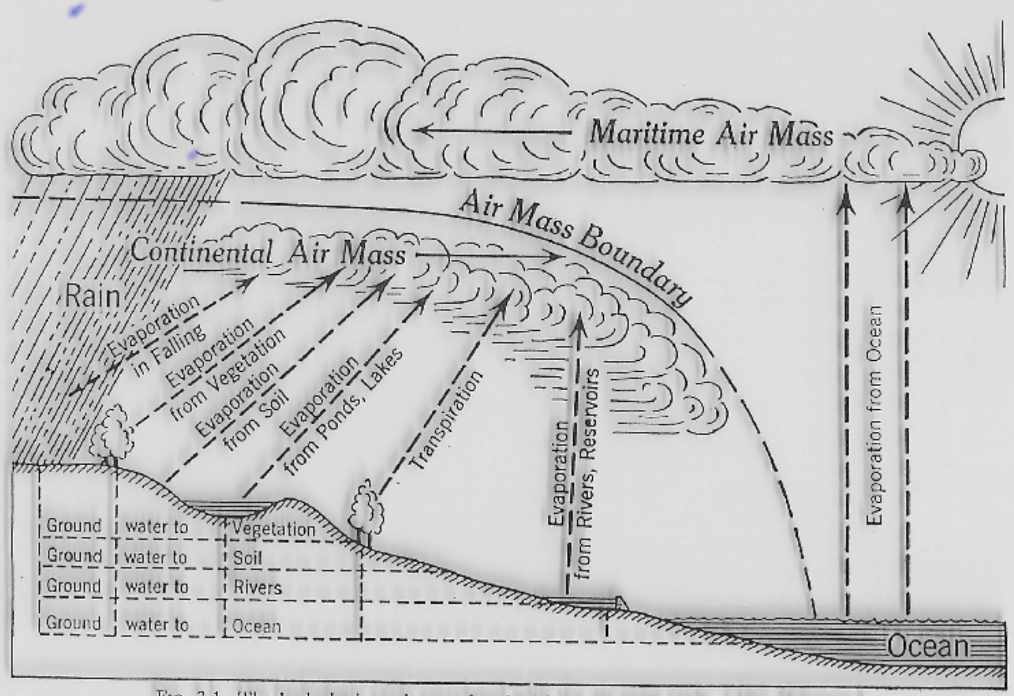
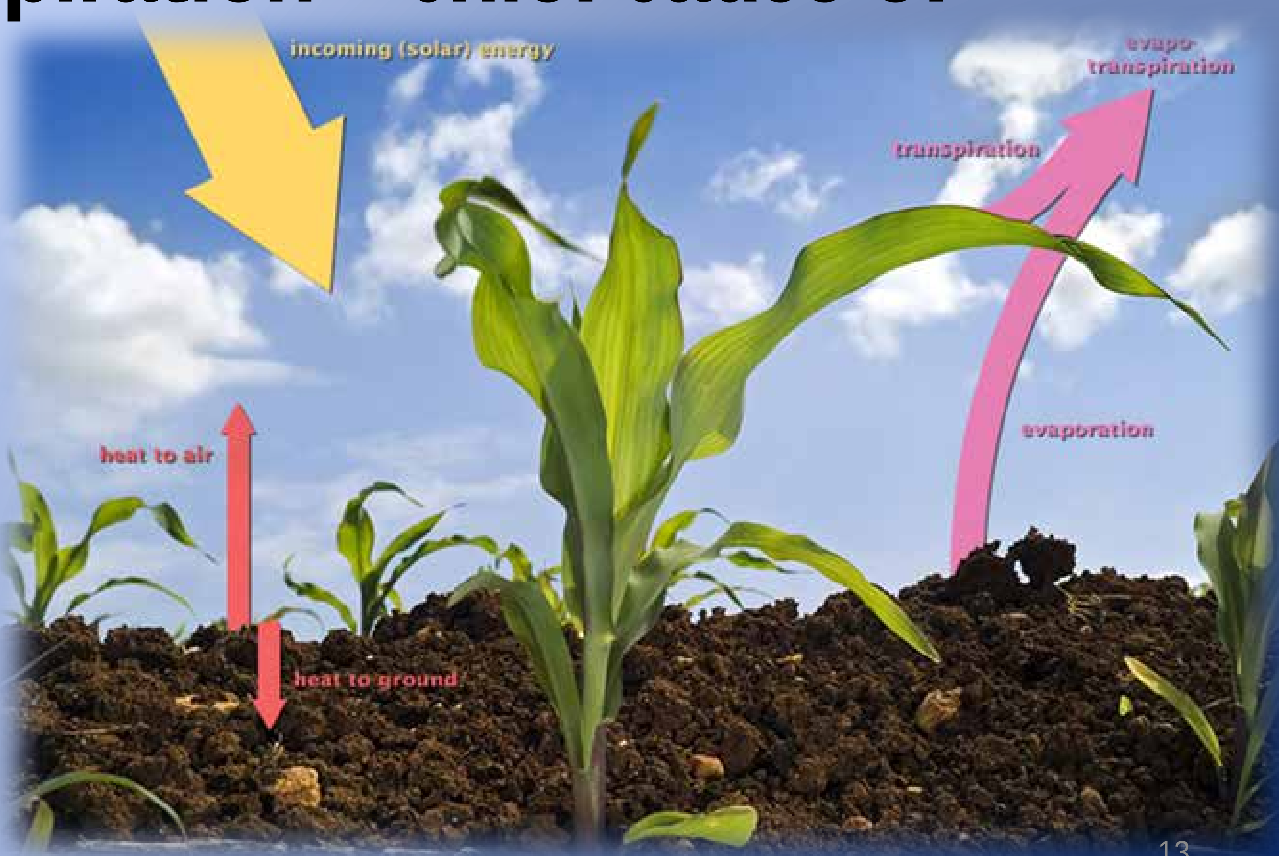


Fig. 3.1. The hydrologic cycle correlated with the air-mass cycle. (*After Holtzman.*)

Hydrologic Cycle cont.

- **Precipitation – prime water source**
- **Evapotranspiration – chief cause of water loss**



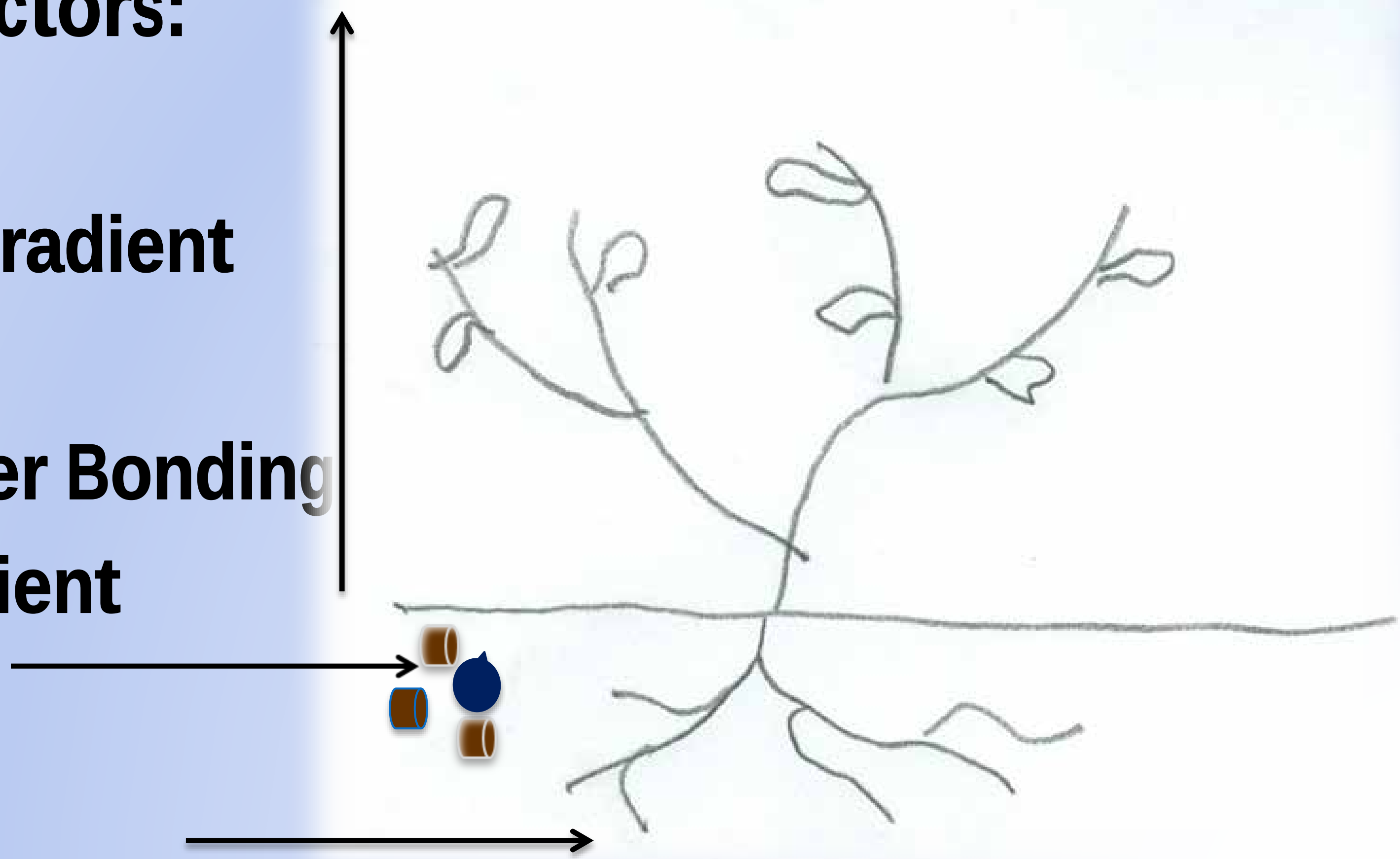
III. Water Movement in Plants
How Water Moves in Plants

Three Factors:

