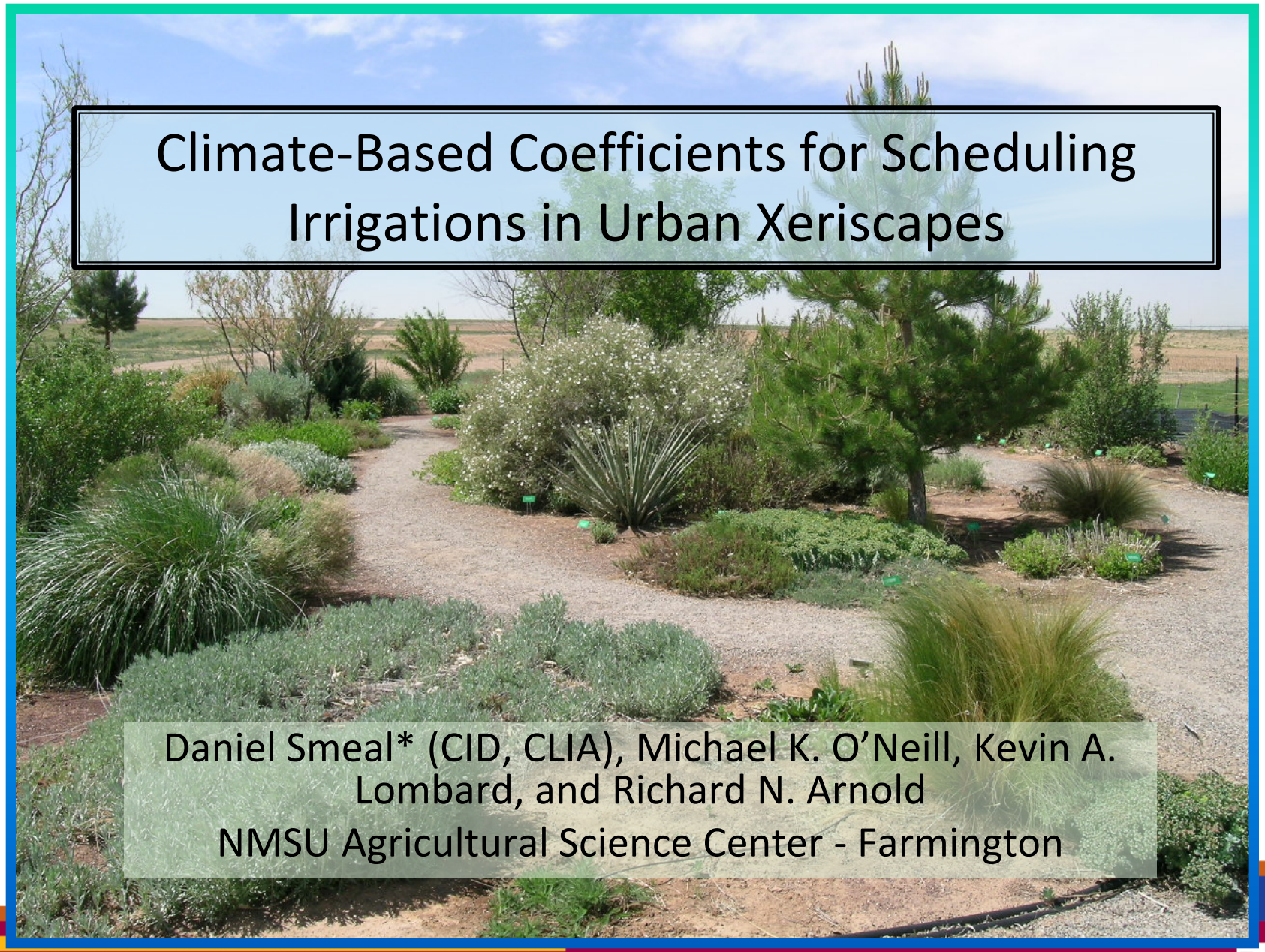

Climate-Based Coefficients for Scheduling Irrigations in Urban Xeriscapes

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Problem

- Water demand exceeding dependable supply.
- Water management plans:
  - Increasing-block water rate structures
  - Water use restrictions/penalties for waste
  - Cash or other incentives for removal of high water-using landscape plants (turf and exotics)

http://www.h2ouniversity.org/html/K2_facts_drought.html

http://news.nationalgeographic.com/news/2007/08/photogalleries/wip-week40/photo4.html

