Simplified Landscape Irrigation Demand Estimation: *A New Paradigm*

Dennis Pittenger
Area Environmental Horticulturist
Los Angeles County/UC Riverside

Goals

- Learn simple method to estimate accurate plant factors and landscape coefficients
- Understand plant water demand estimation principles and variables
- Review research-based insights on landscape water needs

Useful Reference Materials

- U.C.C.E. Center for Landscape and Urban Horticulture
  - www.ucanr.edu/cluh
  - click Landscape Water Management tab in left column
- Irrigation Association's Landscape Irrigation Auditor Book, 2nd Ed. 2011. Chapter 7 and Appendix D.
- Landscape Irrigation System Evaluation and Management. U.C. Cooperative Extension
  - Shaw and Pittenger, 2009. Available online
- California Dept. of Water Resources
  - CIMIS (California Irrigation Management Information System)
  - http://www.cimis.water.ca.gov/cimis

Landscape Water Conservation Programs & Approaches

Demand for Climate-based Landscape Water Need Estimates

- Water budgets
- State & local conservation ordinances
- “Green” development standards & codes
- Smart irrigation controllers
- Sustainable landscapes
- U.S. EPA ‘Water Sense’
- Save water
- Save money

ETo = Reference Evapotranspiration

An estimate of environmental water demand over a planted area

- Climate-based reference
- Inches/day
- ETo = estimated water use of well-watered cool-season turf
- Calculated from weather data
  - Sunlight, temperature, RH, wind
  - ASCE Penman-Monteith equation
- Based on field research with agricultural crops

Climate-Based Water Budgets
Need reliable plant factor estimates

Water Budget or Water Need

Gal. = ETo × PF, K_L , Kc, or ETAF × LA × 0.62

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

- ETo = reference evapotranspiration; climate impact
- PF, K_L, Kc = plant material adjustment factor
- LA = sq. ft. landscape area
- 0.62 = converts depth to volume [gal. ÷ (in. x sq. ft.)]

Typical ETo Adjustment Calculation

Landscape Coefficient (K_L)

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

K_{PLANTS} from WUCOLS or list

$K_{VEG.\ DENSITY}$ and $K_{MICROCLIMATE}$ assigned by user

Need Simpler Paradigm for Estimating Landscape Water Need

- Most approaches complex with false precision
- No Kc's & few PF's for non-turf landscape plants
- ETo has limited application in landscapes
- Range of % ETo (PF) appropriate for landscape plants

Simplified Landscape Irrigation Demand Estimation

S L I D E

…..a new paradigm

for selecting Plant Factors…..

SLIDE Paradigm

Principles:

- Plant factors accurately estimated by broad plant type categories based on science and research
- Landscape water need estimated by weighting sq. ft. of each plant type present

SLIDE Features

- Simple to understand & use
  - Replaces need for huge data base
  - Reduces number of factors or variables
- Accommodates new plants
- Scientifically & conceptually sound
  - Assimilation and application of ≈20 yrs. of data
  - Scientifically traceable
- Provides reliable numbers for calculations
- Wide geographic & climatic application

Current Development Status of SLIDE

- Presenting to key stakeholders and decision makers
- Electronic discussion system among researchers
- Preparing technical manuscript to establish scientific merit

SLIDE Leaders

- Roger Kjelgren – Utah State University
- Richard Beeson – University of Florida
- David Shaw – University of California
- Dennis Pittenger – University of California

National Standard Being Developed

- S623: ***Standardized Procedure for Determining Landscape Plant Water Requirements***

- Am. Society of Agricultural & Biological Engineers (ASABE)