Gravity Gradient

Soil/Water Bonding

Salt Gradient



How Water Moves: Soil/Water Bonding

How tightly the soil holds onto water

- Energy required to remove water from the soil
- Measured as kPa

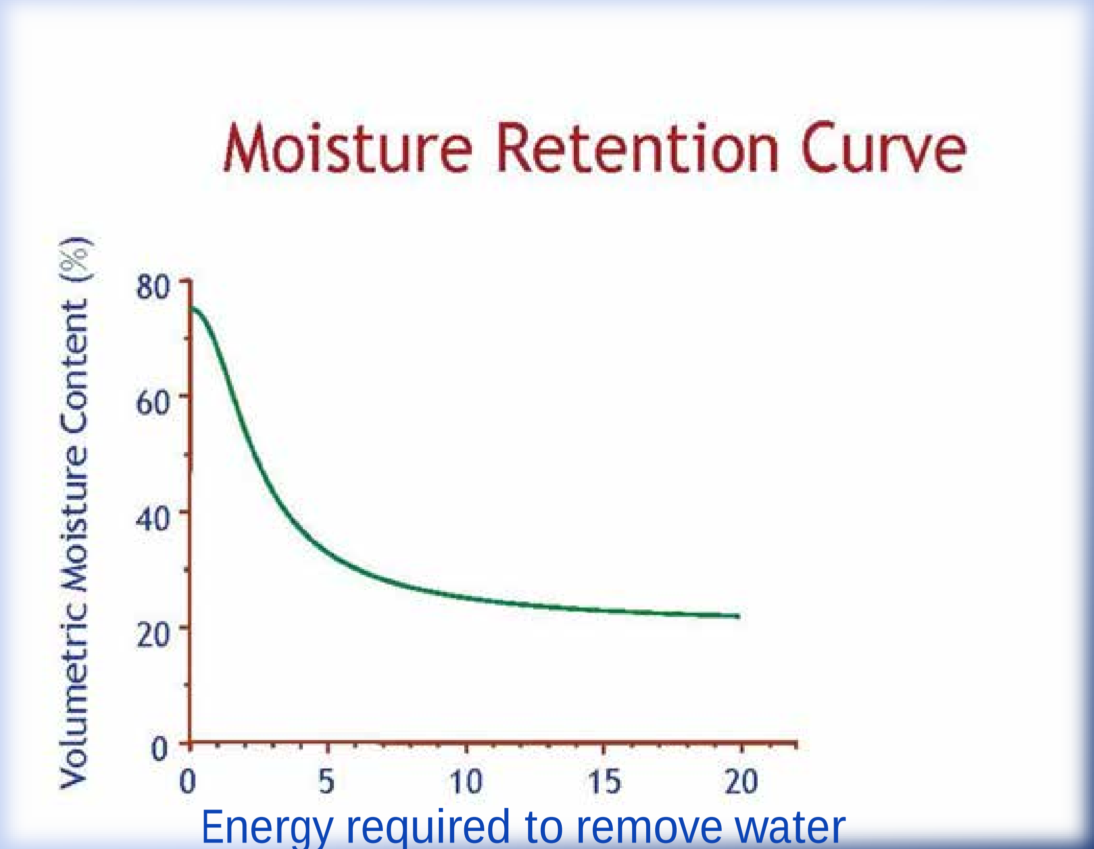


Image Source: adapted from J. H. Lieth

Water Movement in Plants cont.:
Soil/Water Bonding

Available and unavailable moisture

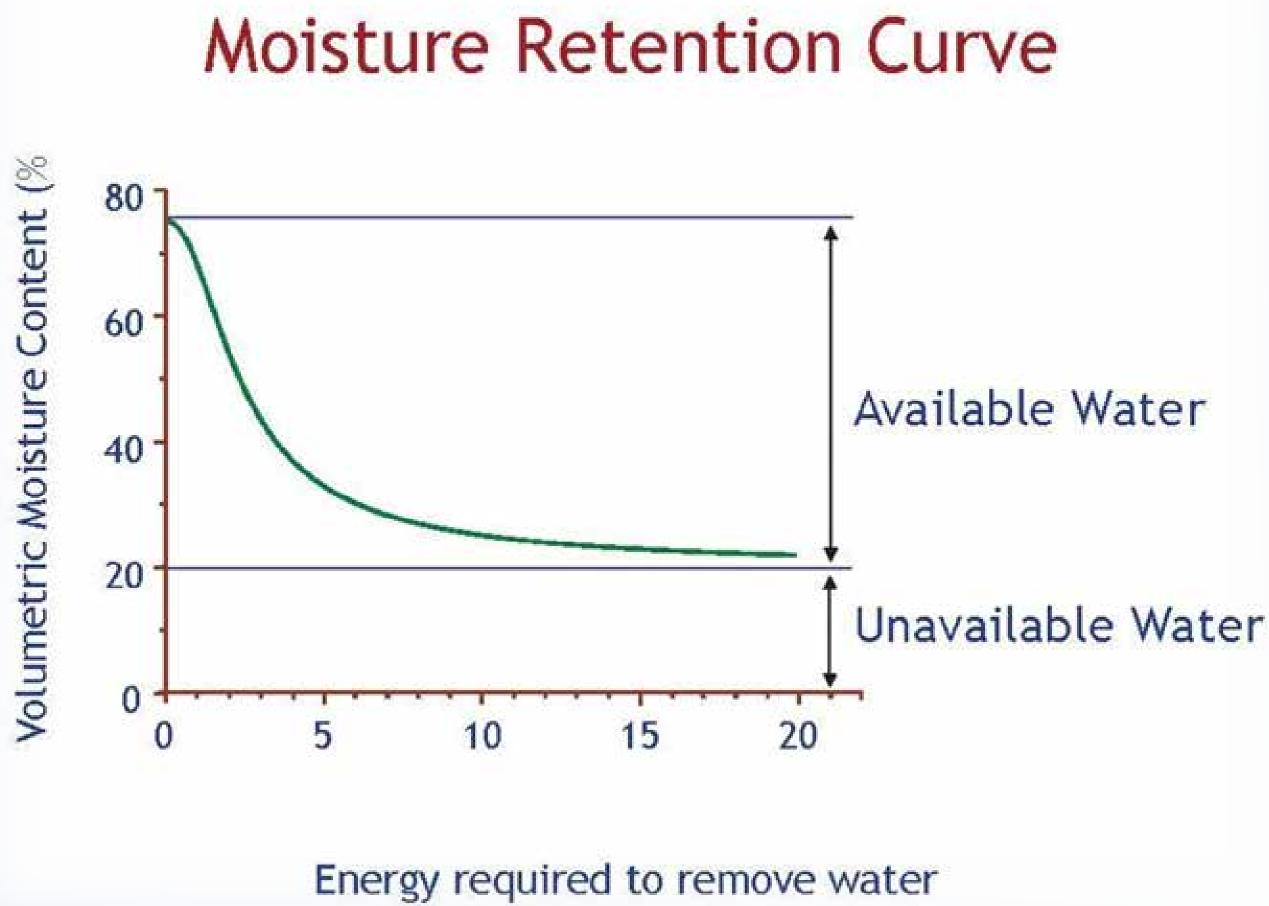


Image Source: adapted from J. H. Lieth

Water Movement in Plants cont.:

Soil/Water Bonding

Available Water By Soil Types:

- Field capacity
- Available H_2O
- Wilt point
- Unavailable water

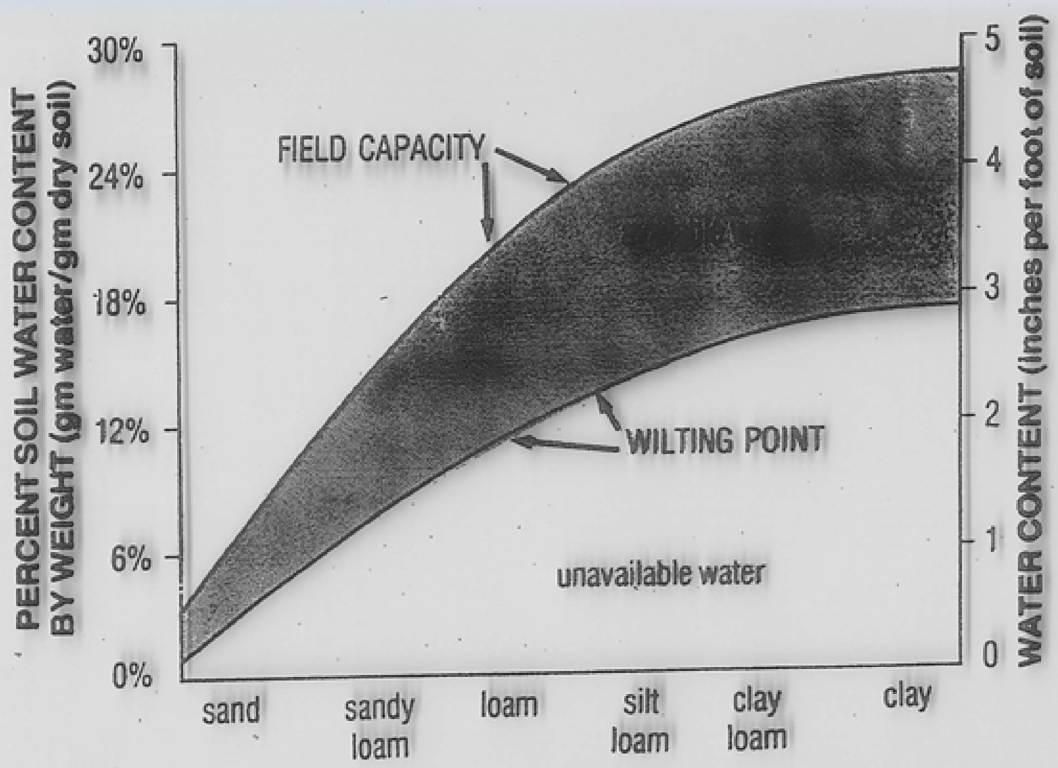


Figure 14. Available water for different soil textures. The proportion and absolute amount of water available to the plant in coarse-textured, sandy soils is less than in fine-textured, clay soils.

