How Much Water Does A Landscape Really Need?

2012 Landscape Industry Show Workshop

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- B.S. & M.S. Horticulture, Ohio State Univ.
- 30 years experience
  - Landscape & urban horticulture
  - Education and applied research programs
  - Landscape irrigation mgt., plant water needs, weather-based irrigation control
  - Presentations, workshops, publications, Web

CEU Credit

- This 2-hour seminar is worth 2 CEUs
- Reminder to keep documentation of your participation
- Check with CLCA if any questions

Useful Reference Materials

- U.C. Center for Landscape and Urban Horticulture
  - www.ucanr.org/sites/UrbanHort, click Landscape Water Management tab in left column
- 2011. Irrigation Association's Landscape Irrigation Auditor Book, 2nd Ed. Chapter 7 and Appendix D
- Landscape Irrigation Mgt. Program – LIMP
  - http://biomet.ucdavis.edu/irrigation-scheduling.html
- 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California – the landscape coefficient method and WUCOLS III
  - Web search "WUCOLS"

Goals

- Understand why & how plants use water
- Discover how plant water needs are estimated scientifically
- Learn how to estimate meaningful landscape coefficients based on research
- Understand effective irrigation scheduling

Landscapes require irrigation when…..

performance expectations exceed plant adaptation to precipitation

Demand for Climate-based Landscape Water Need Estimates

- Water budgets & tiered pricing
- State & local conservation ordinances
- ‘Green’ building & development standards
- Smart irrigation controllers

Climate-Based Water Budgets

Maximum Allowable Water Allocation (or Need)

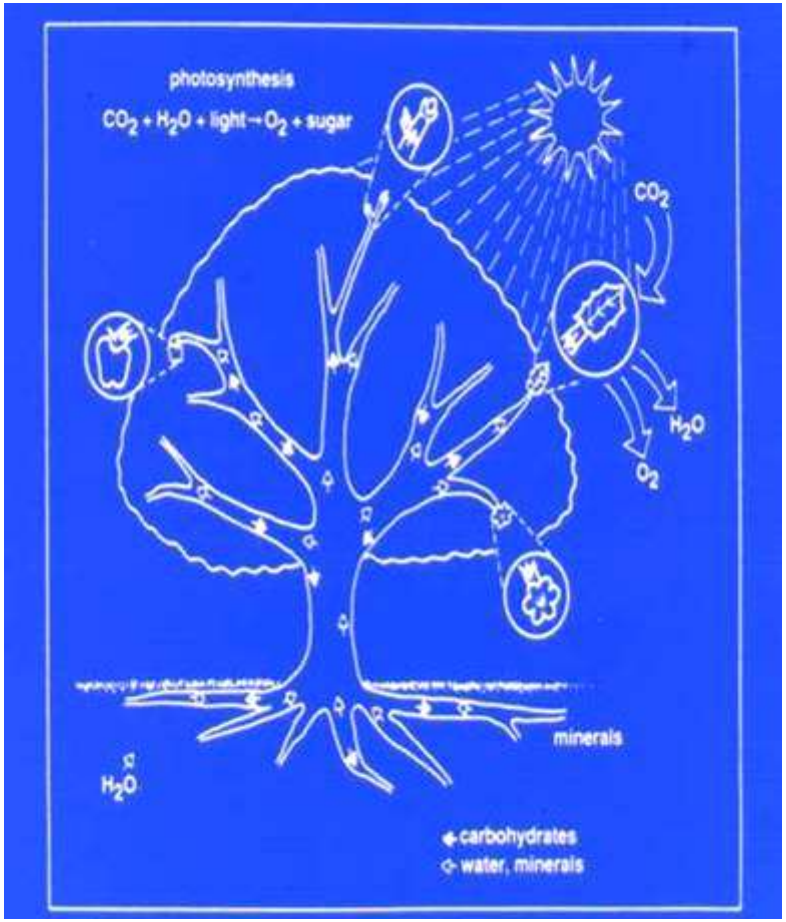
MAWA **= ETo × PF or Kc × LA × 0.62**

gallons = inches × % × sq. ft. × conversion

Why & How Plants Use Water

Why & How Plants Use Water

- Maintain structure
- Photosynthesis & physiological processes
- Cooling (transpiration)
- Transports minerals & nutrients

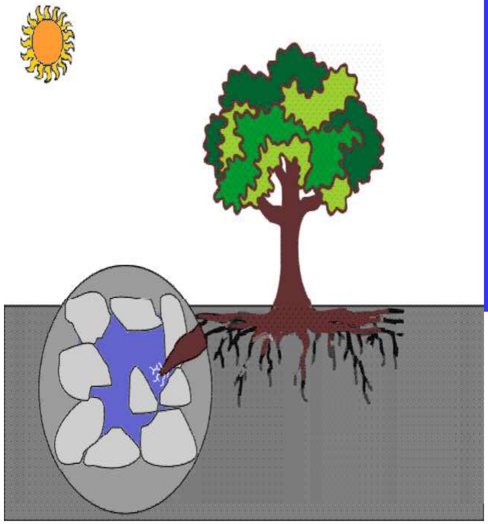


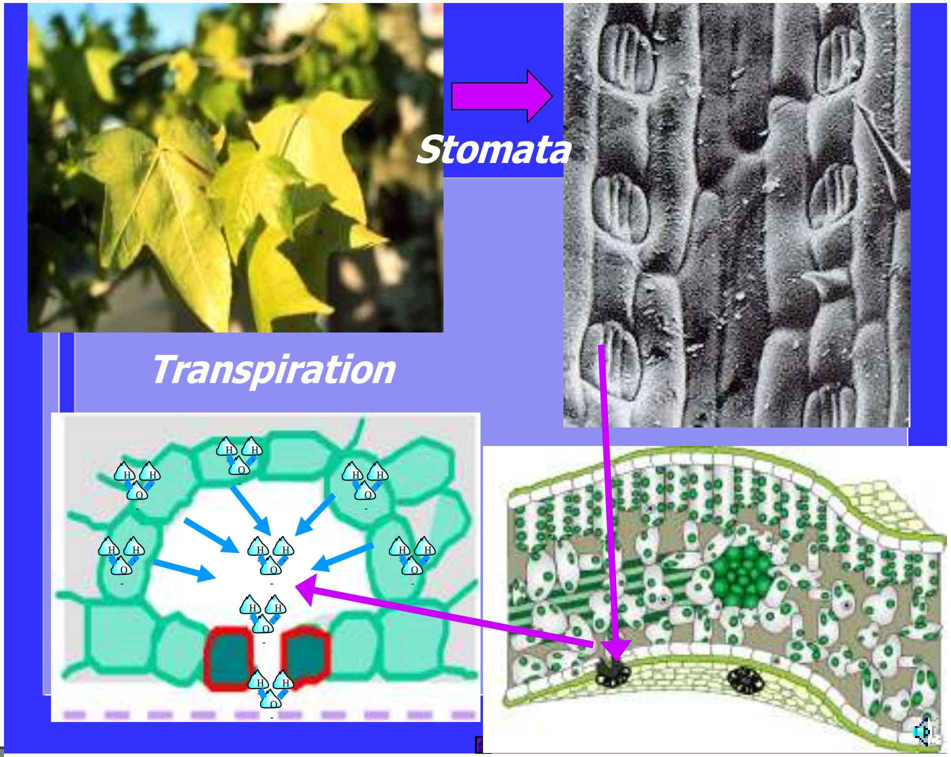
Why & How Plants Use Water

- SPAC:

Soil-Plant-Air-Continuum

- Creates pull



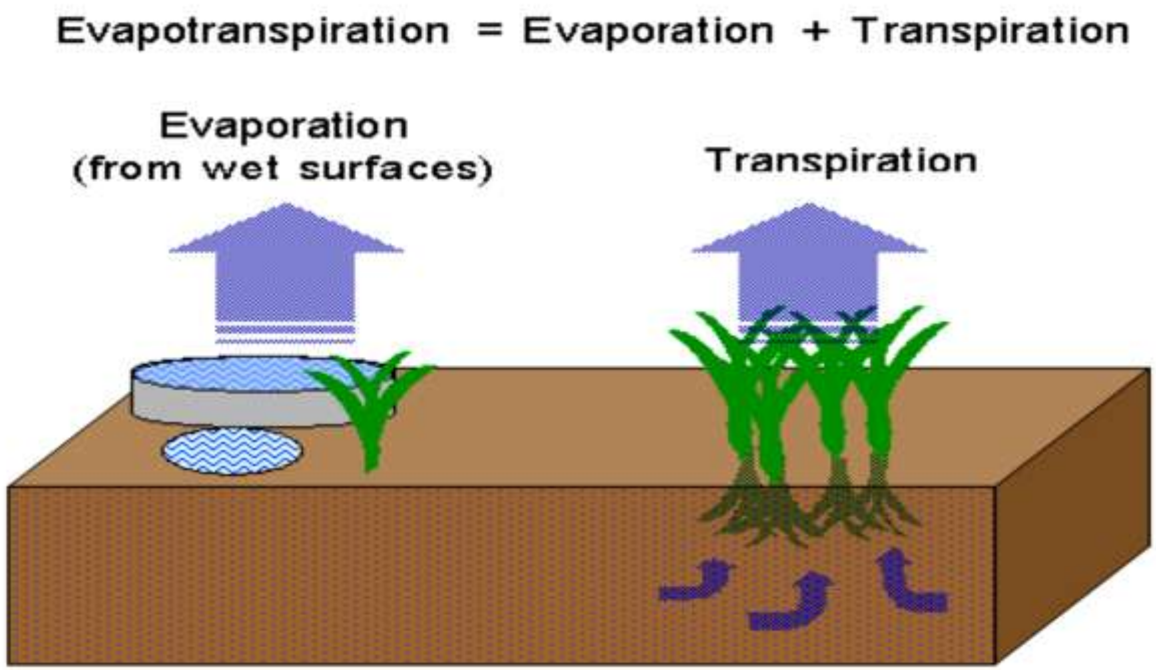


Landscape Water Use

Evaporation +
Transpiration =

Evapotranspiration (ET)

Evapotranspiration (ET)



Factors Affecting Plant Water Use & ET

- Sunlight
- Temperature
- Humidity
- Wind
- Plant species
- Plant size
- Site characteristics

Plant Responses to Water Stress

- Stomata may/may not close
- Photosynthesis & transpiration reduced
- Growth & leaf area reduced
- Premature leaf drop
- Predisposed to disease & insect pests

Estimating Plant Water Use

- Climate & Weather
- Plant Physiology

Estimating Plant Water Needs

- Define a reference for plant water use that is a function of climate
- Compare amount of water needed to maintain given plant with reference amount
- Express plant water need as % of reference
  - Plant Factor (PF or Kp)
  - Crop Coefficient (Kc)

Reference Evapotranspiration (ETo)

An estimate of environmental water demand of a planted area

- Climate-based reference of plant water use
- Inches/day
- Data available real-time & historical tables

Reference ET (ETo)

- ETo = water use of 6-in. tall well-watered cool-season turf
- Calculated by formula using weather data
  - sunlight, temperature, RH, wind

Reference ET (ETo)

CIMIS

(*California Irrigation Management Information System*)

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

Reference ET Alternatives

Estimating Plant Water Use

- Calculate ETo
- Quantify plant's water use (ETcrop)
- ETc ÷ ETo =

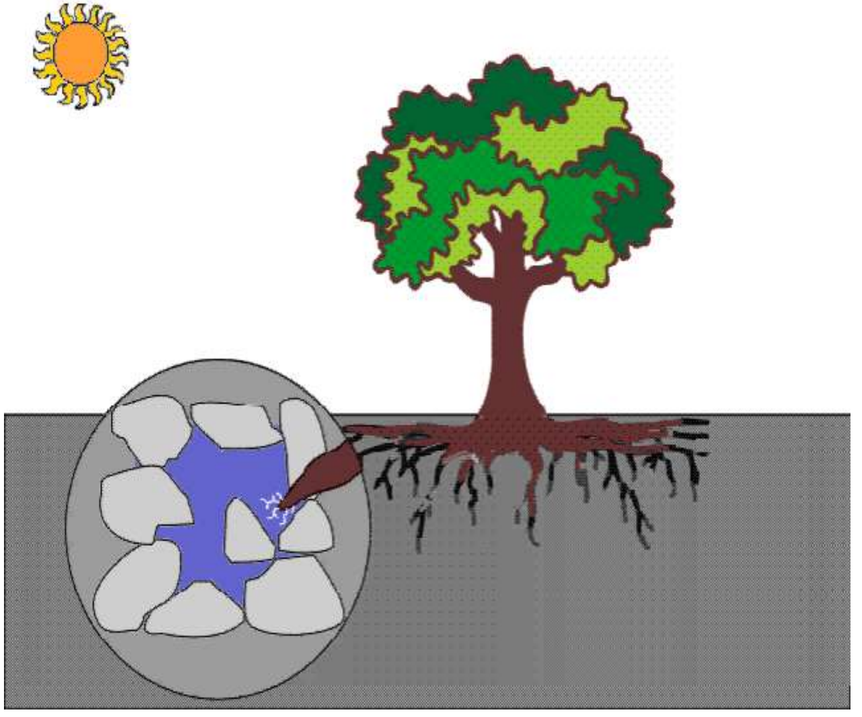
  Crop Coefficient (Kc)
- Assume standard conditions and plant responses