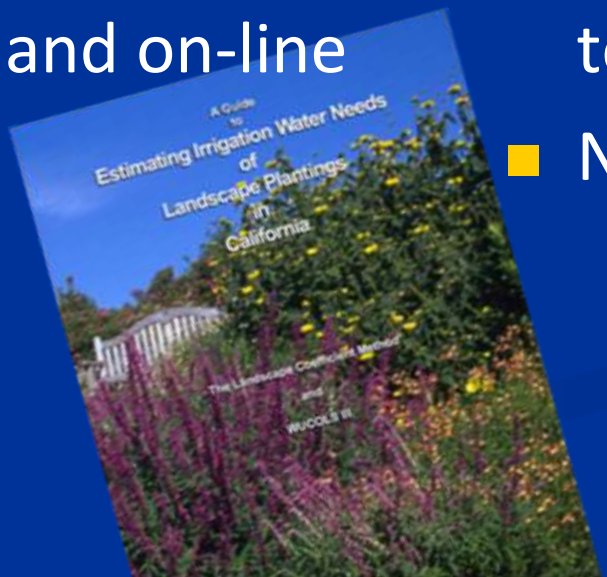
- SLIDE concepts integrated

WUCOLS

Water Use Classification of Landscape Species

PROS

- Source of numbers
- Categories by climate zone and water use
- Includes numerous spp.
- Hardcopy and on-line

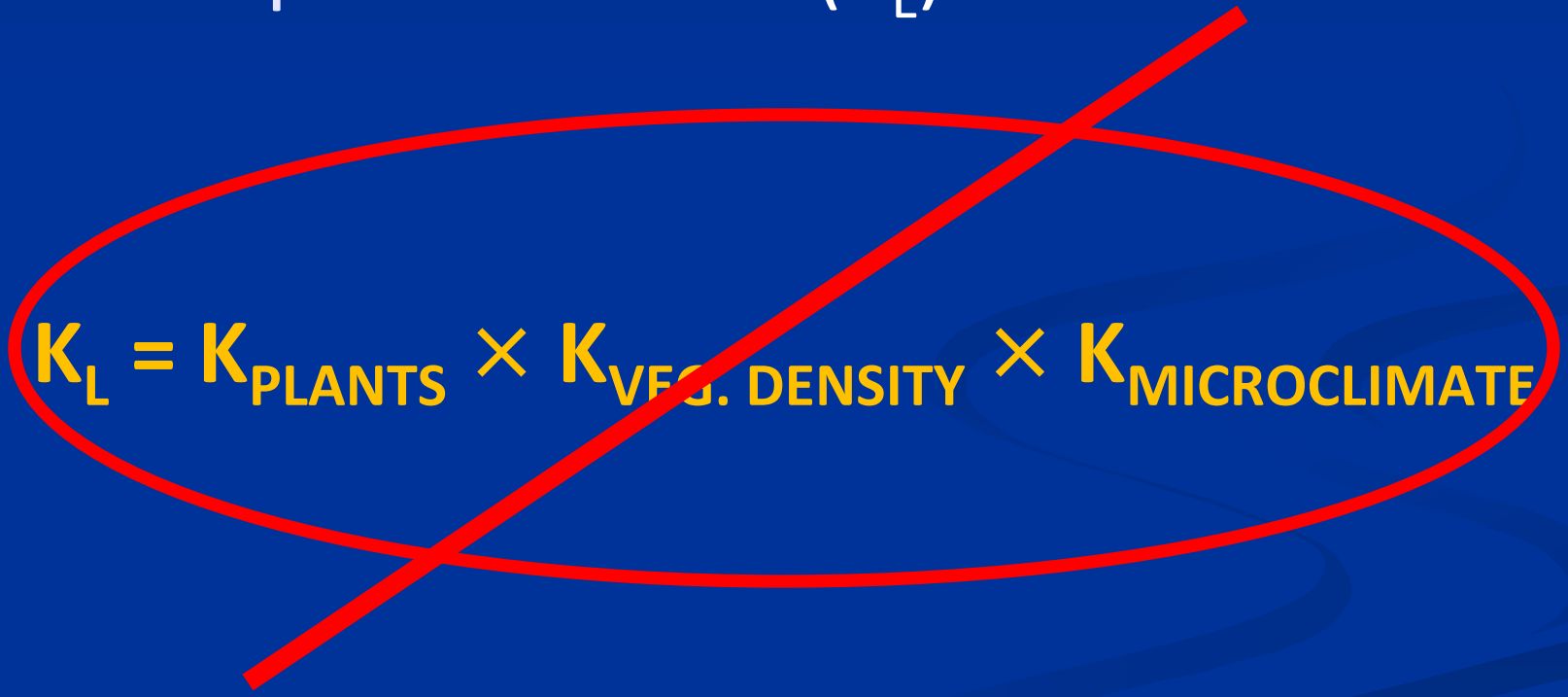


CONS

- Not science based
- Data not reliable
- False sense of precision
- Complex and perplexing to use
- Not readily revised