Soil/Water Bonding

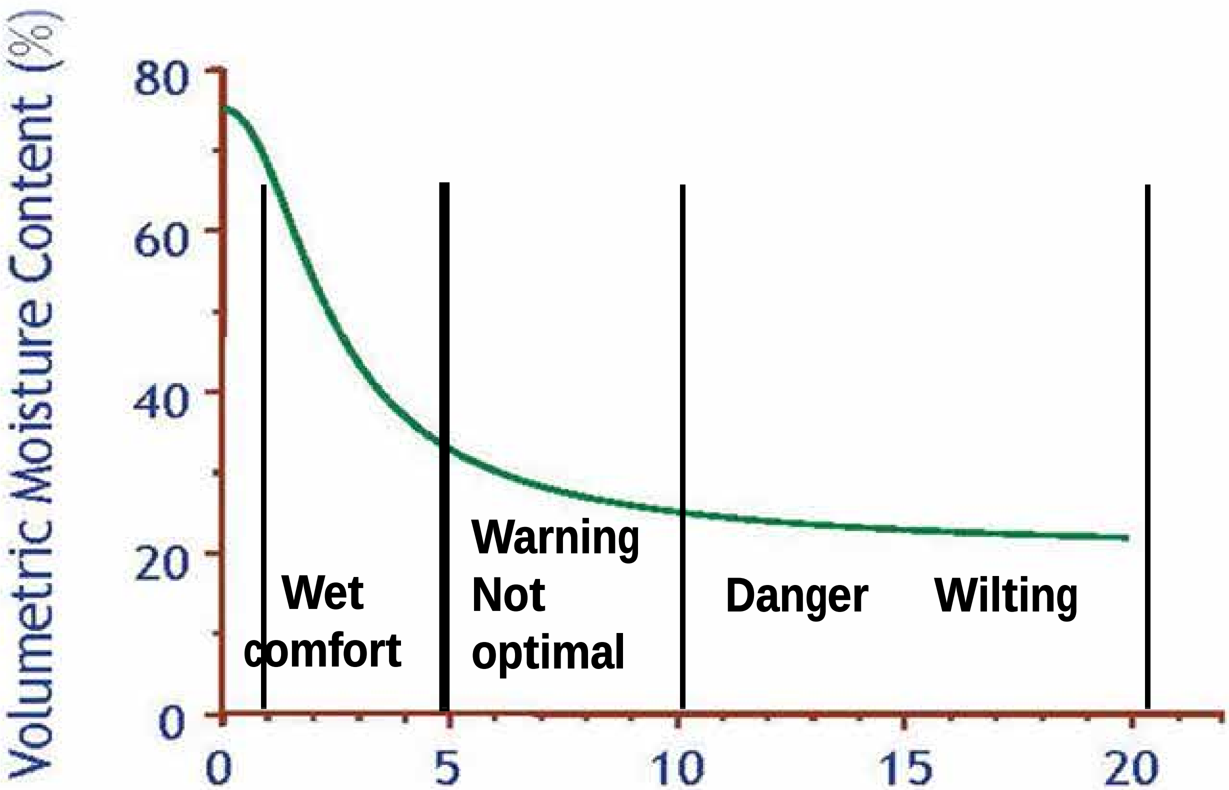
Available Water by Soil Type

- Sandy or “DG” soils .5 – 1.0”/ft. of depth
- Clay 2.0-2.5”/ft. of depth
- Loam
  - Sandy loam 1.0 – 1.5”/ft. of depth
  - Clay loam 1.5 – 2.0”/ft. of depth

Water Movement in Plants, cont.

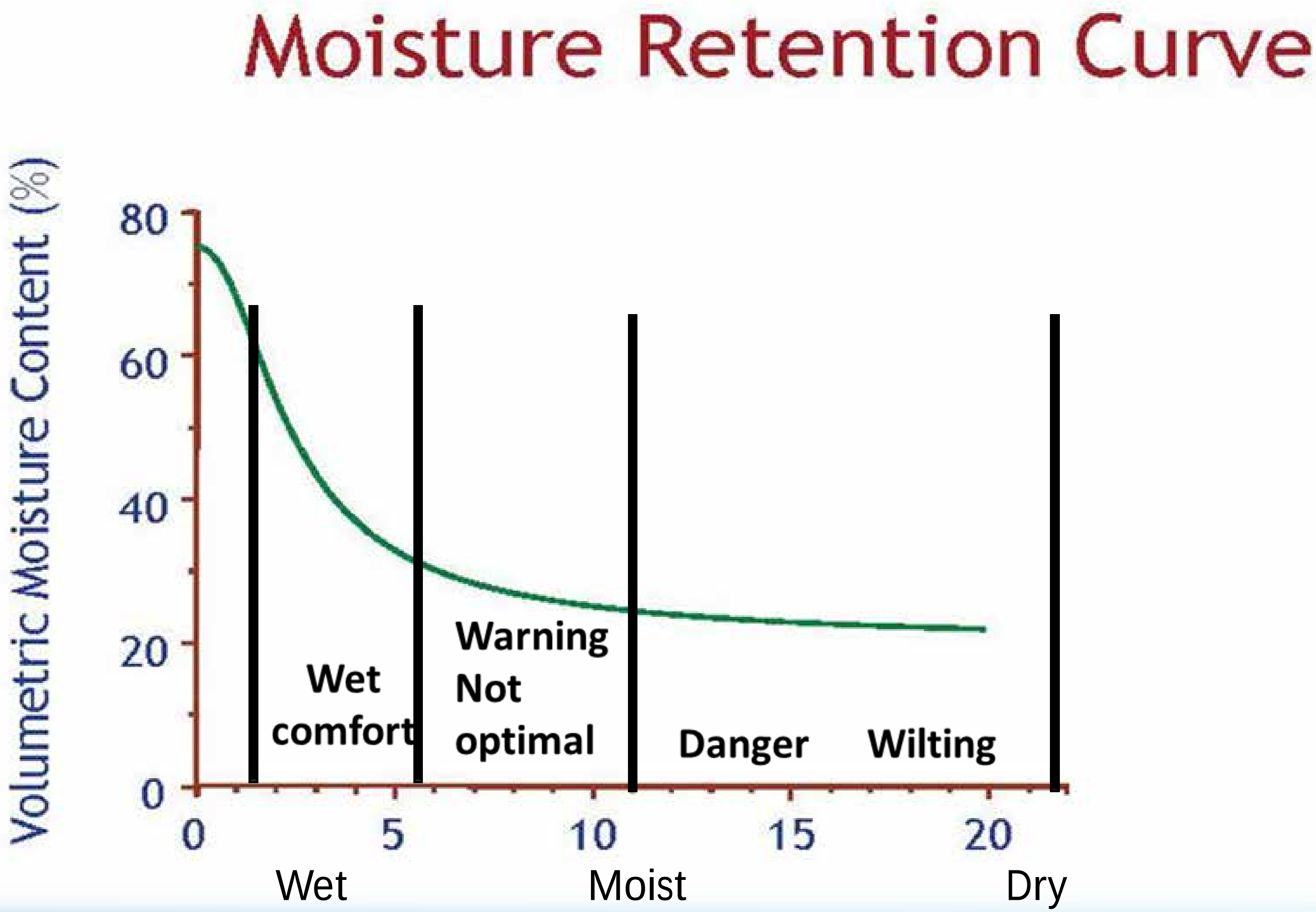
Soil/Water Bonding

How Plants Respond to Decreasing Soil Water Content



Energy Required to Remove Water

How Water Moves-Soil/Water Bonding cont.

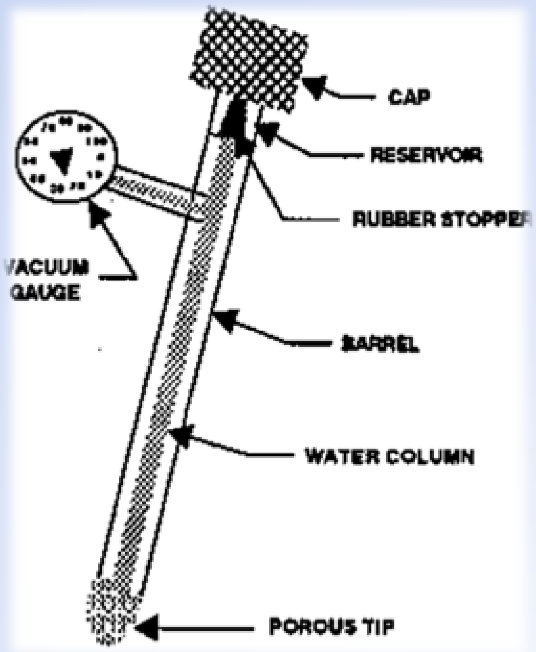


Energy Required to Remove Water

Water Movement in Plants, cont.

Practical implications of using a tensiometer

- Let tension rise to 5 kPa
- Begin irrigating
- Stop irrigating when tension falls to 1 kPa



Managing Irrigation to Optimize Water Use – When, Where, How Much

Available H_2O	Sand	Sandy Loam	Clay Loam	Clay
Close to 0%	Single grains	Loose, flows	Dry clods breaking to powder	Hard baked, difficult to break
50% or less	Will not form ball	Will not form ball	Crumbly, will hold ball	Somewhat pliable, will ball
50-75% enough available	Will not form ball	Will form ball	Forms ball, might slick w/ pressure	Forms ball, ribbons out w/ pressure
75% to field capacity	Weak ball under pressure	Weak ball, does not become slick	Forms ball, pliable, slick if high in clay	Easily ribbons out

Managing Irrigation to Optimize Water Use – When, Where, How Much

Available Moisture	Sand	Sandy loam	Clay loam	Clay
at field capacity – won't hold additional water	squeezing, no free water but water on hand	same as sand	same as sand	feels slick, ribbons out easily
above field capacity – waterlogged	Free water bounced on hand	Free water released when kneaded	Free water squeezes out	Puddles form on surface

Source: Harris and Coppick 1977, p. 4

Water Movement in Plants cont.:

Soil/Water Bonding

Ok, Steve, why did you tell me this?