Assumptions of ETo & Kc

Optimum growth or yield

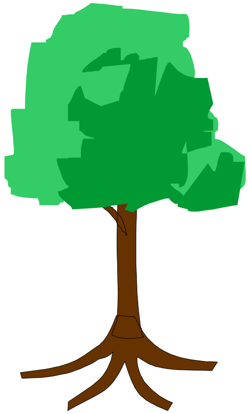
Assumptions of ETo & Kc

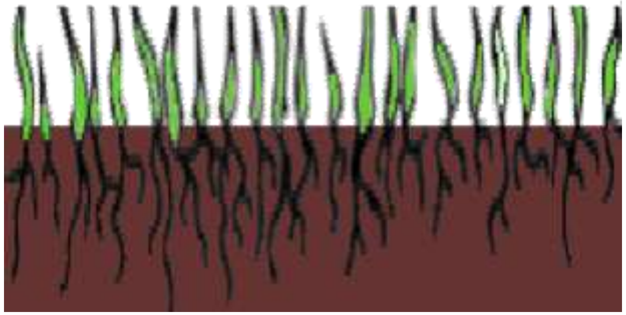
Unlimited soil water



Assumptions of ETo & Kc

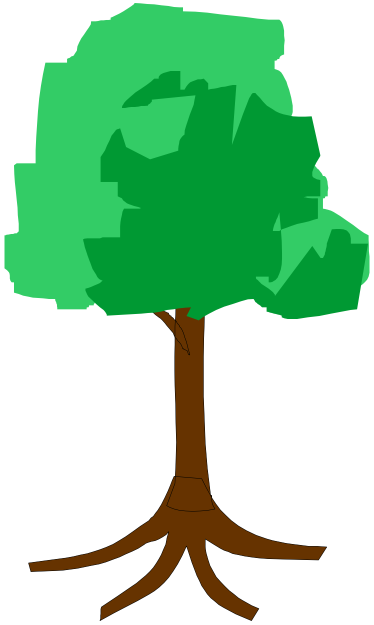
The *Big Leaf*





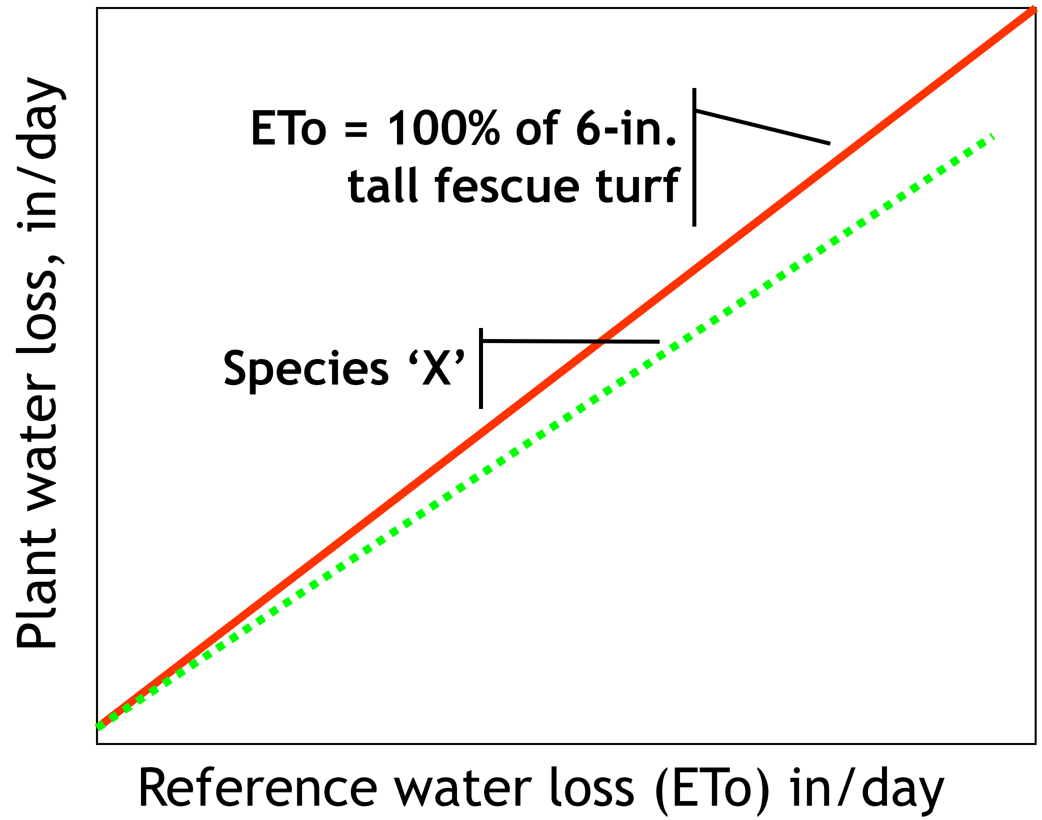
Assumptions of ETo & Kc

Uninterrupted air flow



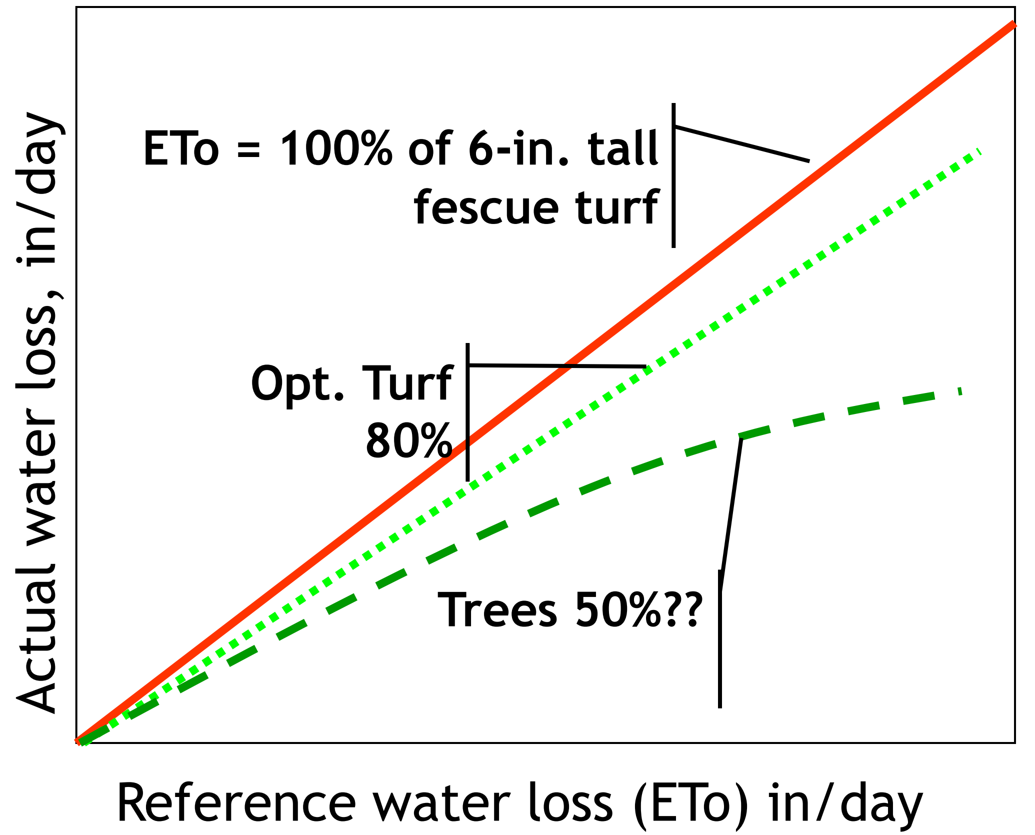
ETo & Estimating Plant Water Use

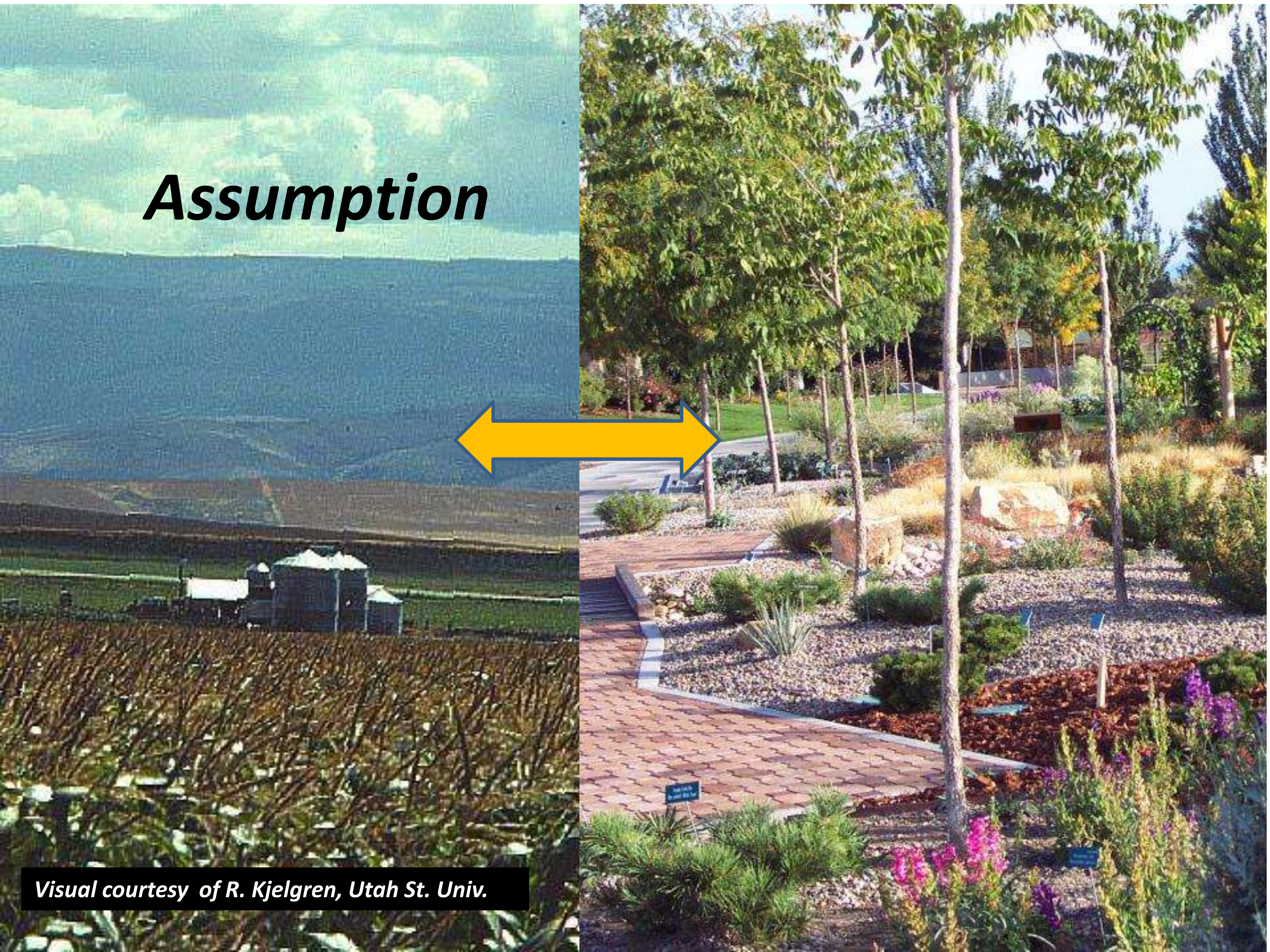
Synchrony of ETo & other plants is assumed



Assumptions of ETo & Kc

ETo & crop water use are synchronized




Assumption
Visual courtesy of R. Kjelgren, Utah St. Univ.