SLIDE Rules

Landscape Coefficient (K_L)



SLIDE Rules

- 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
  - Landscape plants tolerate managed drought
- Most non-turf plants need near 50% ETo
- Plant factors accurately estimated by categorizing plant

Estimating Plant Water Needs Through Science

- Define a reference for plant water use that is a function of climate (ETo)
- Compare water needed to maintain given plant with reference amount
- Express plant water need as % of reference
  - Plant Factor (PF) – *acceptable* appearance, function
  - Crop Coefficient (Kc) – *optimum* growth or yield

Estimating Plant Water Needs Through Science

Estimating Landscape Water Needs Using ETo

- Assumptions:
  - Landscapes need/use water like ag. crops
  - Plant water needs change in lockstep with changes in ETo
  - Plant canopy is uniform
  - Same or similar plants across landscape
  - Ability to irrigate the landscape plants uniformly

ETo Approach OK With Turf

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

Turfgrass Irrigation Needs

- Cool-season Kc:

  80% ETo annual avg.

  (60% ETo minimum)

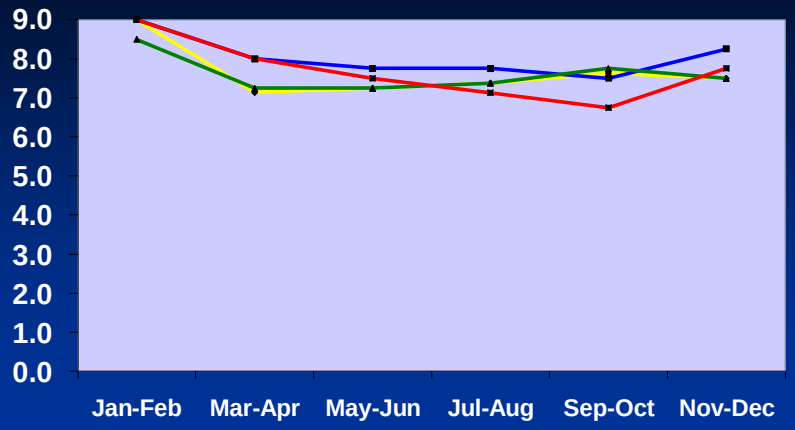
- Warm-season Kc:

  60% ETo annual avg.

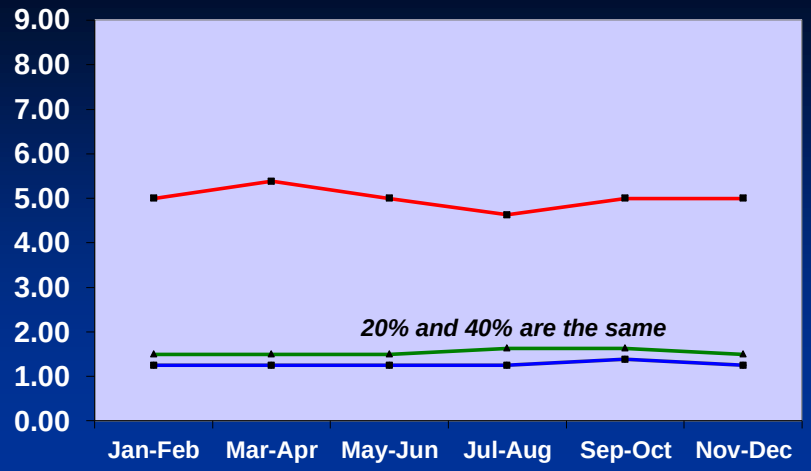
  (40% ETo minimum)