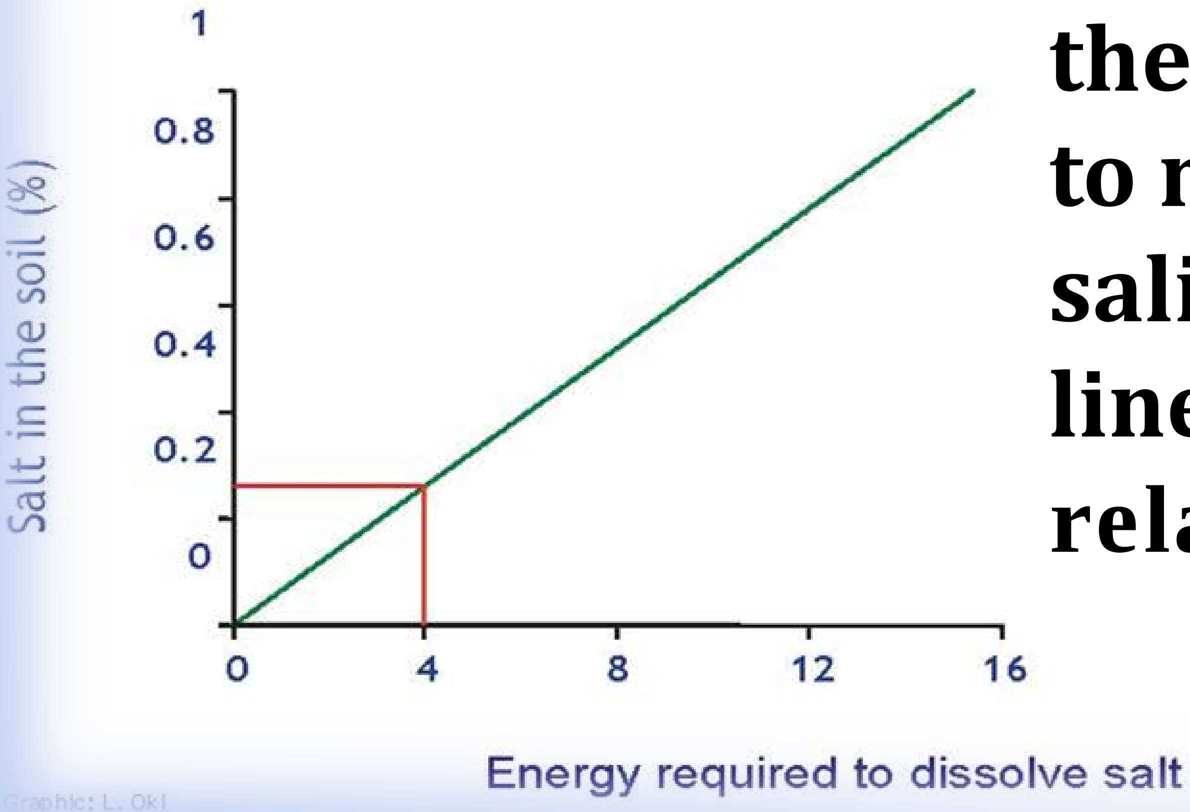
- **Field capacity**
- **Soil differences**
- **Looks and feel can fool you**

Water Movement in Plants
Salt Gradient -

- How salty is the soil?
- How much energy does it take to dissolve it?

Water Movement in Plants, cont.

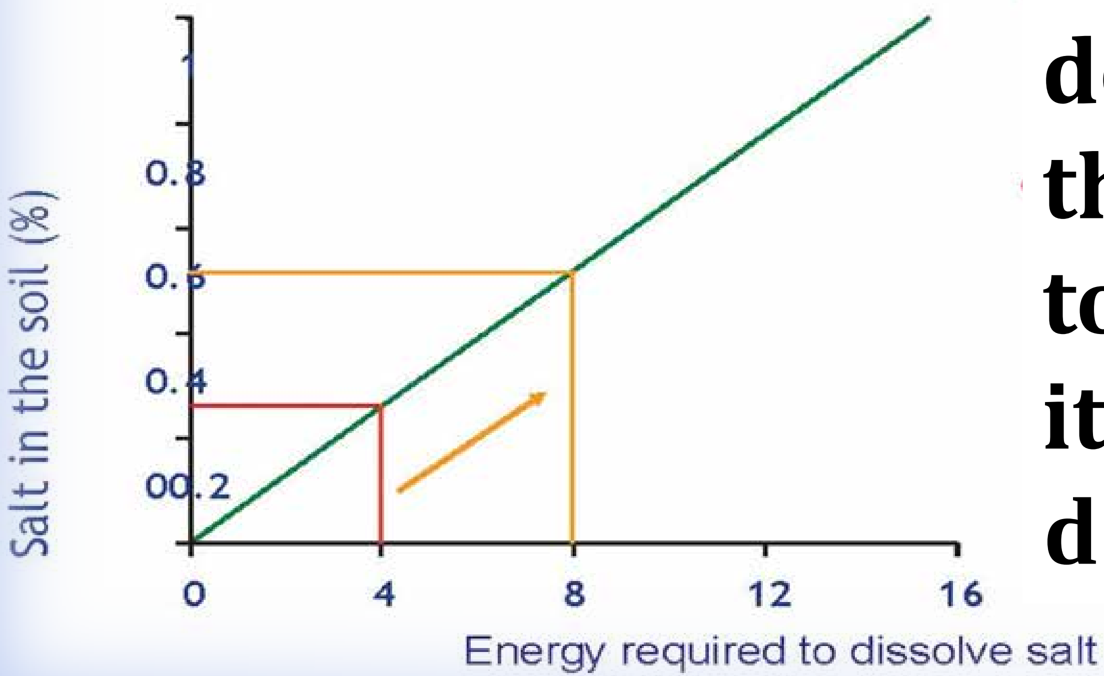
Salt Gradient



Salinity and the energy to remove salinity are linearly related.

Water Movement in Plants, cont.

Salt Gradient

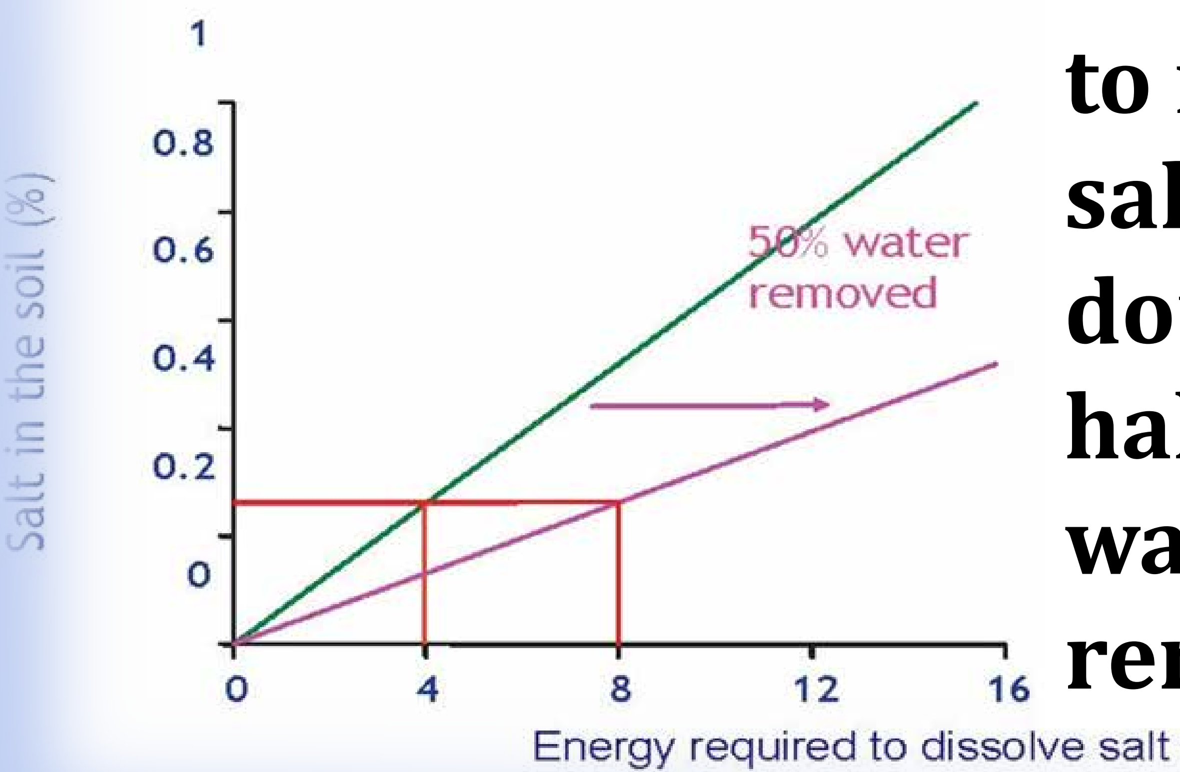


When salinity doubles, the energy to remove it also doubles.

Graphic: L. Oki

Water Movement in Plants, cont.

Salt Gradient



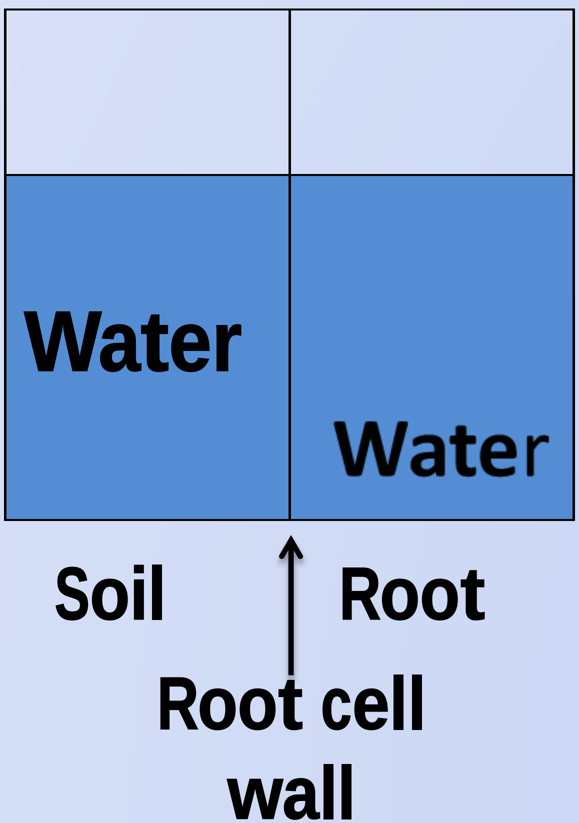
The energy to remove salt also doubles if half the soil water is removed.