Assumptions of ETo & Kc

Violated in landscapes & urban settings

Landscape Plants

Water ***Use*** ≠ Water ***Need***

May *use* more water than they *need* to meet expectations

Estimating Plant Water Needs

- Kc = Crop Coefficient

  = amt. of water needed for *optimum* growth or crop yield

- PF = Plant Factor

  = amt. of water needed for *acceptable* growth, level of appearance, function

Kc & PF Estimates for Landscape Plants

- Turfgrass Kc’s developed
- No true Kc’s for landscape plants
- Few reliable PFs for landscape plants

Turfgrass Irrigation Needs

- Cool-season Kc:
  80% ETo annual avg.
  (60% ETo minimum)
- Warm-season Kc:
  60% ETo annual avg.
  (35% ETo minimum)

Estimating Landscape Plant Water Needs

Estimating Landscape Plant Water Needs

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Field Studies on Landscape Plant Water Needs

- 79 plant species to date
  - 33 trees, 12 groundcovers, 34 shrubs
- Locations – no summer rainfall
  - Inland valley – 28 trees
  - South Coastal – 28 shrubs, 9 groundcovers, 5 trees
  - Low Desert – 6 shrubs, 3 groundcovers

Our Research Approach

- Minimum water needed for acceptable performance/appearance (%ETo = PF)
- Apply multiple % ETo treatments
- Irrigate when:

  $$\Sigma(\text{daily ETo} \times \text{trtmt. \%}) = \text{depletion target}$$

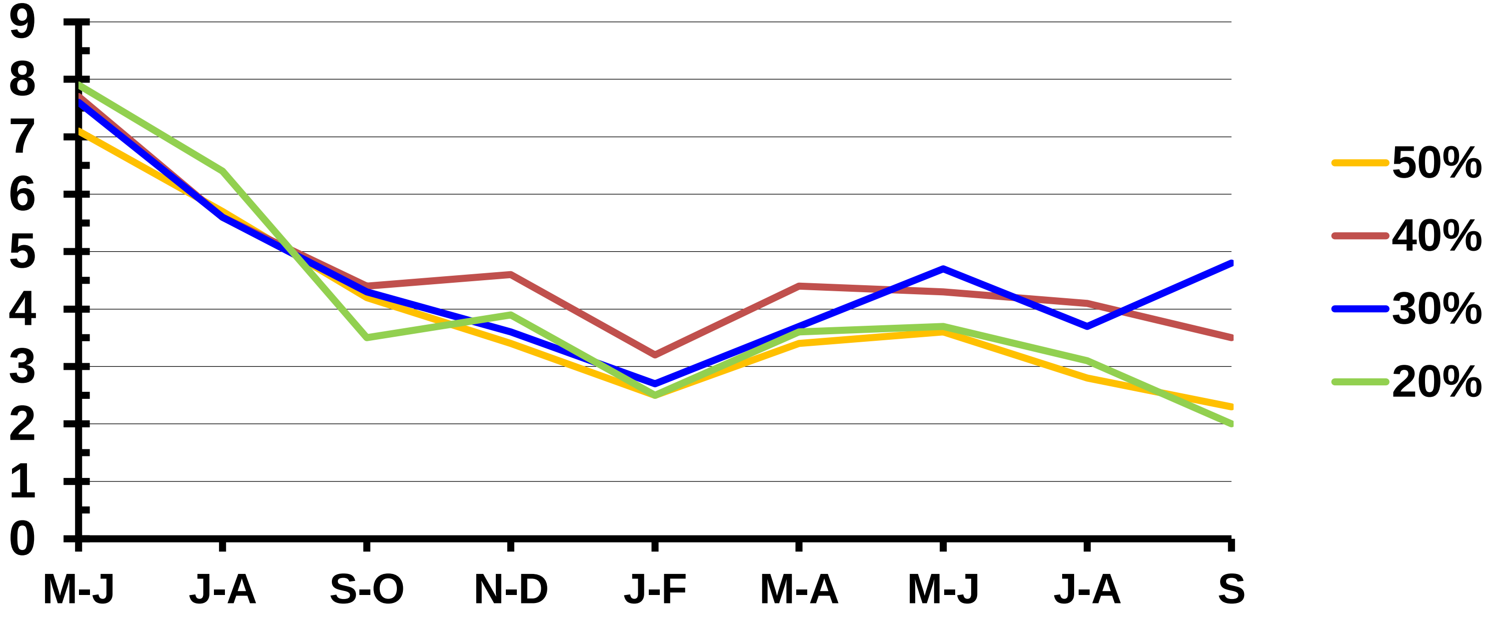
- Evaluate plant performance
  - Aesthetics
  - Growth

Groundcover Irrigation Study

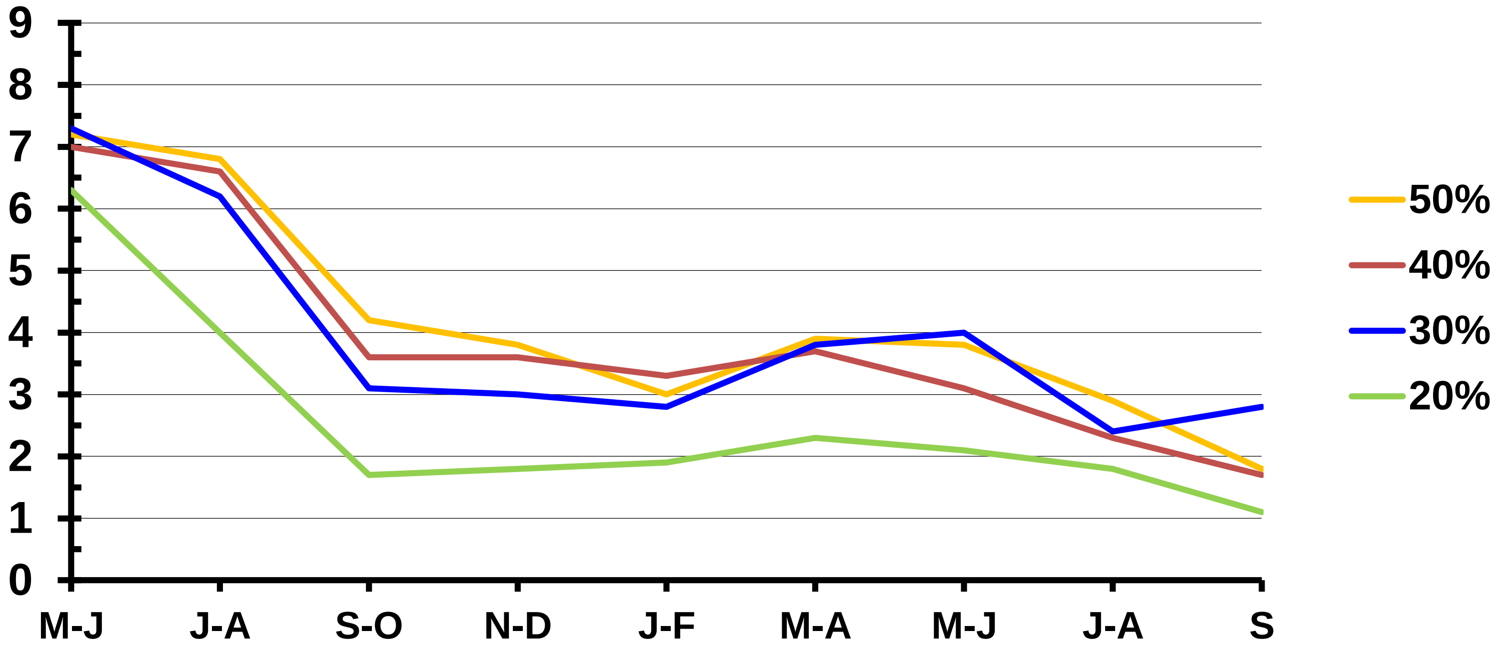
Groundcover Species

- *Baccharis pilularis* ‘Twin Peaks’
- *Drosanthemum hispidum*
- *Vinca major*
- *Osteospermum fruticosum*
- *Hedera helix* ‘Needlepoint’
- *Potentilla tabernaemontanii*

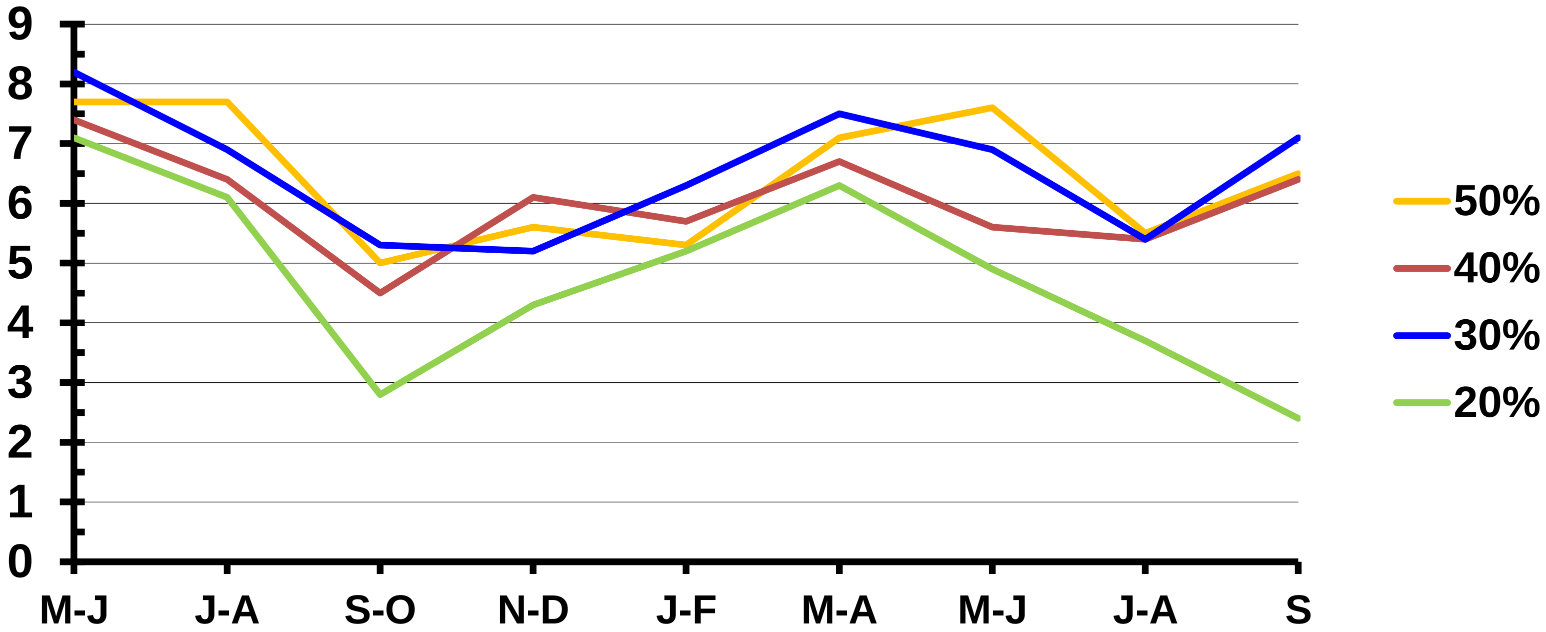
Gazania Overall Quality Ratings 1990-1991