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

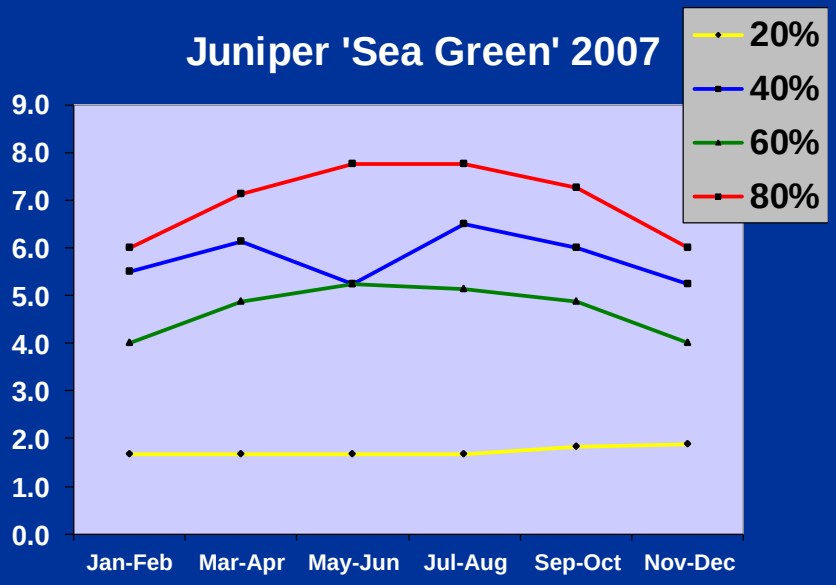
Cassia (Senna) 2007



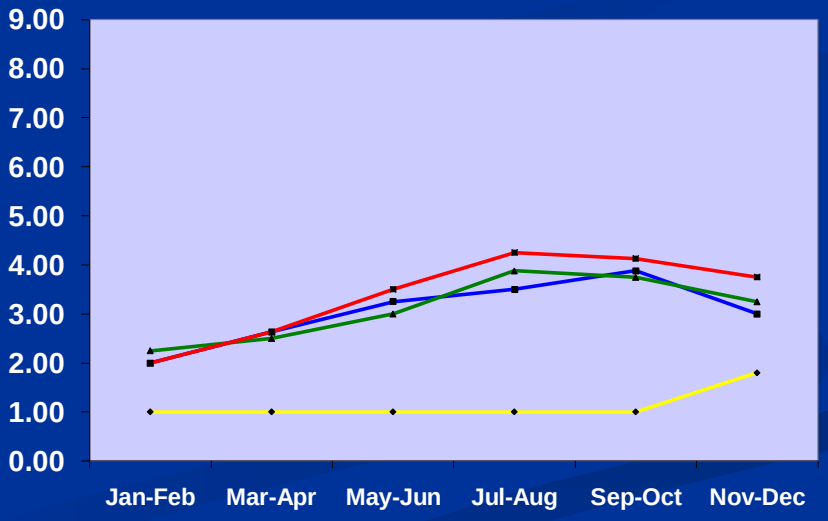
Star Jasmine 2007



Juniper 'Sea Green' 2007



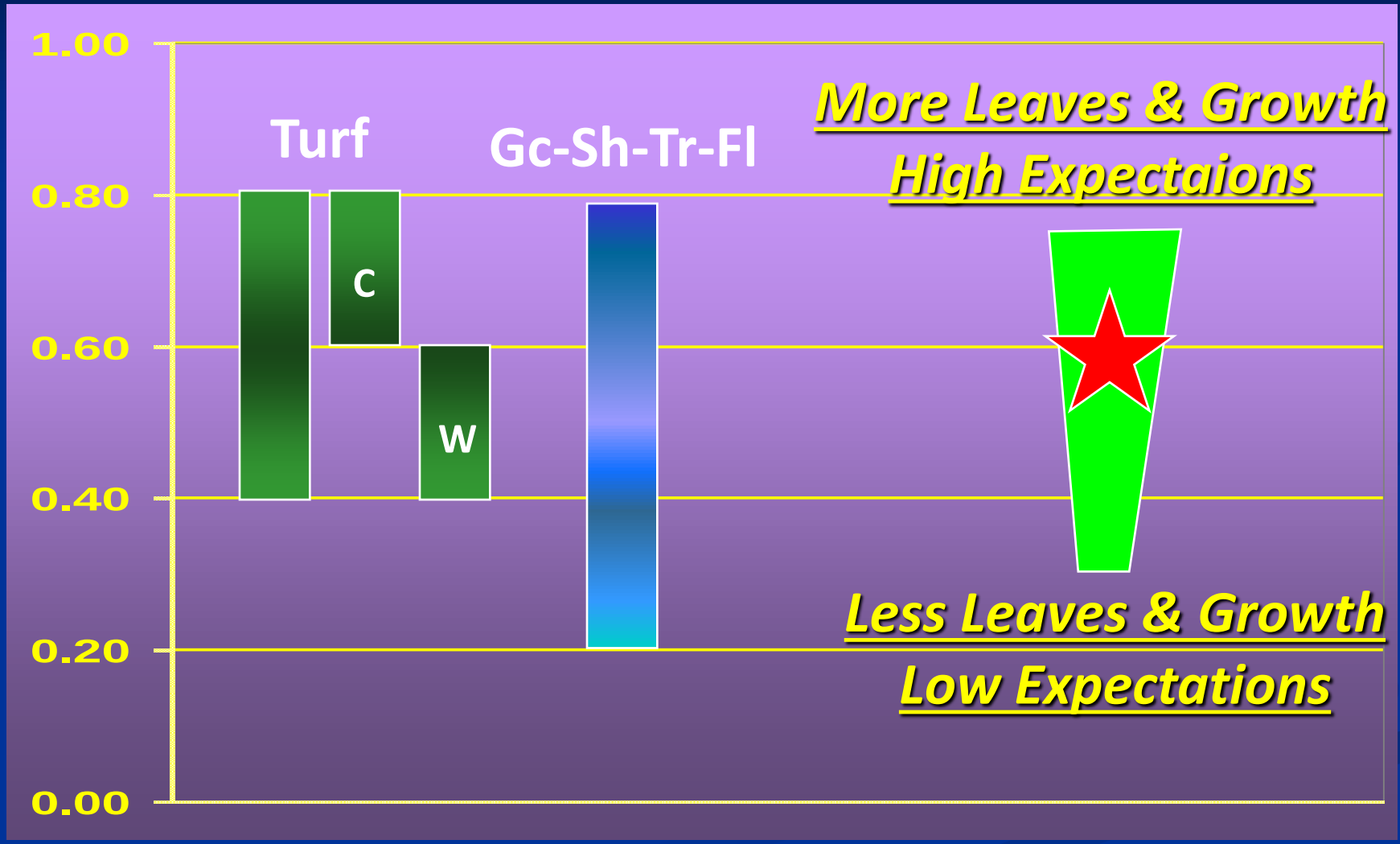
Lantana 2007



Groundcovers, Trees, Shrubs

- ETo × PF model cannot precisely estimate non-turf water need
  - Narrow range of % ETo per species
- Typically acceptable *30-60% ETo*
- Use more water than they need
- Traditional landscape plants perform acceptably with range of low water
- Less water often limits growth, not quality
- Discrepancies with WUCOLS

Using & Adjusting PF & Kc Values



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SLIDE Rules *(DRAFT)*

- Categories of Water Need
  - Turfgrass = 40-60% ETo (w-s) / 60-80% ETo (c-s)
  - Tree/Shrub/Groundcover/Vine = 50-60% ETo
  - Low Expectations/Desert Adapted = 30-40% ETo
  - Annual-Perennial Flowers/Foliage = 70-80% ETo

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 0.7 – 0.9 ETo	5	6	5	9	7	8	**7 (84)**
% Medium Water Needs 0.4 - 0.6 ETo	51	52	57	57	66	68	**59 (707)**
% Low Water Needs 0.1 – 0.3 ETo	38	36	31	32	25	24	**31 (372)**
% Very Low Water Needs < 0.1 ETo	7	5	7	3	2	0.5	**4 (48)**
Control Total	101	99	100	101	100	100.5	