Graphic: L. Oki

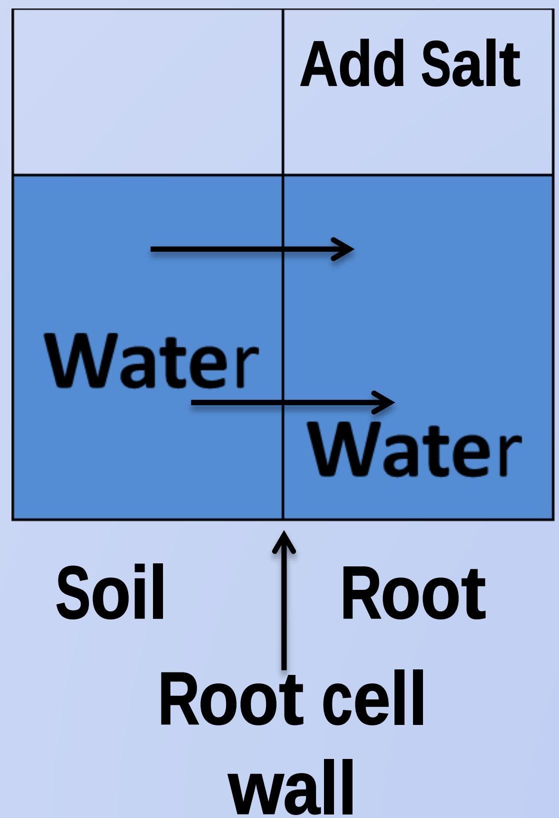
Water Movement in Plants, cont.

Salt Gradient

Equilibrium



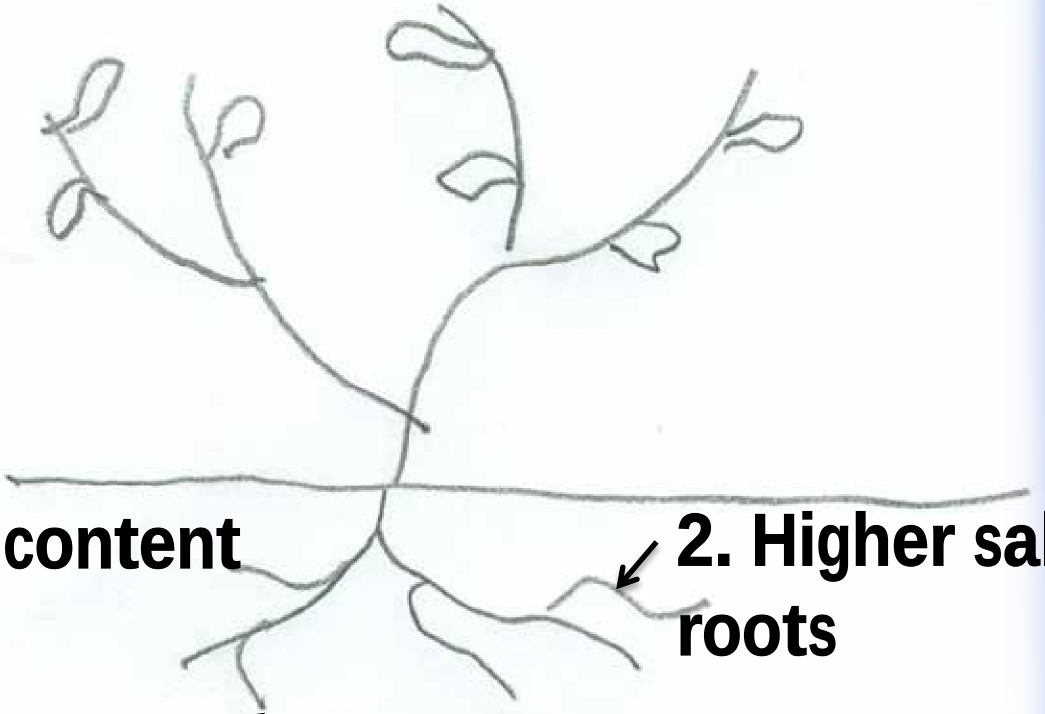
More Salt in Roots



Water Movement in Plants, cont.

Salt Gradient – What does this mean…

- Root pressure



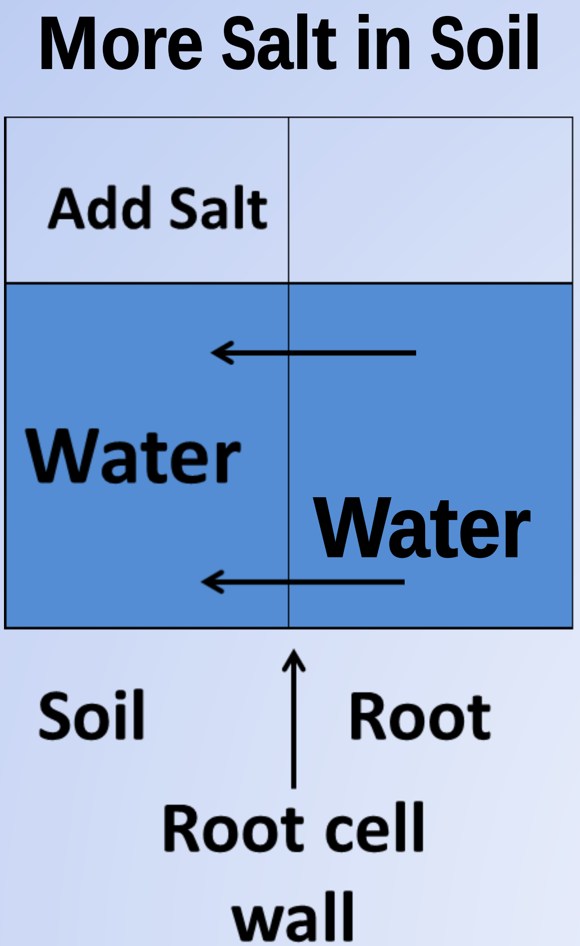
1. Lower salt content in soil

2. Higher salt content in roots

3. Water moves from soil into roots

Water Movement in Plants, cont.
Salt Gradient

When soil is saltier than the sap in the roots:



Water Movement in Plants, cont.

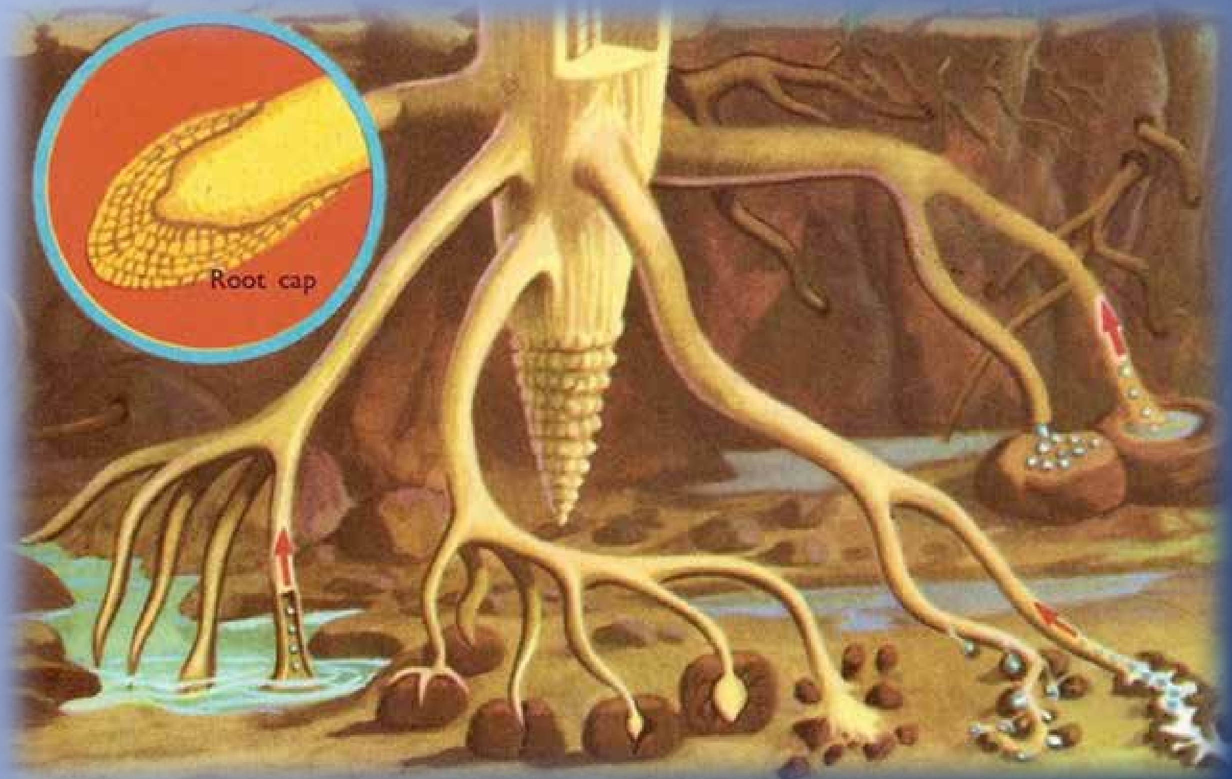
Salt Gradient

Ok, Steve, so what?

- **Local plants not adapted to salinity**
- **Over fertilizing**
- **Horse manure and other manures**
- **White crust on soil – what's that?**
- **Container plants – ring around the collar**