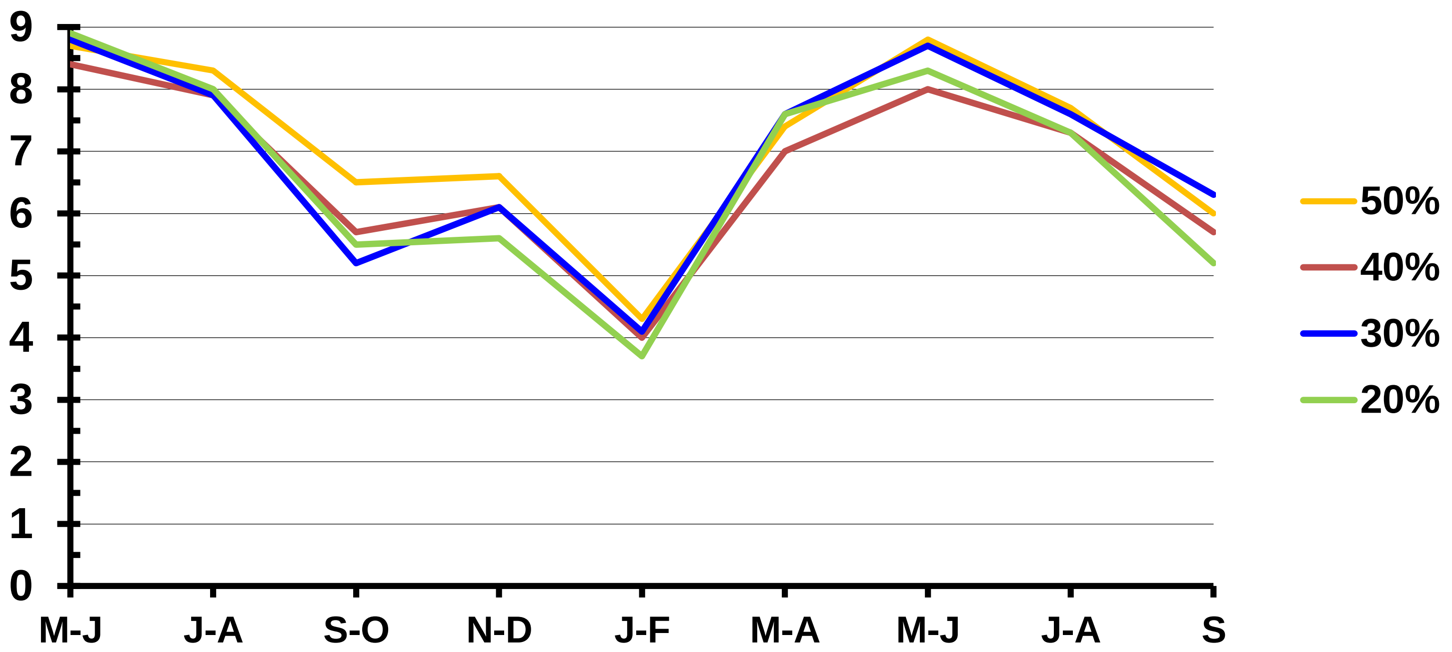
Potentilla Overall Quality Ratings 1990-1991



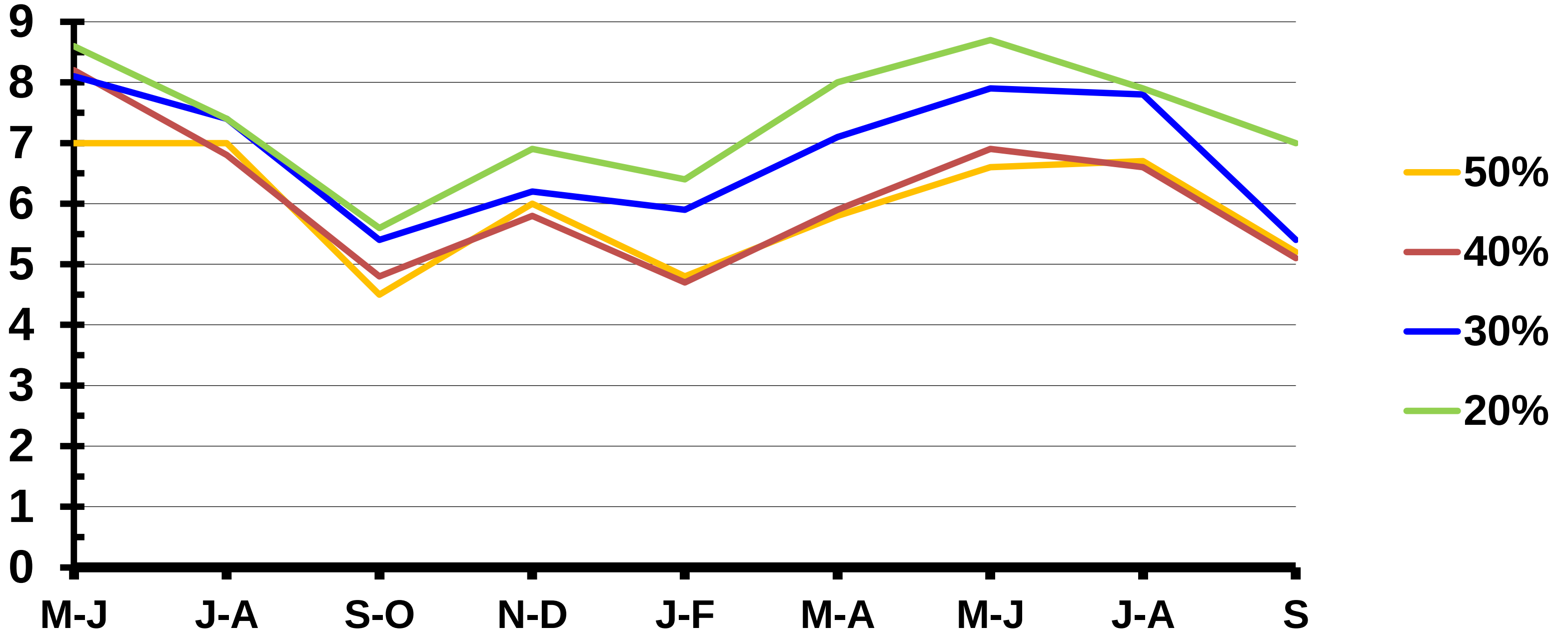
Vinca Overall Quality Ratings
1990-1991



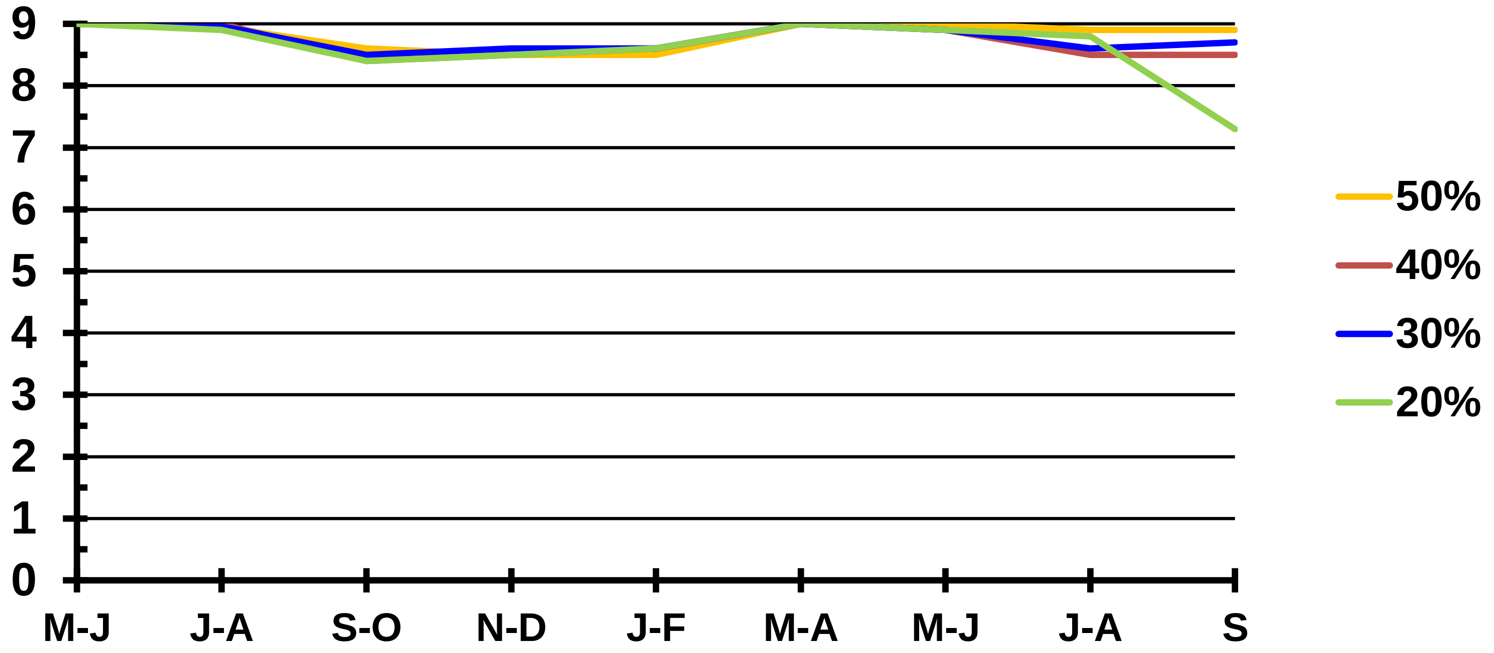
Hedera Overall Quality Ratings 1990-1991



Baccharis Overall Quality Ratings 1990-1991



Drosanthemum Overall Quality 1990-1991

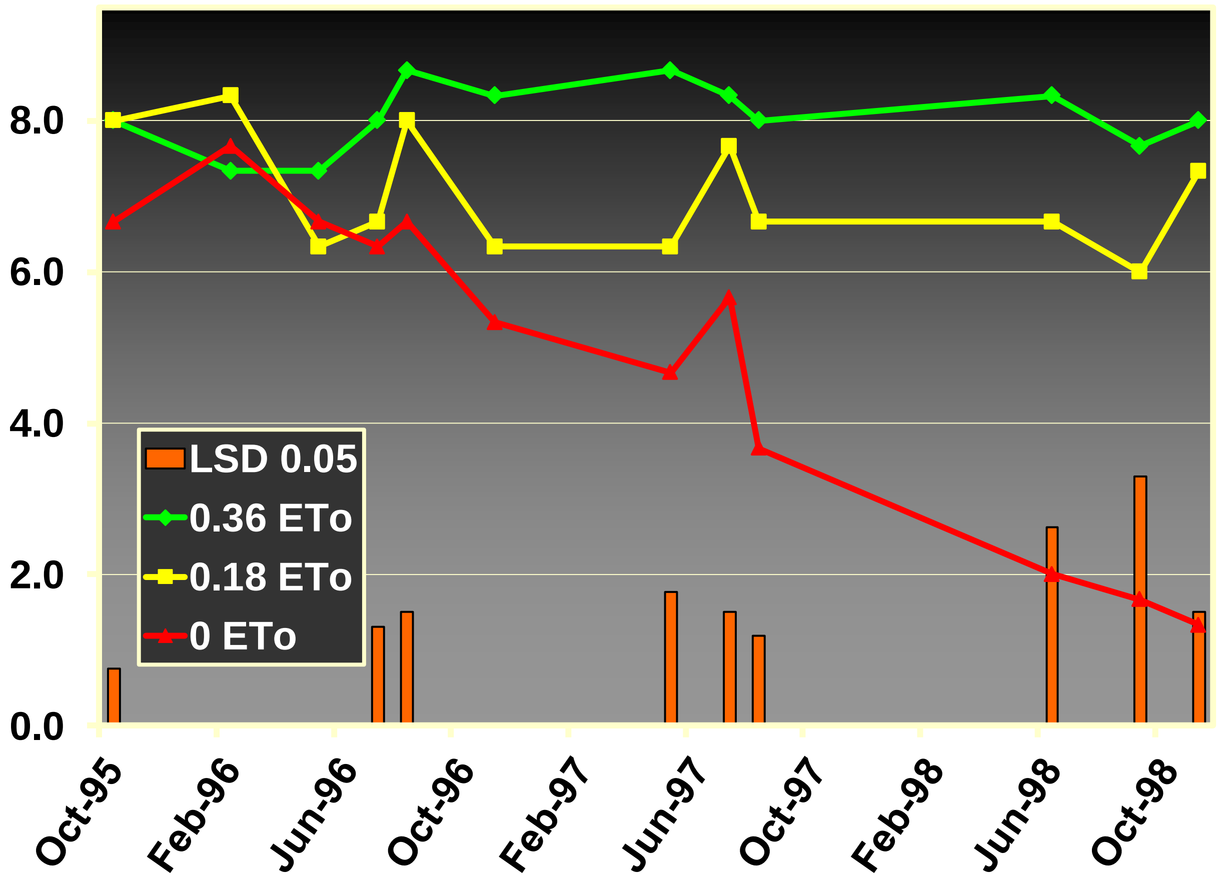


Apply 30% of Accumulated ETo

Treatments Applied:

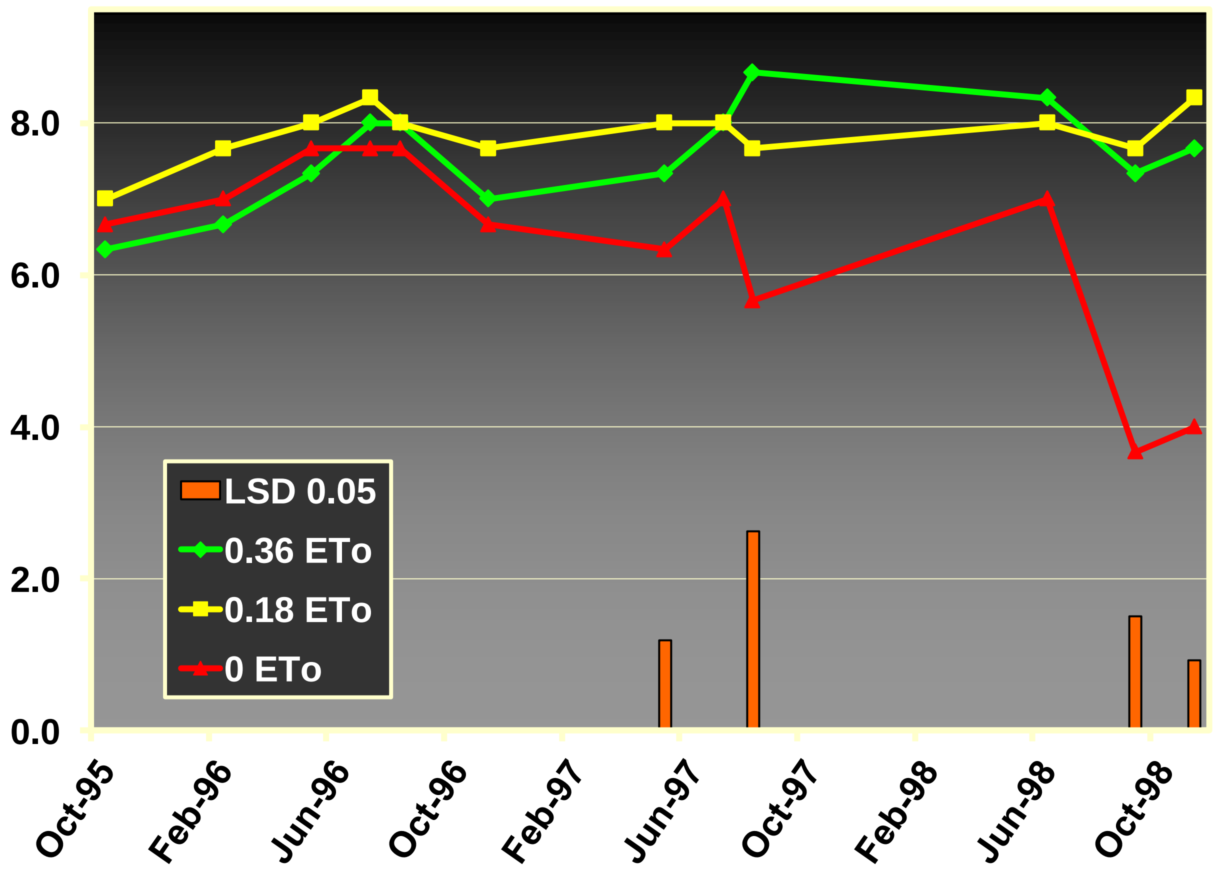
- 3 days per week
- 1 day per week
- 1 day every 2 weeks
- 1 day every 4 weeks

Phormium tenax
Aesthetic Quality Ratings

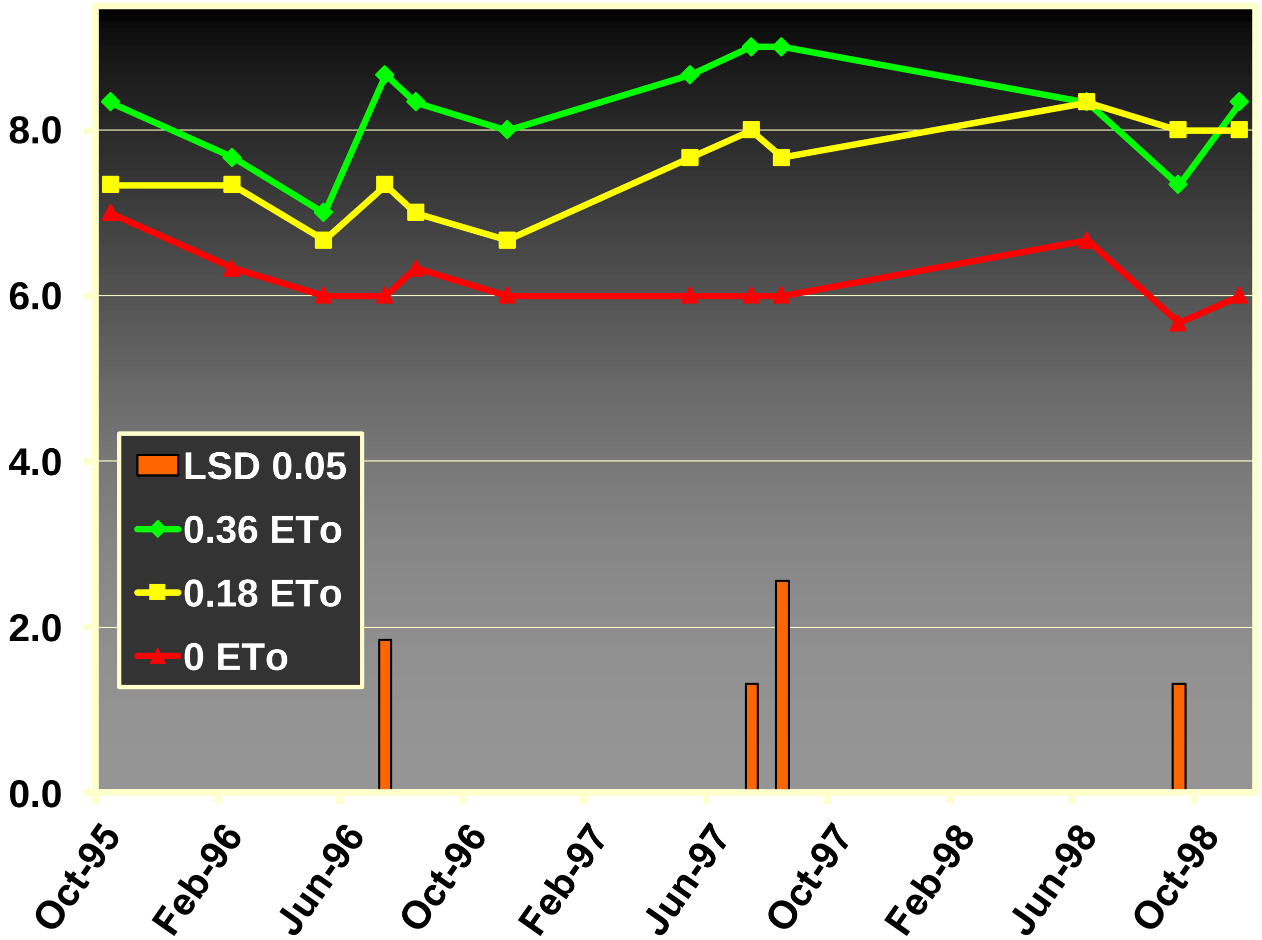


Phormium tenax

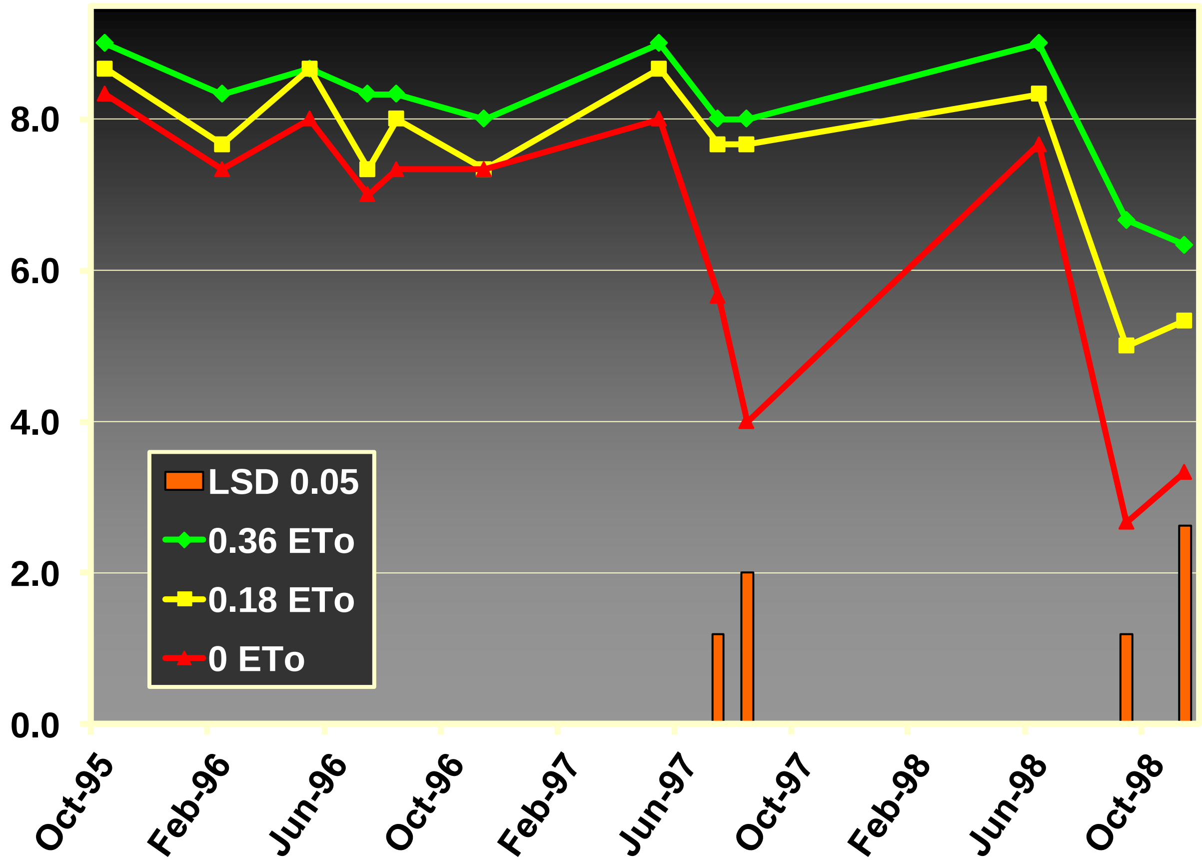
Raphiolepis indica
Aesthetic Quality Ratings