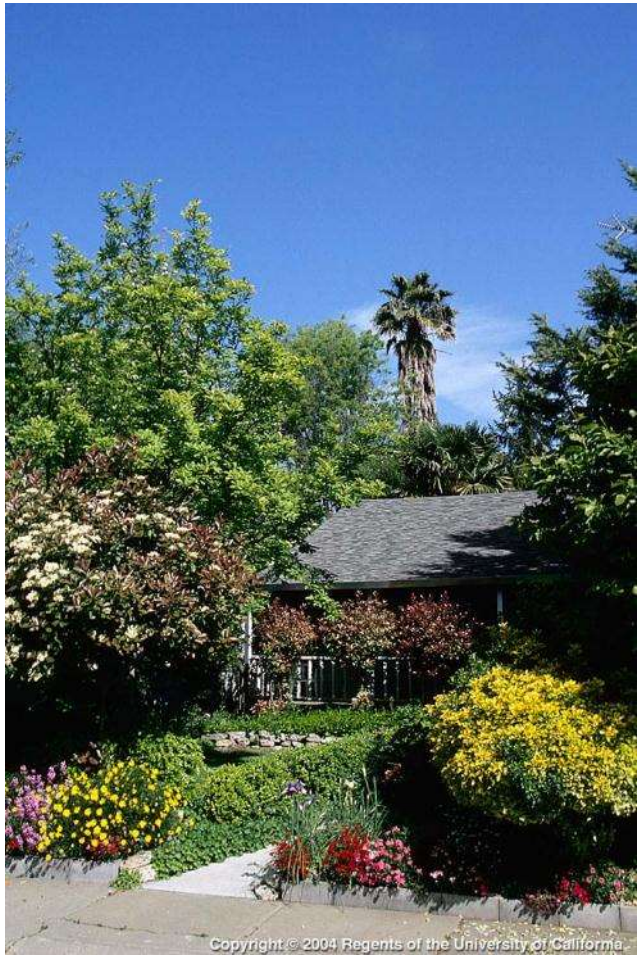
(WUCOLS III, 2000)

SLIDE Rules

- Leaf area influences landscape water demand
- Canopy size & Projected Canopy Area Issues
  - Crown projection area × ETo × PF
  - Guidelines for new or sparsely planted landscapes

Applying SLIDE Rules in Design

- Design sq. ft. of turf desired
  - Kc 0.6 or 0.8 for optimum growth
- Kp 0.5 - 0.6 woody & non-turf plants in remaining area
  - Reduce to 0.2 - 0.4 for desert adapted or reduced expectations
  - Increase to 0.7 - 0.8 for flowers
  - Reduce with persistent shade
- ETo × Kp × sq. ft. per zone
  - Sum zones' water needs
- Compare to budget or allocation



Applying SLIDE Rules

Established Landscapes

Landscape Water Budget or Water Need

$$\textbf{Gallons} = \textbf{ETo} \times \sum(\textbf{PF} \times \textbf{LA})_{1\text{-}x} \times \textbf{0.62}$$

$$\sum = (PF_1 \times LA_1) + (PF_2 \times LA_2) + (PF_3 \times LA_3).....$$

Divide each zone by DU

- ETo = reference evapotranspiration, CIMIS, etc.; climate impact
- PF = plant material factor (turf, shrub-tree-vine-gc, flowers, etc.)
- LA = sq. ft. landscape area
- 0.62 = converts depth to volume [gal. ÷ (in. x sq. ft.)]

Applying SLIDE Rules

New Plantings or Widely Spaced Plants

Landscape Water Budget or Water Need

Gallons = ETo × ∑(PF × CA)$_{1\text{-}x}$ × 0.62

$$\sum = (PF_1 \times CA_1) + (PF_2 \times CA_2) + (PF_3 \times CA_3).....$$

Divide each zone by DU

- ETo = reference evapotranspiration, CIMIS, etc.; climate impact
- PF = plant material factor (turf, shrub-tree-vine-gc, flowers, etc.)
- CA = sq. ft. of canopy projection ($\pi \times r^2$)
- 0.62 = converts depth to volume [gal. ÷ (in. x sq. ft.)]