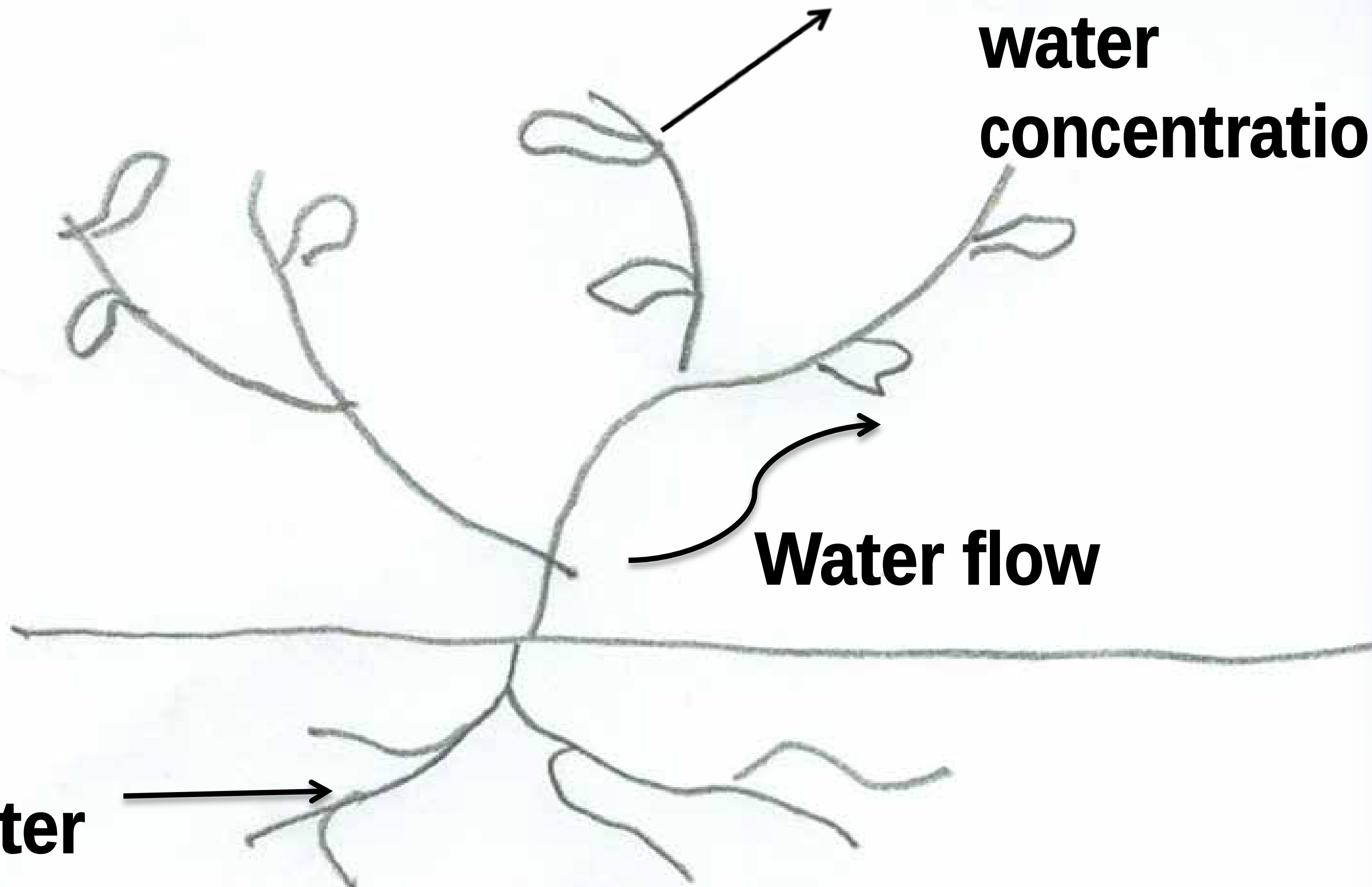
Water Movement in Plants

Gravity Gradient-
The energy required to lift water.



Water Movement in Plants
Gravity Gradient

Transpiration – it's the pull



Factoids (Gee Whiz)

- In most species, 98% of the water entering the plant is lost through transpiration
- 48 ft. silver maple transpires up to 58 gal./hr.
- A broad leaf forest transpires about 8000gal./acre/day

Factoids, cont.

- The average tomato plant transpires about 30 gal. during its growing season
- Corn transpires about 55 gal./plant in its growing season
- The Average Lawn uses 55 gal/sq ft/year
- The average dishwasher uses 4 to 6 gal per load
- The Average kitchen faucet uses 2 gal/minute
- It takes 300 barrels of water to make one barrel of beer
  - Most efficient brewery uses 3 to 4 barrels
  - Rest of the use comes primarily from irrigation and milling of the barley and hops

IV. Managing Irrigation to Optimize Water Use

<u>Objectives:</u>

- When, Where, How Much
- Creating an Irrigation Plan
- Keys to Watering Efficiently
- Decrease Run Off of Fertilizers/ Pesticides

Managing Irrigation to Optimize Water Use, cont.

When, Where, How Much

- **Apply water to meet and not exceed plant demand**
- **Apply water where it can be beneficially used**
- **Apply water at**

the intended rate

Managing Irrigation to Optimize Water Use – When, Where, How Much

Determining When:

Check the Plants

- Wilted, curled leaves
- Poor fruit or flower production
- Dull or grey-green foliage
- Leaf drop
- Smaller than normal new leaves
- Foot prints remain in lawn

Managing Irrigation to Optimize Water Use – When, Where, How Much

Determining when

Check the soil

- **At the root zone**
- **Screw driver test**
- **Hand feel test**

Managing Irrigation to Optimize Water Use – When, Where, How Much

Determine When, cont'd.

Always check during:

- **Periods of high winds – turn off**
- **Temperatures above 86 F.**
- **Little or no rain**

Managing Irrigation to Optimize Water Use – When, Where, How Much

Determining When

<u>Timing - Early morning</u>

- Reduces water loss
- Reduces fungal problems
- Water soaks in deeper

LATE AFTERNOON OR EARLY EVENING THE WORST

Managing Irrigation to Optimize Water Use – When, Where, How Much

<u>Determining Where:</u>

- **Only in areas that need**
- **Avoid overspray**
- **Avoid runoff**

Managing Irrigation to Optimize Water Use – When, Where, How Much

<u>Determining How Much:</u>

- Only what is needed
- Hand feel test or tensiometer
- How deep

Lawns, flower beds, garden 12”

Shrubs 1–2 ft.

Trees 2-3 ft.

Managing Irrigation to Optimize Water Use

Creating an Irrigation Plan

See handout

Base the plan on specific need(s) of your garden

Managing Irrigation to Optimize Water Use

Creating an Irrigation Plan

Considerations:

- **How large**
- **How much rainfall and when**
- **Type of soil**
- **Area subject to drought or flooding**
- **Practicality of watering – cost and availability**
- **Type of irrigation – high or low pressure**
- **Where would each type be best used**

Managing Irrigation to Optimize Water Use

Keys to Watering Efficiently:

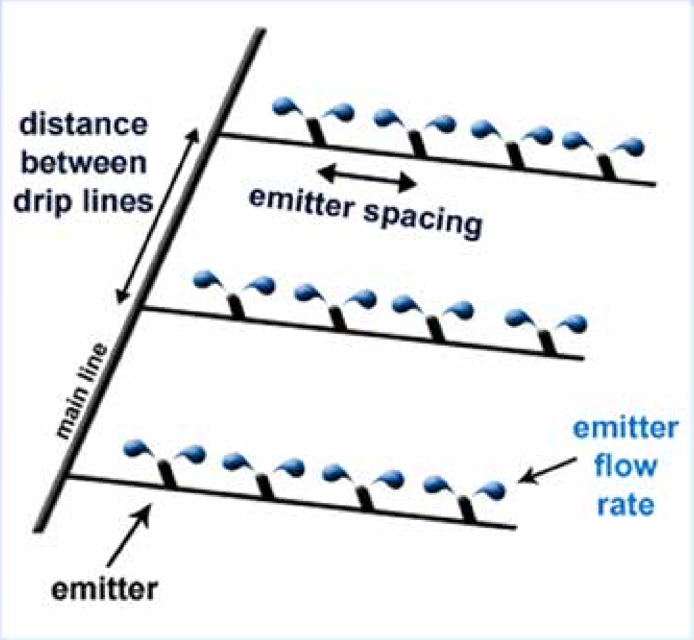
See handout – "Water Management Tips For Your Landscape"

- **Appropriate controller**
- **Program correctly**
- **Regularly change controller schedule**
- **Choose appropriate plant materials**
- **Soil prep**
- **Proper horticultural practices**

V. Methods of Applying Water

Considerations

- Controller or timer
- High pressure
- Low pressure
- Flood, row, basin
- How to water



Methods of Applying Water

Controller/timer

- Use appropriate one for your conditions
- Adequate number of stations
- Flexible programing
- Adjust controller to match needs
- Avoid windy conditions
- Program for morning application
- Consider distribution uniformity
- Consider irrigation efficiency

Methods of Applying Water

High Pressure Systems (sprinklers)

- Characteristics
- Benefits and Challenges

Use “Can Method” to determine application rate and distribution uniformity

Methods of Applying Water

<u>**Low Pressure Systems (drip, misters, etc.)**</u>

- **Characteristics**
- **Benefits and Challenges**

Infiltration measuring/uniformity

Methods of Applying Water

<u>Flood, Row, and Basin</u>

- **Flood**

  Benefits and challenges

- **Row**

  Benefits and challenges

- **Basin**

  Benefits and challenges

How to Water

- New plantings

  No drought tolerant plants

  Consistent, deep watering until root system established

  Perennials – 1 year

  Shrubs and trees – 2 + years
- Established plants

  Yes – fewer, deep watering

  No – frequent, shallow watering
- Slopes or heavy clay soil – pulse or cycle irrigation

VI. Water Conservation

How to Water

- Soil types: sandy or DG, loam, clay
- Seasons

Adjust frequently – duration and days

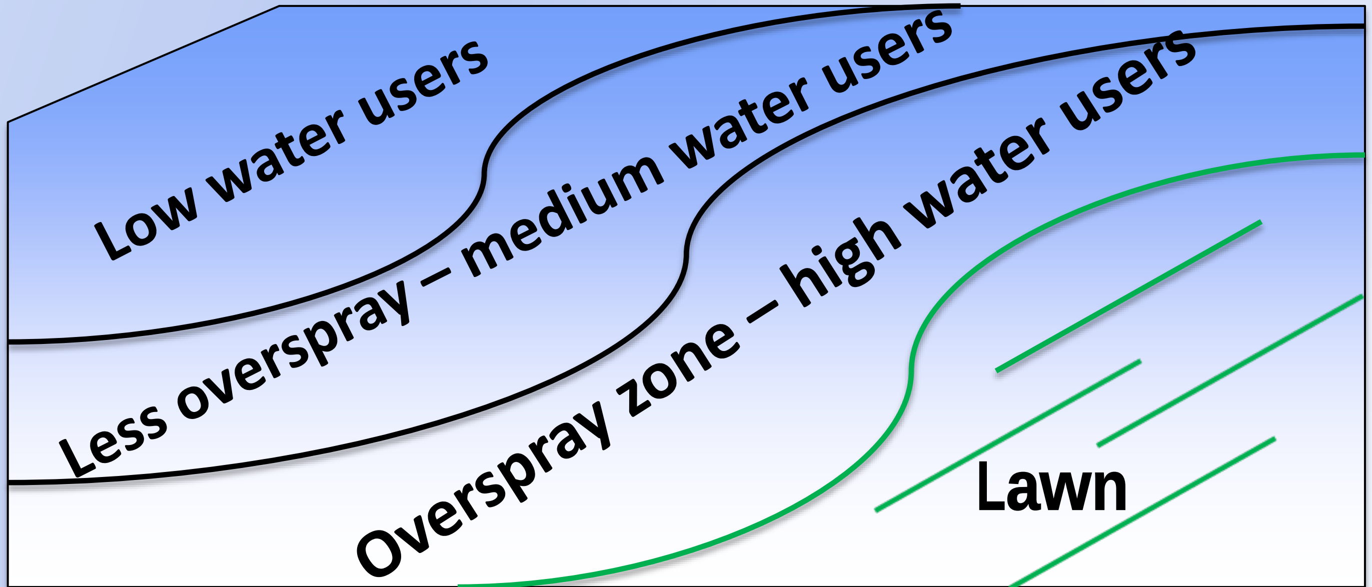
Dec/ Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
0%	0%	5%	30%	60%	90%	100%	90%	60%	30%	5%

July = maximum use

Water Conservation- How to Water

Hydrozones

- Grouping plants with similar water needs together
- Or, use plants that tolerate a range of moisture levels together or in transitional areas



Water Conservation cont.