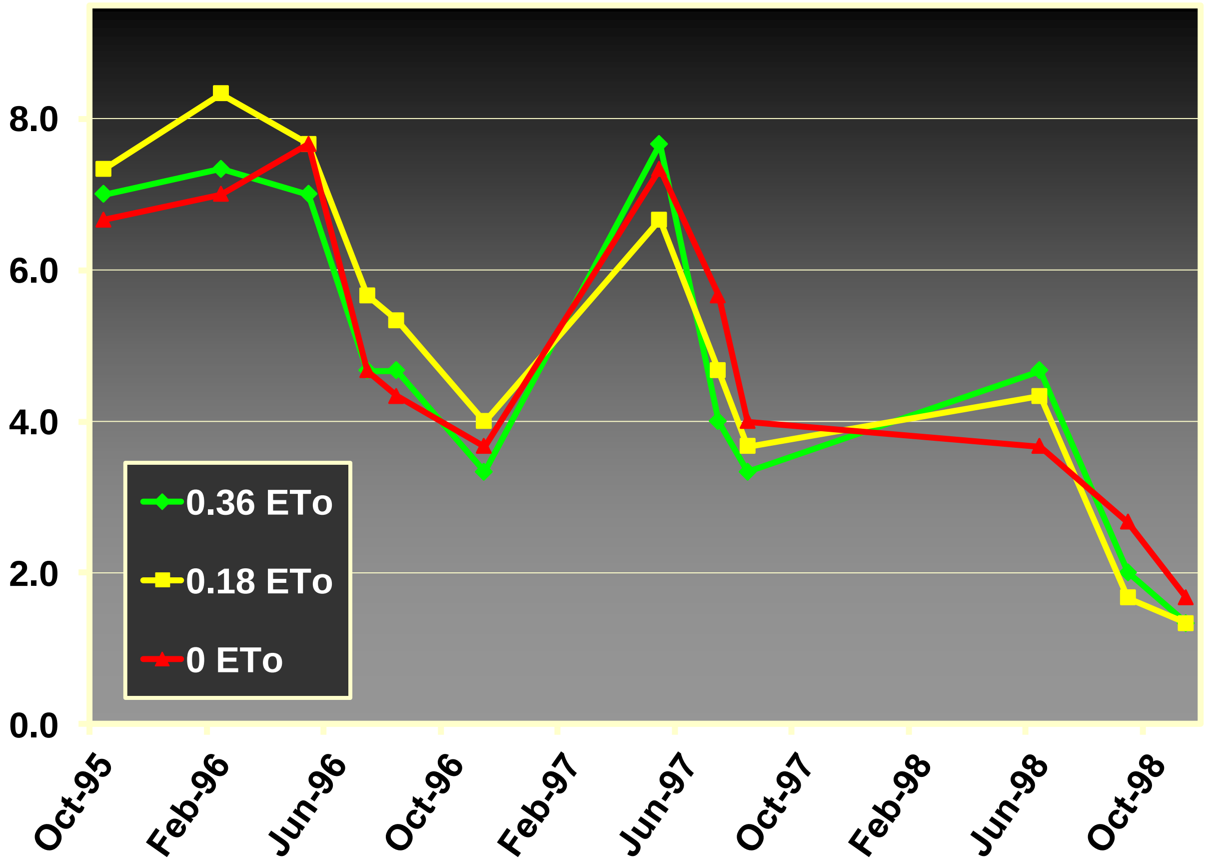
Arbutus unedo
Aesthetic Quality Ratings



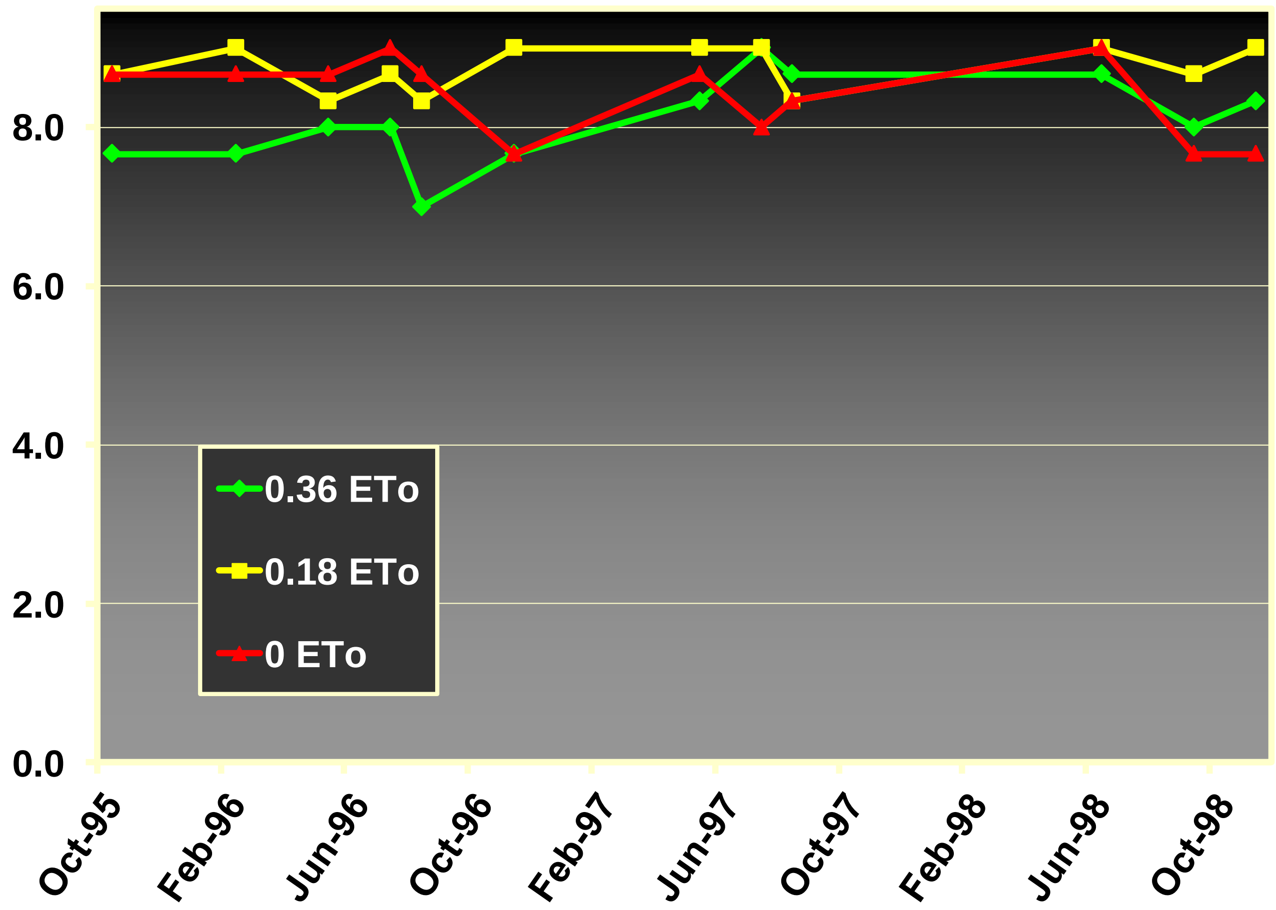
Ligustrum japonicum
Aesthetic Quality Ratings

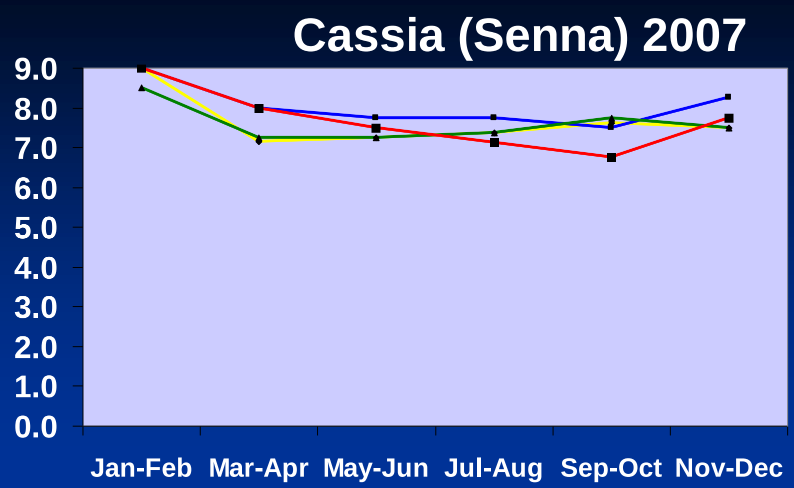


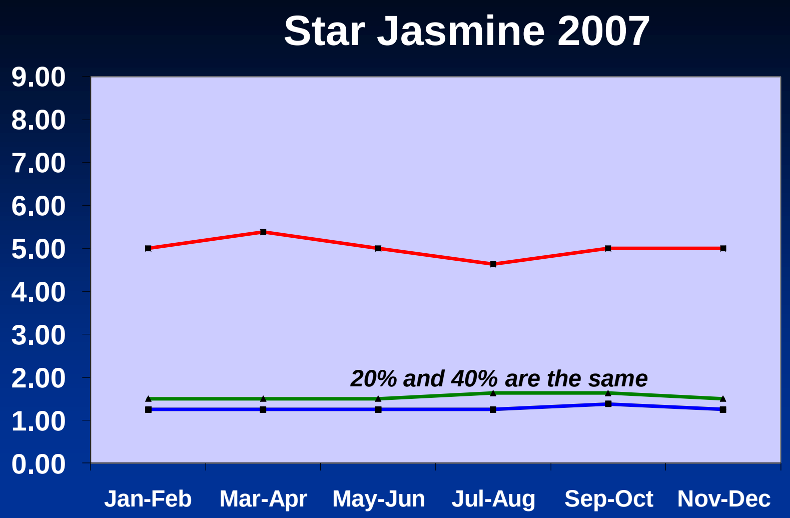
Salvia leucantha
Aesthetic Quality Ratings

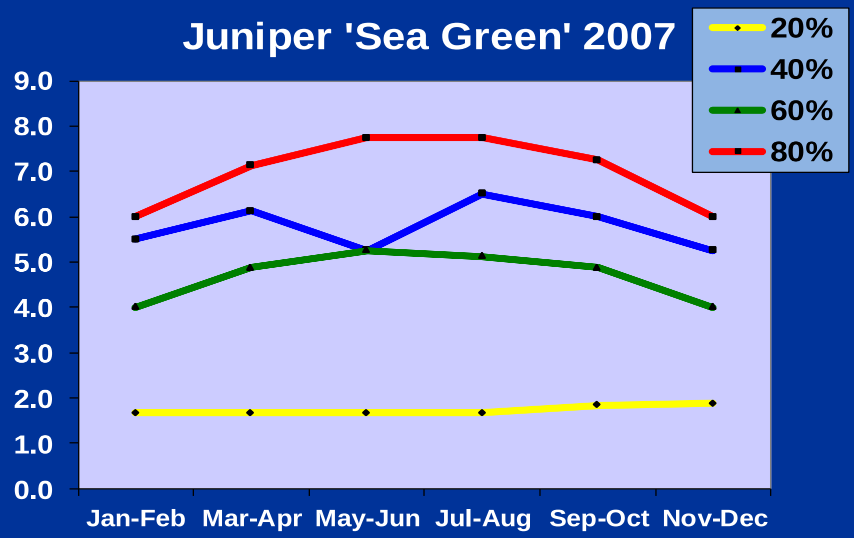


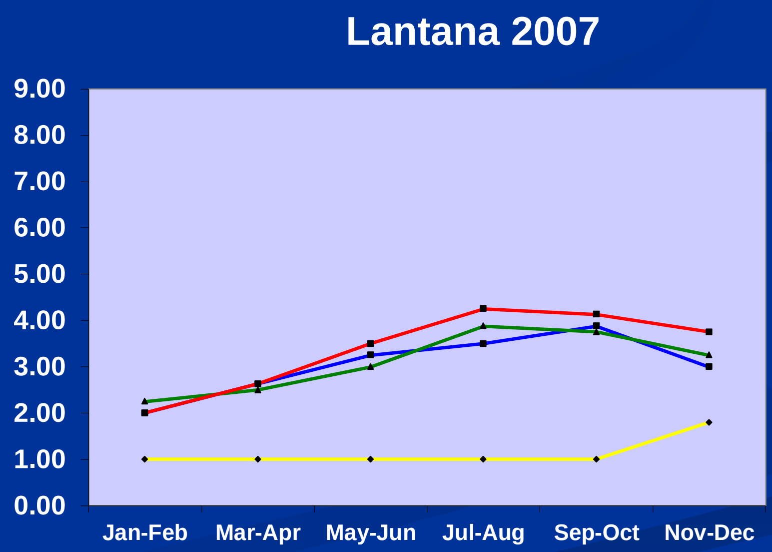
Pyracantha 'Santa Cruz'
Aesthetic Quality Ratings




Cassia (Senna) 2007
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec


Star Jasmine 2007
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
20% and 40% are the same
Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec


Juniper 'Sea Green' 2007
20%
40%
60%
80%
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec


Lantana 2007
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec

Groundcovers, Trees, Shrubs

- Traditional landscape plants can perform acceptably with low water
- Less water often limits growth, not appearance
- Typically acceptable *30-60% ETo*
  - Range 0-80%
- Discrepancies with WUCOLS
- ETo unreliable predictor of landscape water need

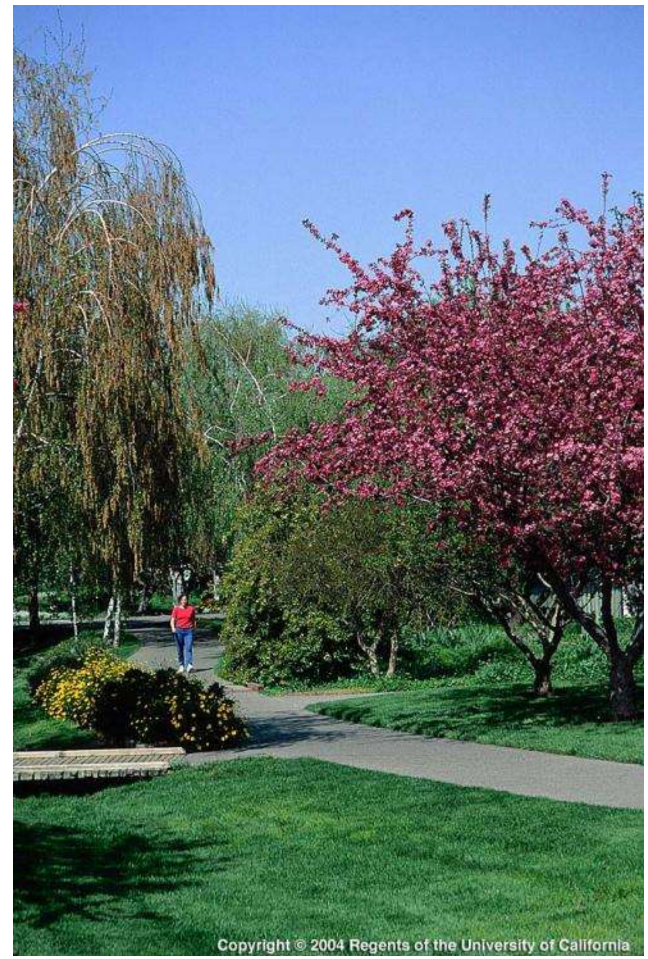
Why Adjust ETo?