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Response

- Businesses and homeowners are replacing sprinkler-irrigated grass lawns with drip irrigated xeriscapes.

home-and-garden.webshots.com/photo/1154774187...

weblogs.baltimoresun.com/.../gardening/2010/08/

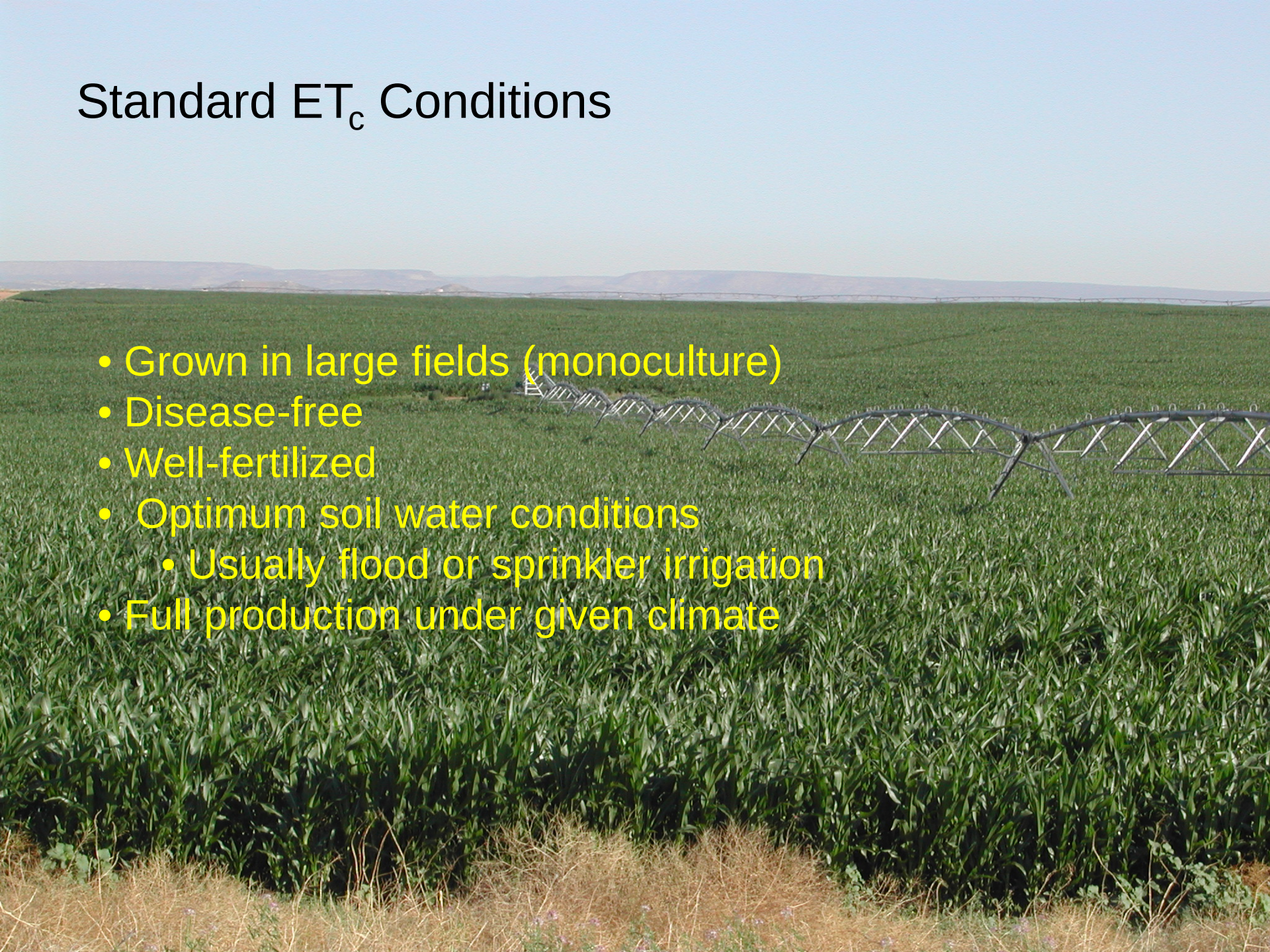
New Problem

- Irrigation techniques and management strategies must be modified to accommodate these ‘unfamiliar’ landscapes.
- Data (such as plant water requirement estimates) for developing these new strategies are lacking.
- Xeriscapes may be over watered or not watered properly.