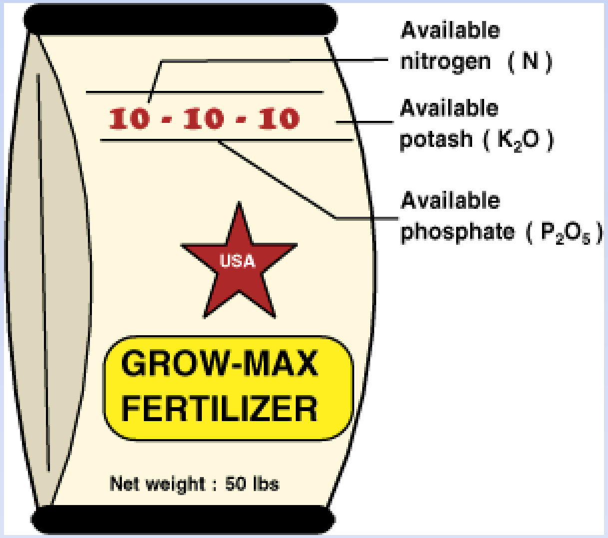
- Mulch
  - Benefits and cautions
- Time of day/weather conditions
- Anti-transpirents/polymers

Water Conservation

Fertilizers

- Sparingly or not at all in summer
- Phosphorus (P) to increase drought tolerance
- Nitrogen (N) and Potassium (K) REDUCE drought tolerance

***Over Fertilizing leads to nitrates going into sewers, streams, rivers, ocean and aquifers ***



VII. Measuring Water Loss

Evapotranspiration

CIMIS

Methods for measuring water loss

Measuring Water Loss

Evapotranspiration (ET)

- What is it?
- Implications
- Factors affecting
- Measuring its rate

Measuring Water Loss

CIMIS – California Irrigation Management Information System

<u>Assumptions</u>

Et_o – reference evapotranspiration

K_C – water use reports per crop

K_L – coefficient to estimate site water use

Measuring Water Loss

CIMIS sites applicable for our area

Sacramento (use for Folsom, El Dorado Hills, Cameron Park)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
.98	1.76	3.17	4.72	6.35	7.68	8.36	7.2	5.43	3.66	1.65	.92

Camino (use for Shingle Springs, Rescue, Placerville, Camino, Pollock Pines)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
.98	1.68	2.48	3.9	5.98	7.2	7.75	6.82	5.1	3.1	1.5	.93

Measuring Water Loss

Method 1: Calculating loss for a large landscape

Method 2: Calculating loss based on square footage using plants of same water needs

Method 3: Calculating loss for a single plant

Method 4: Calculating direct water replacement based on water used

Measuring Water Loss

<u>Method 1:</u> Calculating water need based on landscape plantings (types of plants in a landscape)

- Reference ET (ET_o) – CIMIS reports
- A landscape coefficient (K_L) – to convert Et_o to the landscape evapotranspiration (ET_L)
- Formula for conversion:

$$ET_L = ET_o \times K_L$$

$$K_L = K_S \times K_D \times K_{MC}$$

K_S = Species Factor
K_D = Density Factor
K_{MC} = Microclimate Factor

Measuring Water Loss

Example:

Formula: $ET_L = ET_o \times K_L$

If

$K_L = .65$ **and** $ET_o = .5\text{"}/\text{wk.}$

Then

$ET_L = .65 \times .5$

$= .325\text{"}/\text{wk.}$

References: A Guide to Estimating Irrigation Water Use Need of Landscape Planting in California

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

http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf

Measuring Water Loss

Method 2: Calculating water need based on square footage (assuming plants are all of same water demand: L, M, H)

1. Determine water demand from table below:

Plant Type:	Water Demand Percent Range:	
	High:	Low:
Low water use -	.26	.13
Medium water use -	.45	.26
High water use -	.64	.45

Measuring Water Loss
Method 2, cont'd

2. **Multiply the ET_o (from table) for either Sacramento or Camino in inches/month by the water demand for the type of plants you have. <u>*Note*</u>: *If you have a mixed landscape, you need to use the first method***
3. **Multiply the result by .623 to convert inches to gallons per square foot**
4. **Determine total square footage of area to be irrigated (assume 450 SF for this example)**
5. **Multiply the gallons per square foot by the number of square feet to determine the total number of gallons required to measure water loss**

Measuring Water Loss
Method 2, cont'd

For example, consider Camino in July, ET_o = 7.75 inches per month. We have low water use plants, use the high end of the range (.26). And we have 450 SF to irrigate. Then:

7.75 inches/month x .26	= 2.01 inches/month
2.01 x .623	= 1.25 (to convert inches/month to gallons/month)
1.25 x 450	= 562.5 gallons/month

If you want just inches/month, then apply 2.01 inches/month across the entire area

Source: Harvesting Rainwater for Landscape Use, University of Arizona Cooperative Extension, Patricia H. Waterfall

Measuring Water Loss

Method 3: Rough calculation for single plant water need

- Use the guide to Estimating Irrigation Water Use (WUCOLS)
- Water Use Classification of Landscape Species (Google – WUCOLS IV)

1. Determine your region
2. Find plant
3. Determine if it is a high, medium or low water user
4. Use table to determine actual water use

- Use this number as a rough guide to that plant's summer water needs

Measuring Water Loss

Method 4: Direct replacement, no crop or landscape features considered

- Use Table in handout to determine gallons/day for specific plant or for large area square footage (computed using Camino data)
- Gives the number of gallons of water per day to replace ET loss over a given square footage
- You can calculate the gallons used for any square footage by multiplying 1 $ft.^2$ values by the given square footage

To convert system from GPM to Inches of Water per $Ft.^2$ (see calculation in handout)

GPM x 1.6 = inches of H_2O)/ft^2/min.

OR $GPM = \frac{\text{inches of } H_2O/ft^2/min}{1.6}$

Measuring Water Loss

Summary

We now have multiple ways to determine the irrigation needs of:

- **A large landscape – planting of varied plants**
- **A landscape of single water demand plants based on square footage**
- **A rough calculation for a single plant**
- **Direct replacement of water used**

VIII. Surviving Drought

Things I can do to:

- **Reduce water usage**
- **Save my landscape**

Surviving Drought

Things I can do:

- Remove/replace lawn
  - But have a plan
  - What will I replace it with?
- Plant drought tolerant plants
  - No drought tolerant plants when first planted
  - May have to wait
- Install/use drip irrigation

Surviving Drought

<u>Things I can do</u>:

- Practice water harvesting
  - More coming
- Save and use grey water
  - Grey water is untreated waste water from your washing machine, shower, and bathroom sinks
- Establish Hydrozones
- Reduce fertilizer use

Surviving Drought

<u>Things I can do:</u>

- **Watering**
  - **Water at night or early morning**
  - **Do not water in high wind**
  - **Avoid or reduce overspray**
  - **Water less frequently, but deeply**
  - **Gradually reduce water application – 10% at a time**
  - **Practice water cycling as needed**
  - **Manage irrigation to match microclimates**
- **Mulch**
- **Crowd plants**
- **Encourage development of extensive root system**

Surviving Drought

<u>Things I can do</u>:

- Prioritize plants to save
  - Select plants to receive limited amounts of water available
- Determine which plants can tolerate limited water
- Which plant can be easily replaced – sacrifice them
- Remove lower priority plants from crowded areas
- Recognize water stress symptoms to determine how long plants can go without irrigation

Surviving Drought

Things I can do:

- Eliminate competition – remove weeds
- Repair irrigation leaks
- Use polymers in containers

Sources:

http://ccuh.ucdavis.edu/industry/landscapewaterconservationresourcesfordrought.xisx
http://ccuh.ucdavis.edu/drought-messages-for-landscape-managers

Surviving Drought

Things I can do:

- Water harvesting
  - What is it?
  - The capture, diversion, and storage of rainwater for plant irrigation and other uses
- Can be simple or complex
  - How much are you willing to spend?
  - To use the system, it must rain ... duh!
  - Unless you have a large system, water harvesting can only help marginally

Sources:

Harvesting Rainwater, University of Arizona Cooperative Extension, by Patricia H Waterfall

Rainwater Harvesting Methods, http://www.watercache.com/education/rainwater-how/

Surviving Drought

<u>Save and use grey water</u>

- Warm up water from showers and sinks
- Water used to clean fruits and vegetables
- Be careful with dishwater, shower water and laundry water
  - Use only if use friendly soaps and products = biodegradable, non-toxic, sodium and borax free
  - Don't use on acid-loving plants (azaleas, blueberries); soap tends to be high pH (basic), these plants want low pH (acid) soil
- El Dorado County requires permit for all gray water use except laundry water
  - Some rules: do not store more than 24 hours, must stay on your property, must not be used on edible parts of plants

Surviving Drought

<u>**In the vegetable garden**</u>**:**

- **Double dig the beds**
- **Add compost up to 2%**
- **Use water-retaining compost: plant matter, rice hulls, polymers (?)**
- **Plant vegetables that produce in abundance: tomatoes, squash, peppers, and eggplant**
  - **Use soaker hoses or drip individual plants**
  - **Crowd the plants close together**
  - **Mulch**

Surviving Drought

<u>Trees</u>

- Plant native or drought-resistant types
- Choose trees over lawn – trees are a long term investment
- Water should soak into the ground, not run-off

<u>Young Trees</u>

- Water twice per week, about 5 gallons
- Water directly at the base of tree with hose or bucket