Useful Equations

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

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

Applying SLIDE Rules

10,000 sq. ft. landscape with 500 sq. ft. patio + 250 sq. ft. walkway

- ***Allocation or Budget (MAWA)*** **= ETo × AF × Sq. Ft. × 0.62**
- **Gal. = 44 in. × 0.7 × 9,250 sq. ft. × 0.62 = 176,638 gallons = 31 in.**

- ***Demand = ETo ×*** $\sum$***[(PF × LA ÷ DU)$_1$ + (PF × LA ÷ DU)$_2$ …] × 0.62***

  (= tall fescue + mixed trees, shrubs, groundcovers + color beds)

  (= 25% + 70% + 5%)

  = 44 in. × $\sum$[(0.8 × 2,300) + (0.5 × 6,450) + (0.7 × 500)] × 0.62

  = 44 in. × $\sum$[(1,840 ÷ 0.7) + (3,225 ÷ 0.85) + (350 ÷ 0.75)] × 0.62

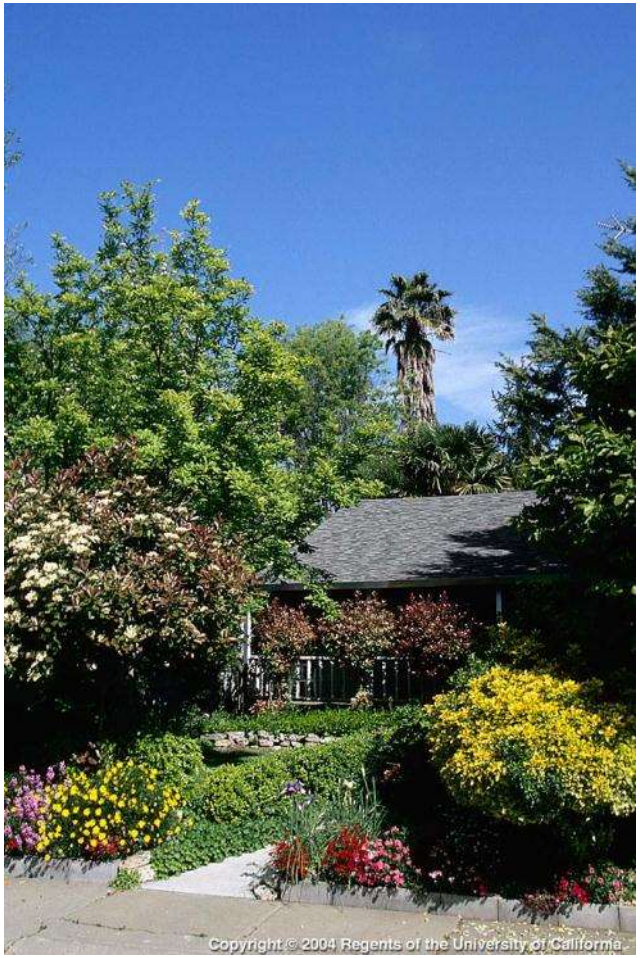
  = 44 in. × [2,629 + 3,794 + 467] × 0.62

  = 187,959 gallons = 34 inches

- ***About 11,000 gallons or 3 inches Over Budget!!!***

Options to Reduce Water Needs

- Improve DU
- Adjust plant spp. mix
  - Turf = 31 gal./sq. ft.
  - G-S-T = 16 gal./sq. ft.
  - Color = 25 gal./sq. ft.
- Reduce planted area
- Lower expectations



Expectations Met & Water Conserved

SLIDE Paradigm

Principles:

- Based on science - plant factors accurately estimated by broad plant type categories
- Landscape water need estimated by weighting sq. ft. of each plant type

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dennis.pittenger@ucr.edu
Phone: 951.827.3320

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