Climate-Based Irrigation Scheduling: Classical Approach (agriculture and turf): Crop evapotranspiration estimates: $ET_C = ET_{REF} \times K_C$

- Reference ET (ET_o or ET_r)- calculated from weather data (T, RH, SR, W)
  - represents a correlation between weather data and actual measured ET of a reference crop such as clipped grass (ET_o) or alfalfa (ET_r) under **standard conditions**
- Crop coefficient (K_c)
  - correction factor to account for variability between ET_o and actual crop ET (ET_c) specific to the crop, growth stage, size, canopy coverage, etc. (formulated under **standard conditions**)

Standard ET_c Conditions

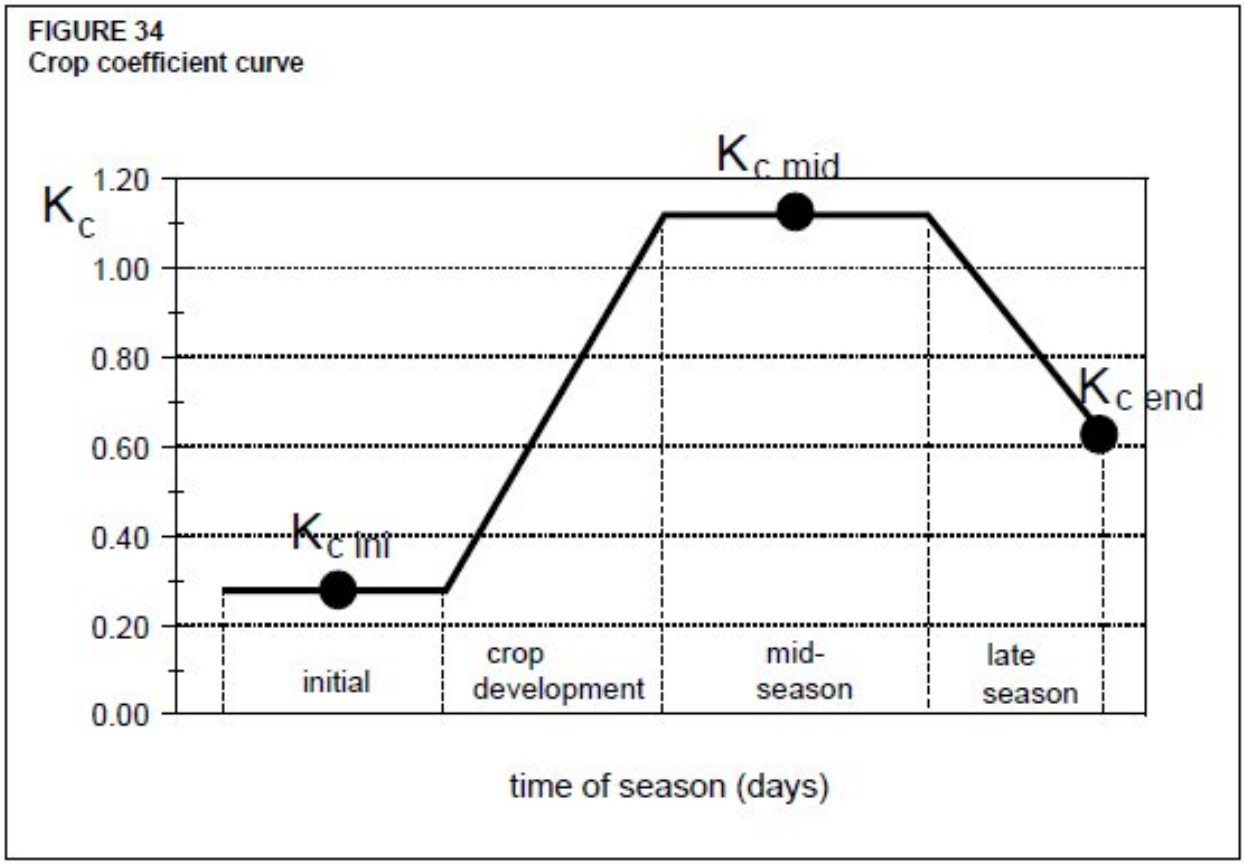


- Grown in large fields (monoculture)
- Disease-free
- Well-fertilized
- Optimum soil water conditions
  - Usually flood or sprinkler irrigation
- Full production under given climate