Surviving Drought

Mature Trees

- Water twice per week with 1 to 1.5 inches of water
- Water deeply
- Put water in the drip zone – move hose to several places around the tree

Deciduous Trees

- Critical to give sufficient water in late winter/early spring when new buds and leaves are forming
  - Do not prune unless absolutely necessary
  - Do not fertilize if tree is drought stressed

Source: Sokada@ sacbee.com

Surviving Drought

<u>Lawns</u>

- **Pro's for lawns:**
  - Coverage for recreational areas
  - Provides cushion beneficial for contact and physically intensive sport
  - Cools the immediate environment
  - Reduces reradiated heat
  - Reduces soil erosion, dust, glare, and fire danger
  - Increases water infiltration
  - Enhances water quality
- **Con's:**
  - High water use
  - High maintenance

Surviving Drought

Lawns

- Water use rates (ET)
  - Different grasses have different use rates
  - Rates vary from .24 to .39 inches/day

Ø See following table

Source: Adapted from Beard and Beard, 2004

Surviving Drought – Lawns (cont'd)
ET Rate common CA turfgrasses

Relative Ranking	ET rate (in./day)	Cool season turfgrasses	Warm season turfgrasses
very low	< 0.24		buffalograss
low	0.24		bermudagrass zoysiagrass
medium	.024 – 0.28	hard fescue Chewing's fescue red fescue Seashore paspalum St Augustine grass	
high	0.33 – 0.39	perennial ryegrass Kikuyugrass	
very high	> 0.39	tall fescue creeping bentgrass annual bluegrass Kentucky bluegrass rough bluegrass annual ryegrass	

Surviving Drought

Lawns

- **Water use not the same as ability to survive drought**
  - **Warm season grasses with good drought tolerance: bermudagrass**
  - **Cool season grass: tall fescue**

Ø See following table

Surviving Drought
Drought Resistance of CA turfgrasses

Relative Ranking	Cool-season turfgrasses	Warm-season turfgrasses
superior	---	bermudagrass (common) bermudagrass (hybrid) buffalograss
excellent	---	seashore paspalum zoysiagrass
good	---	St Augustinegrass kikuyugrass
medium	tall fescue	---
fair	perennial ryegrass Kentucky bluegrass creeping bentgrass hard fescue Chewing's fescue red fescue	---
poor	colonial bentgrass annual bluegrass	---
very poor	rough bluegrass	---

Surviving Drought

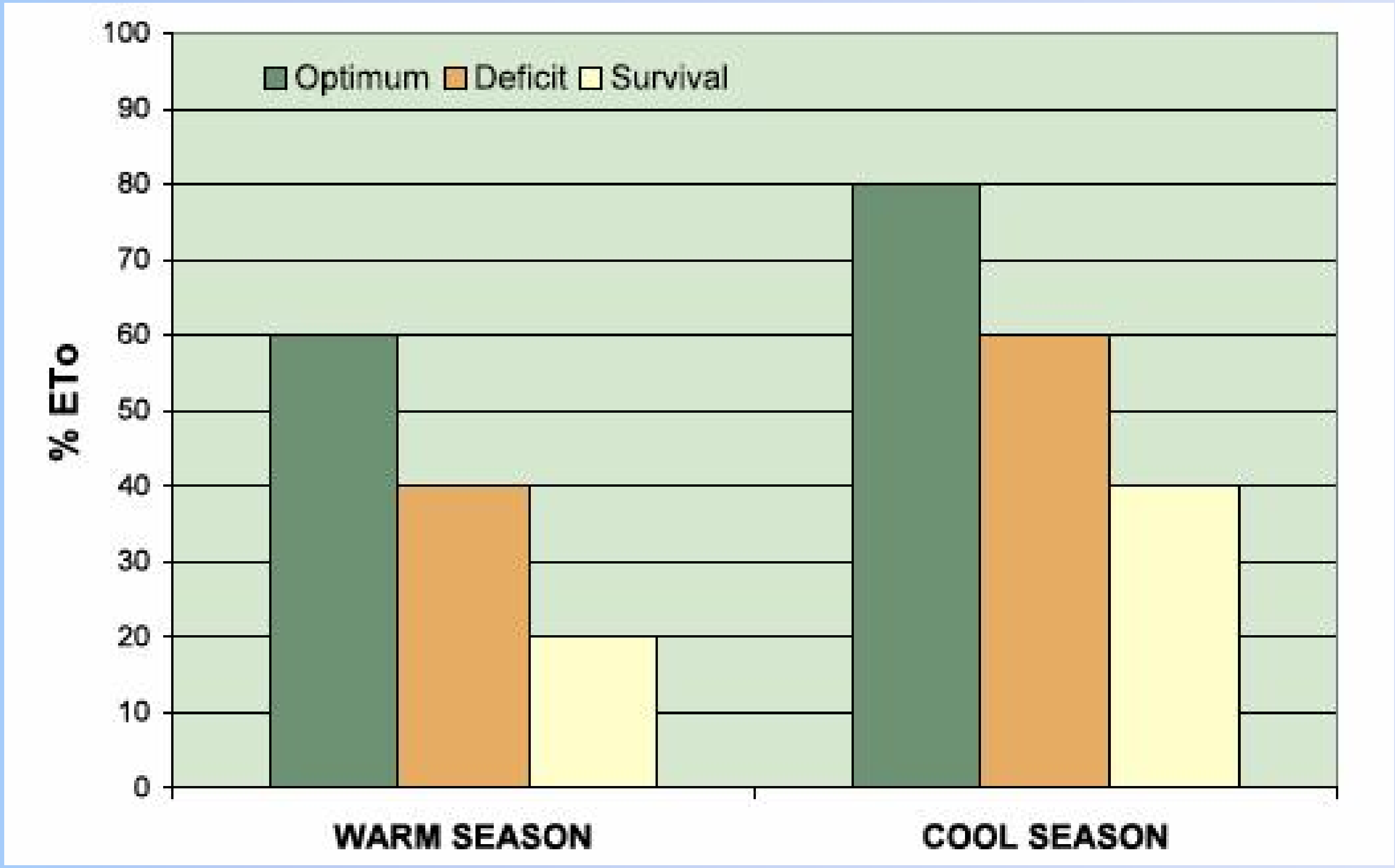
Lawns

- **Irrigation practices involve three strategies:**
  - **Optimum irrigation = good looking lawn**
  - **Deficit irrigation = maintains adequate appearance with less growth**
  - **Survival irrigation = only enough water to allow survival and potential recovery**

Ø **See following chart**

Surviving Drought

Turfgrass optimum, deficit, survival water requirements



Surviving Drought

Lawns

- Using ET_o to determine how much water
  - Remember $ET = ET_o \times K_C$ (for grass)
  - K_C to use depends on your survival strategy
- If cool season turf + "deficit" strategy, use $K_C = .6$
- If "survival" strategy, use $K_C = .4$
  - And use Et_o for either Sacramento or Camino – see handout

Ø See following table

Surviving Drought - Lawns

K_C values for optimum, deficit, survival levels

Turfgrass performance level	Cool-season turfgrasses K_C	Warm-season turfgrasses K_C
optimum	0.80	0.60
deficit	0.60	0.40
survival	0.40	0.20

Surviving Drought

__Lawns__

- **Mowing strategies**
  - **Frequency of mowing effects ET: tall grass= high ET**
  - **Keep grass mowed, but mow at tallest recommended height for type of grass**
  - **Mowing when it is hot or dry can injure plants**
  - **In a drought summer, mow infrequently at a taller height**

Ø See following table

Surviving Drought - Lawns
Mowing height ranges for common turfgrasses

Turfgrass species	Cutting Height range (inches)
<u>Cool season turfgrasses</u>	
creeping bentgrass	0.2-0.5
colonial bentgrass	0.5-1.0
red fescue	1.0-2.0
Kentucky bluegrass	1.5-2.5
perennial ryegrass	1.5-2.5
tall fescue	1.5-3.0
<u>Warm-season turfgrasses</u>	
bermudagrass	0.5-1.0
zoysiagrass	0.5-1.0
seashore paspalum	0.5-1.0
St Augustinegrass	0.5-1.5
kikuyugrass	0.5-1.0

Surviving Drought

Lawns

- **Fertilizing**
  - **Most cool season grasses need about 2 lbs actual nitrogen/1,000 square feet (SF) in a season**
  - **Apply ¼ each application: March-April-September- mid October**
  - **Do not apply nitrogen from May-August**
  - **Warm season grasses need .25 lb nitrogen per 1,000 SF between April and September**
  - **Potassium may increase drought tolerance; apply 1 to 2 lbs per 1,000 SF March or April**

Source: UCANR Publication 8395, "Managing Turfgrasses during Drought," M. Ali Harivandi, et al

Surviving Drought

Comparison of Traditional Landscape vs Water-Wise Landscape*

Traditional		Water-Wise	
Moderate to high Water use shrubs, 100 ft^2, Azalea, Gardenia, Hydrangea	140 G/W**	Low Water Use Shrubs, Ceanothus, Manzanita, Nandina, Rock Rose	79 G/W
Annual Flowers 100 ft^2, Petunia, Impatience, Lobelia	92 G/W	Low Water Perennials 100 ft^2, Salvia, Lavender, Agastache, Achillea	61 G/W
Large Tree Canopy Diameter 20 ft, Tulip Tree, Coast Redwood, Birch	230 G/W	Low Water Tree, Canopy Diameter 10 ft, Redbud, Crape Myrtle, Smoke Tree	57 G/W
Cool Season Turf 200 ft^2, Tall Fescue, Blue Grass	248 G/W	Non-Turf Perennial Ground Cover, 200 ft^2, Germander, Manzanita, Rosemary, Hypericum	122 G/W
Total	**710 G/W**	**Total**	**319 G/W**

*Based on 500 ft^2 sample landscape, in August, clay soil, landscape established at least one year.

** Gallons per week

Source: Sacramento Bee Graphic

Other Sources

Arboretum All Stars:
http://arboretum.ucdavis.edu/arboretum_all_stars.aspx

Regional Water Authority Plant Guide: www.pwah20.org (click on the link to water wise gardening)

www.riverfriendly.org

http://www.ipm.ucdavis.edu/TOOLS/TURF/MAINTAIN/cazone7.html

Google Water Use Classification of Landscape Species, or

Google WUCOLS IV

Questions?

Thank You!