Landscape Coefficient Components

$$K_L = K_{PLANTS} + K_{VEG.\ DENSITY} + K_{MICROCLIMATE}$$

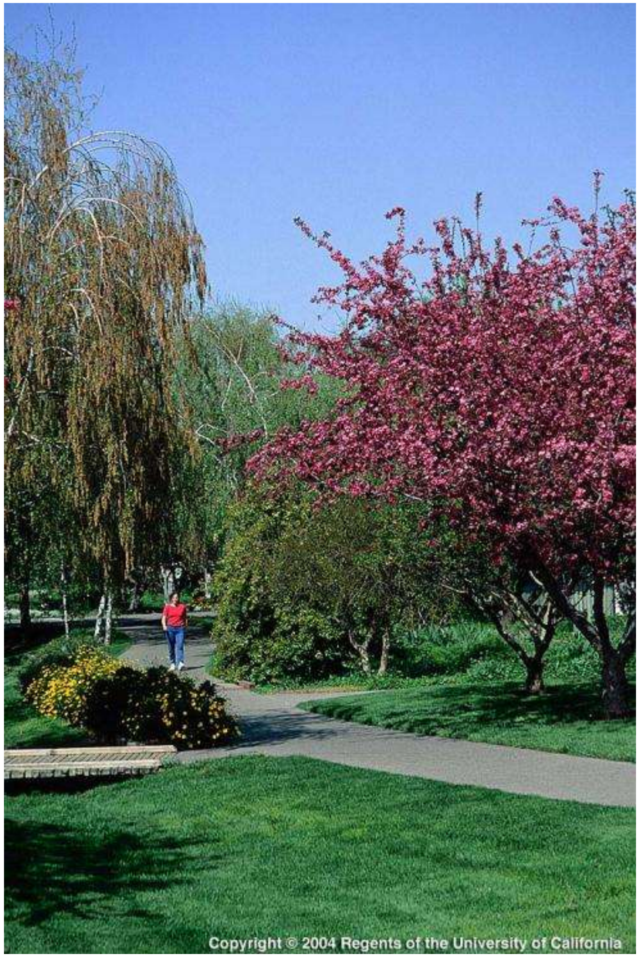
Vegetation Density Factor (Kd)

- Assumes plant mix & leaf area directly affect water need
- ETo accounts for dense cover
- Assumes factor is 0.5-1.3
- No scientific basis for assigning value!!



Microclimate Factor (Kmc)

- Assumes shade & reflected heat predictably affect water need
- Research shows effects can be *un*predictable
- Assumes factor is 0.5-1.4
- No scientific basis for assigning value!!



Plant Material Factor

- Plant material factor types
  - Kc = Crop Coefficient

    = amt. of water needed for *optimum* growth or crop yield
  - PF = Plant Factor

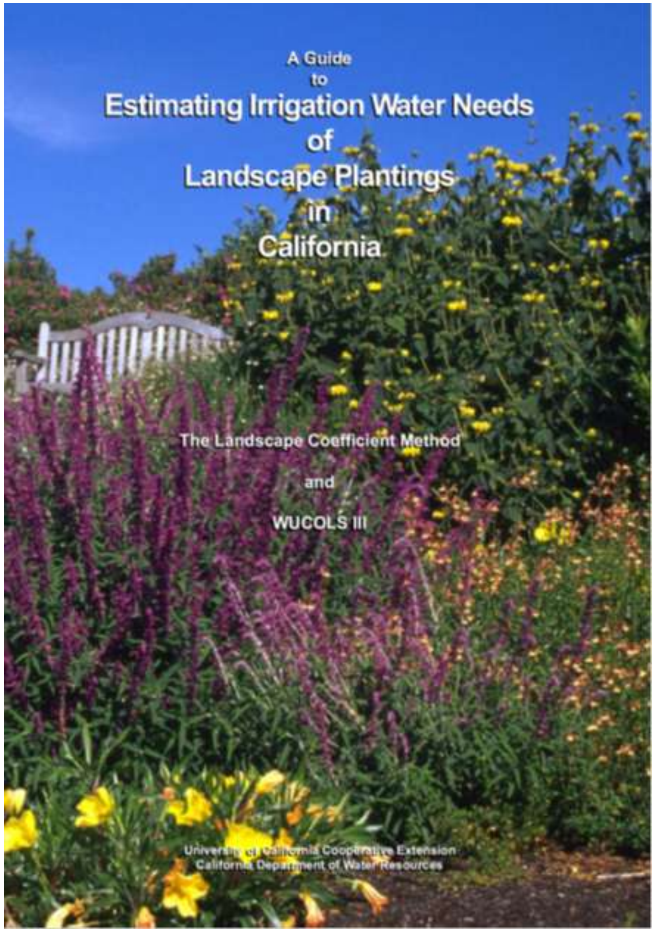
    = amt. of water needed for *acceptable* growth, level of appearance, function

Water Use vs. Water Need

Expectations

WUCOLS

- Not research based
- Adds complexity without improving water budgeting
- Unreliable – false precision
- Default source of “numbers”



WUCOLS Analysis

WUCOLS ZONE	1	2	3	4	5	6	AVG.
# of species appropriate to zone	1602	1088	1969	1185	529	820	1199
% High Water Needs 70-90%	5	6	5	9	7	8	**7 (84)**
% Medium Water Needs 40-60%	51	52	57	57	66	68	**59 (707)**
% Low Water Needs 10-30%	38	36	31	32	25	24	**31 (372)**
% Very Low Water Needs <10%	7	5	7	3	2	0.5	**4 (48)**
Control Total	101	99	100	101	100	100.5	

(WUCOLS III, 2000)

Research Take Home

- More water does not always yield better plant performance
  - Water *Use* ≠ Water *Need*
- WUCOLS unreliable – false precision
  - ≈30% match + ≈ 30% partial match
  - ≈ 40% disagreement
- Budget 50%-60% ETo for non-turf plantings
  - Exact PFs not needed for water budgeting
  - Adjust to meet expectations

Simplified Landscape Irrigation Demand Estimation

SLIDE

…..a new paradigm

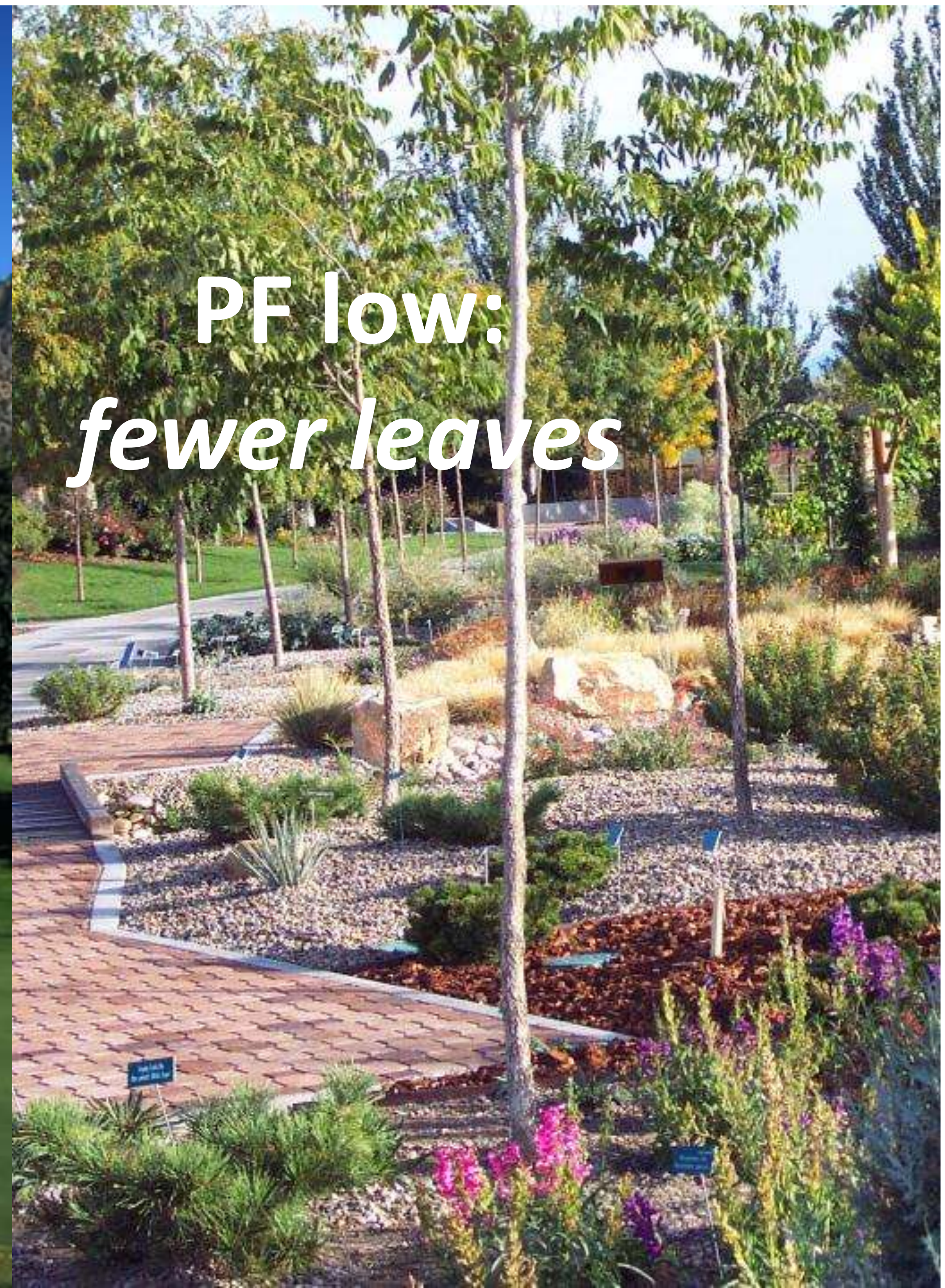
SLIDE Rules *(DRAFT)*

- Landscape plant water USE ≠ NEED
  - Plants often use more than they need
  - Meet minimum expectations in a range of % ETo
  - ETo concept has limited accuracy in landscapes
- Most non-turf plants need near 50% ETo
- Landscape plants can be placed in % ETo water needed based on plant type
- Many landscape plants can tolerate managed drought