Xeriscape: Non-Standard ET_c Conditions

- Small plots or isolated plants
- Species mix, variable heights, canopy areas, etc.
- Drip-irrigated
- Soil water deficits OK
- Acceptability or quality precedent over production

Typical Crop-Coefficient



Allen, R.G., et al. 1998, FAO Irrig. Drain. Paper 56

California: Water Use Classification of Landscape Species (WUCOLS)

- Landscape coefficient (K_L)

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

  Where:

  K_S = species coefficient

  K_D = density coefficient

  K_{MC} = microclimate coefficient

- Extensive list of plants with speculative K_S values based on observations of natural habitats

Modified approach: P. Waller 2010 Northern Arizona

- $LPD = ET_{REF} \times K_L \times D^2$

  Where:

  LPD = plant water requirement, L/day

  ET_{REF} = reference ET, mm (ET_O)

  K_L = landscape coefficient

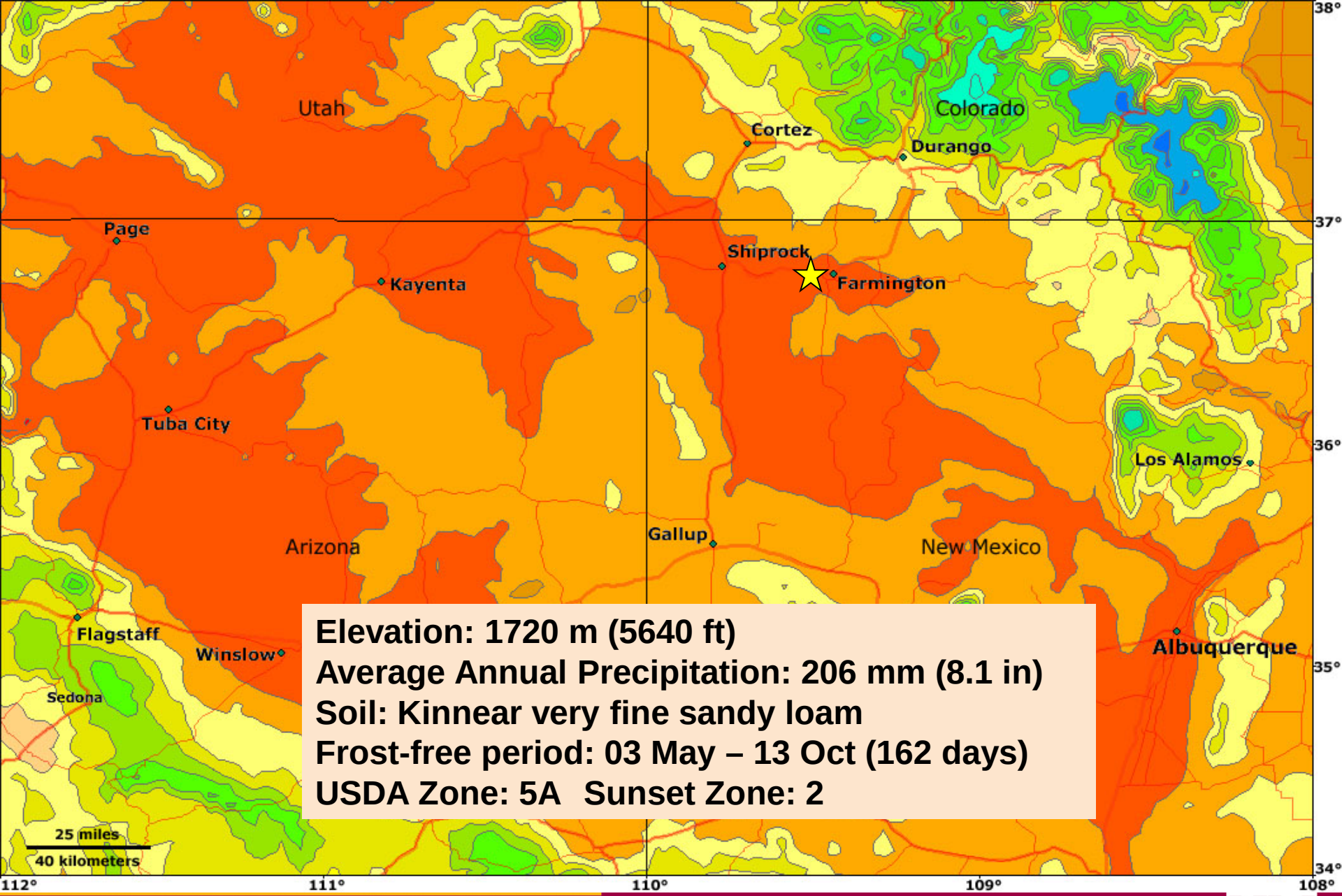
  D = canopy diameter, m^2

  Assuming 78% irrigation efficiency

Objectives

- Provide a demonstration of drought-tolerant plants suitable for use in xeriscapes of the Intermountain West
- Formulate climate-based species coefficients (K_S) that might be useful for scheduling irrigations on these plants

Materials and Methods



Elevation: 1720 m (5640 ft)
Average Annual Precipitation: 206 mm (8.1 in)
Soil: Kinnear very fine sandy loam
Frost-free period: 03 May – 13 Oct (162 days)
USDA Zone: 5A Sunset Zone: 2

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Xeriscape Garden (planted 2002-2003)

Irrigation Treatments

- Irrigation as ratio of reference ET (ET_{rs})

  $I = (ET_{rs} – P_E) \times TF \times CA$

  Where:

  I = irrigation applied per plant per week, L/plant

  ET_{rs} = total ref. ET (ASCE-EWRI) for the week, mm

  P_E = effective precipitation (60% of totals > 5 mm), mm

  TF = treatment factor (ratio of ET_{rs}): 0, 0.2, 0.4, 0.6

  CA = canopy area, m^2 per plant ($0.785 \times D^2$)

  Index plant: D = 1.2 m (CA = 1.16 m^2)

New Mexico Climate Center Network
Farmington ASC Weather Station

Canopy Areas: Aerial Photos.

Species Coefficients (K_S)

- Extrapolated for each species from measured CA and minimum TF where acceptable quality was observed:
  $K_S = I/(ET_{RS} \times D^2 \times 0.785)$

  Where:

  K_S = extrapolated species coefficient

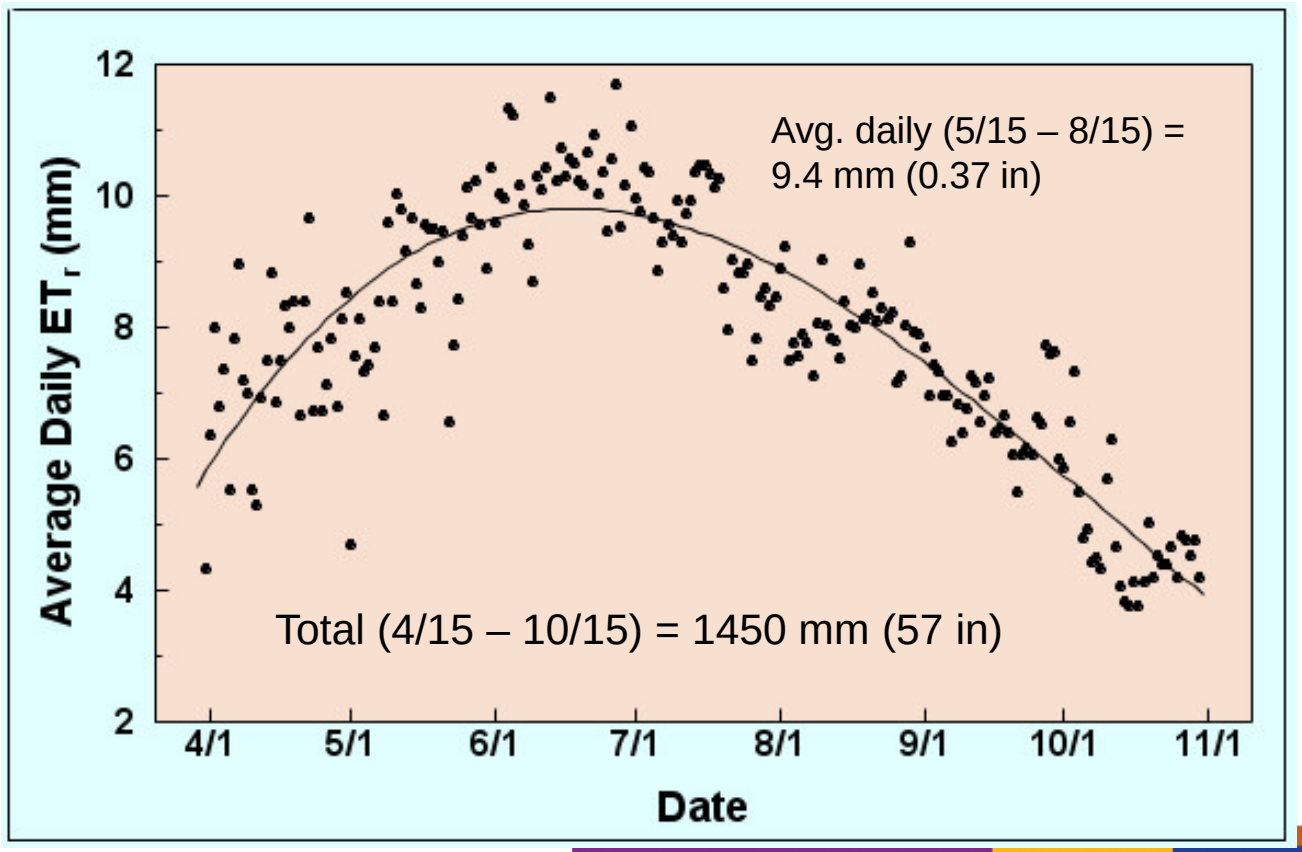
  I = irrigation applied to plant, L (incl. P_E)

  ET_{RS} = total reference ET, mm (for same time period)

  D = measured canopy diameter, m^2

Results

Average Daily ET_r at Farmington NM (2005 – 2009)



Sample Species List with K_S

Species	Diameter (m)	K_S	Peak IR (L/week)†
Brickellia californica (California bricklebush)	1.52	0.22	22.7
Buddleia davidii (butterfly bush)	1.85	0.15	23.0
Caryopteris clandonensis (blue mist)	0.81	0.54	15.2
Chilopsis linearis (desert willow)	3.68	0.05‡	0
Echinacea purpurea (purple coneflower)	0.69	1.66	37.7
Gaillardia aristata (blanket flower)	0.86	0.78	26.4
Hesperaloe parviflora (red yucca)	1.19	0.19	10.9
Prunus besseyi (western sandcherrry)	1.40	0.10	7.1
Salvia greggii (cherry sage)	0.95	0.39	14.9
Sedum telephium (autumn joy sedum)	0.67	0.62	11.2

† At peak daily ET_{RS} of 9.4 mm between 15 May and 15 August
‡ Low 0.05 K_S reflects 3.1 inch of effective precipitation

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Suggested Formula: Irrigation Requirement (IR) Per Plant

- $IR = (ET_{rs} – P_E) \times K_S \times D^2 \times 0.785/IE$
  - Where:
    - IR = irrigation requirement per plant (L)
    - ET_{rs} = P-M tall canopy reference ET, (mm)
    - PE = effective precipitation (60% of events > 5 mm)
    - K_S = species coefficient
    - D = plant diameter (m)
    - 0.785 = constant (plant diameter to circular CA)
    - IE = irrigation efficiency (decimal)

Summary

- Species coefficients (K_S), considering individual plant canopy area and minimum drip irrigation volume for acceptability, were formulated for several plants suitable for use in xeriscapes of the Intermountain West U.S.
- A simple formula that correlates K_S and plant canopy diameter with ET_R has been proposed for estimating the water requirements of these plants.

Summary

- It appears an average K_S of 0.3 can be used for developing water management plans on mixed-species xeriscapes in the Intermountain Western U.S.
- Further research is needed to identify the effects of irrigation frequency on small perennials that have limited root zones.