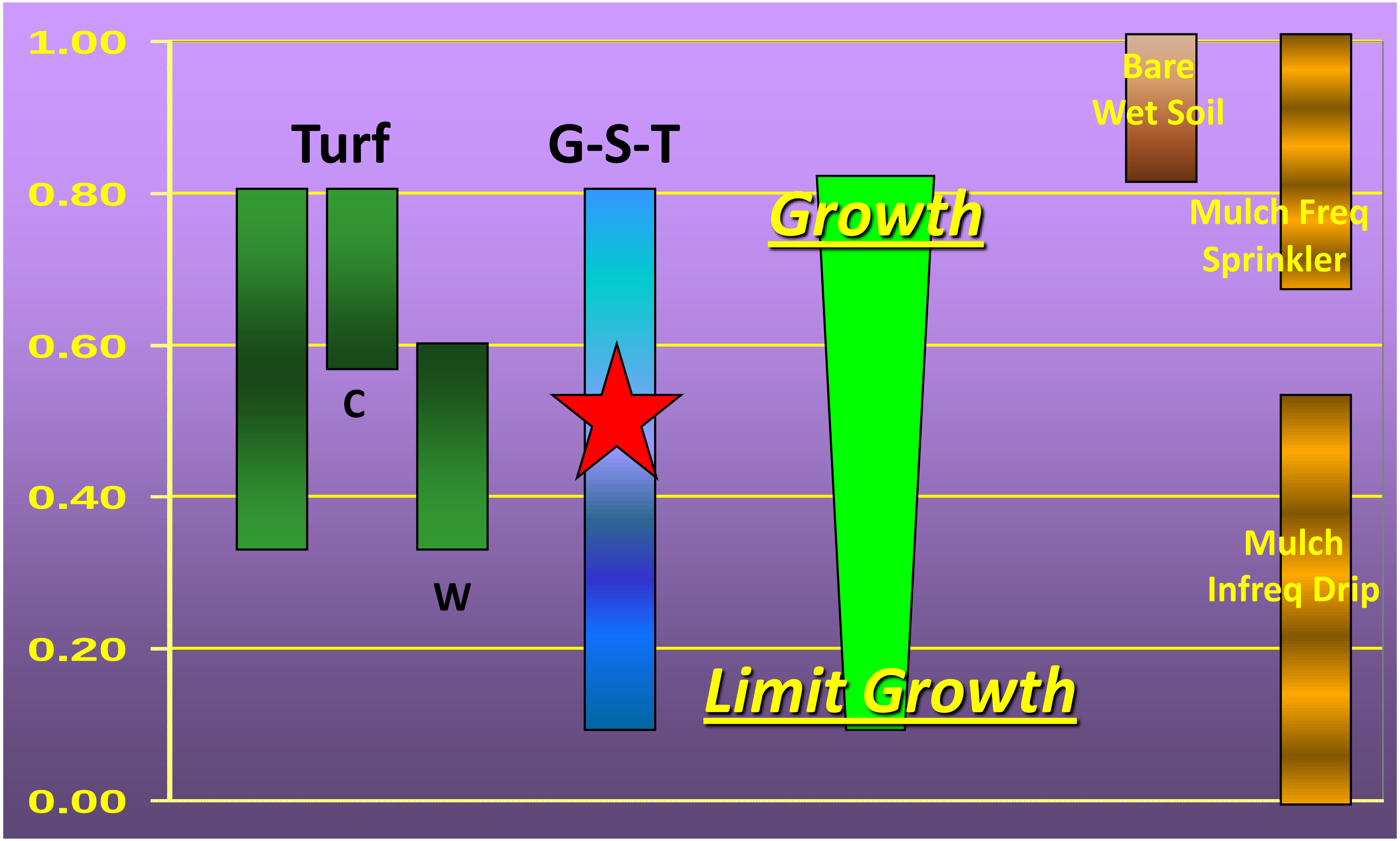
SLIDE Rules *(DRAFT)*

- Categories of Water Need (*under discussion*)
  - Turfgrass = 60-80% ETo
  - Annual-Perennial Flowers/Foliage = 70-80% ETo
  - Tree/Shrub/Groundcover/Vine = 50-70% ETo
  - Very Drought Tolerant Plants = 20-40 % ET
    - Desert Natives/Research Proven Drought Tolerance
    - Physical traits


PF high: *more leaves*
Visual courtesy of R. Kjelgren, Utah St. Univ.


PF low: *fewer leaves*

Using & Adjusting PF & Kc Values



Center for Landscape & Urban Horticulture
University of California Cooperative Extension

Landscape Coefficient Take Home

- Imprecision inherent in K_L components
- Exact PFs not needed
- Woody plants have broad %ETo
- Assign turf Kc
- Assign 50%-60% ETo for non-turf plants
  - Reduce to 30%-40% for known drought tolerant
  - Increase to 75% ETo for flowers and foliage
- Ignore Kd
- Use Kmc with shade only
- Adjust to meet performance expectations

Irrigation Scheduling.....

applying water at the time and in the amount needed for plants to perform to expectations

Key Concepts For Effective Water Management & Irrigation Scheduling

- Distribute water as uniformly as possible
- Apply depth of water equal to the need of plants and that wets root systems
- Avoid runoff
- Verify Smart Controller performance

Priorities for Conserving Landscape Irrigation

1. Maximize irrigation system efficiency
2. Improve schedules
3. Reduce turf area

Steps to Develop Irrigation Schedules

1. Walk-through inspection
2. Calculate PR & DU
3. Estimate plant water needs
4. Calculate station run times
5. Decide irrigation frequency
6. Observe and adjust

System Evaluation
Data Analysis

- Can/should DU be improved?
- Ideal vs. actual schedules for each zone
- System hardware improvements needed?
- Are more irrigation cycles needed?
- Cultural practices affecting irrigation management?

Calculating System Performance Characteristics

- Precipitation rate
- Distribution uniformity
- Each station

Useful Equations

$$\text{Inches} = \frac{\text{Gallons}}{\text{Sq. Ft.} \times 0.623}$$

$$\text{Gallons} = \text{Inches} \times \text{Sq. Ft.} \times 0.623$$

$$\text{Gallons} \div 748 = \text{Billing Units}$$

Precipitation Rate (PR)

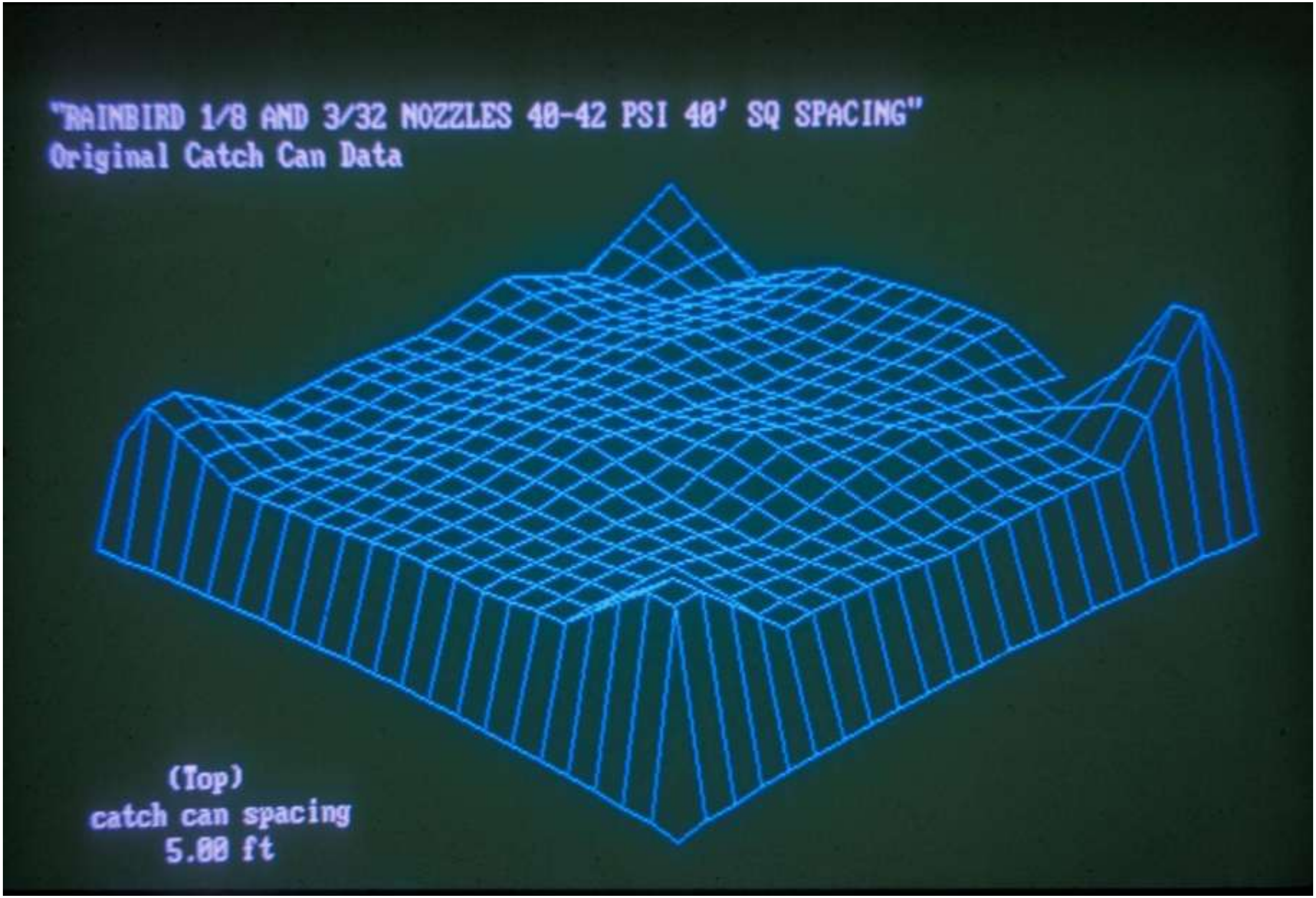
- Depth or volume applied per unit of time
- Inches per hour

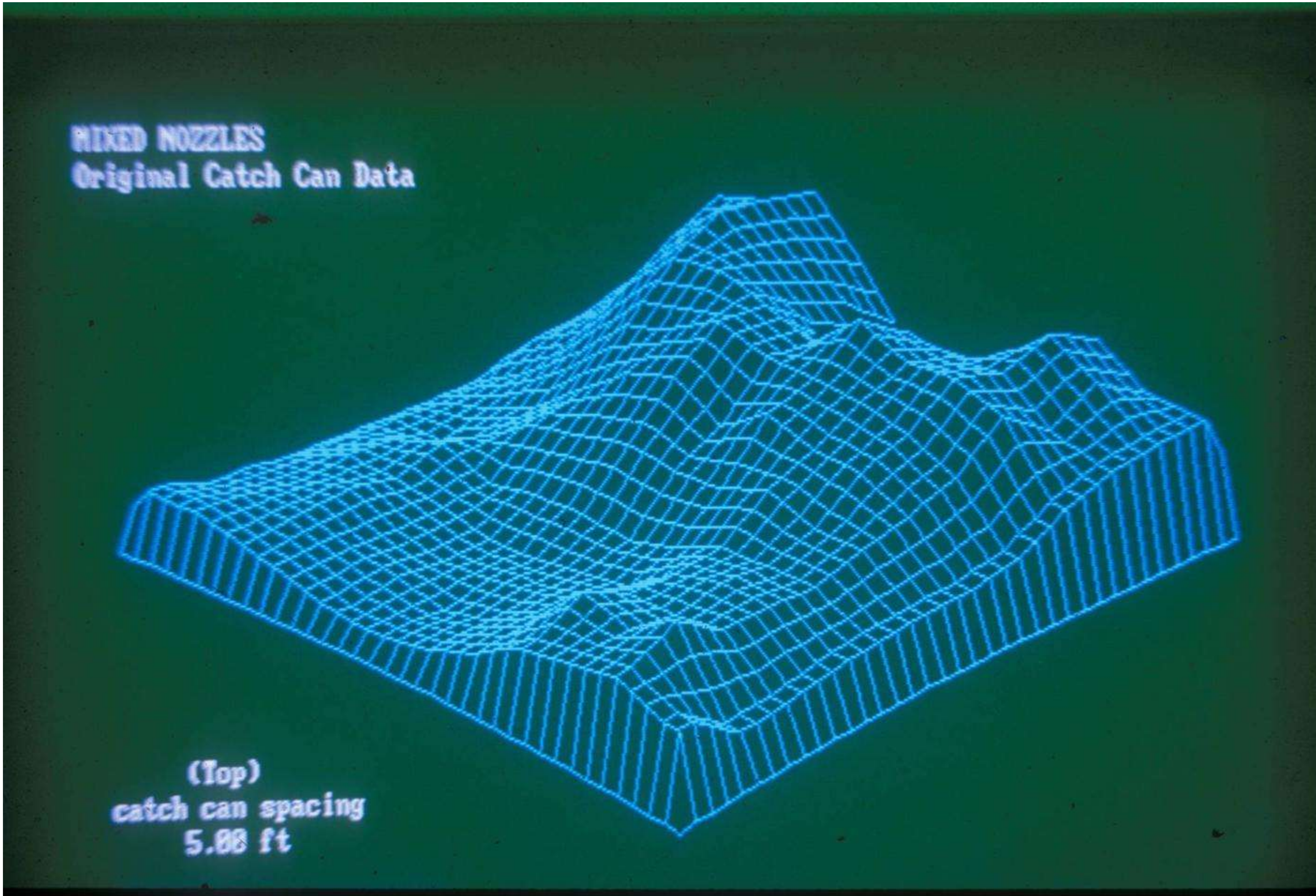
$$PR\ (In/Hr) = \frac{\text{Avg. catch depth inches x 60}}{\text{Test time minutes}}$$

Distribution Uniformity

$$DU = \frac{\text{Low Quarter Average}}{\text{Overall Average}}$$

The low quarter average is the mean of the 25% of the measurements receiving the least amount of water


"RAINBIRD 1/8 AND 3/32 NOZZLES 40-42 PSI 40' SQ SPACING"
Original Catch Can Data
(Top)
catch can spacing
5.00 ft


MIXED NOZZLES
Original Catch Can Data
(Top)
catch can spacing
5.00 ft

Run Time

$$\text{Run Time (minutes.)} = \frac{\text{ETo x PF x 60}}{\text{PR x DU}}$$

ETo = inches per day or week from CIMIS or table
PF = decimal from SLIDE
PR = inches per hour from system evaluation
DU = decimal from system evaluation

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Making a Difference for California

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