Creating a Landscape Water Budget Calculator for a Desert City

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Objectives

The objectives of this research are to:

1) Develop landscape water budget (WB) calculator.

2) Develop reliable landscape plants coefficients.

3) Use different landscape water budget calculation approaches to satisfy different users backgrounds.

Introduction

The main source of water for New Mexico's Largest city, Albuquerque (Fig. 1), is ground water. Withdrawal from the Albuquerque Basin exceeds replenishment from percolation from Rio Grande River bed and precipitation (Earp and Witherspoon, 2006). Agricultural and hydrological drought indices showed that New Mexico is suffering from long-term drought (Gutzler, 2003).

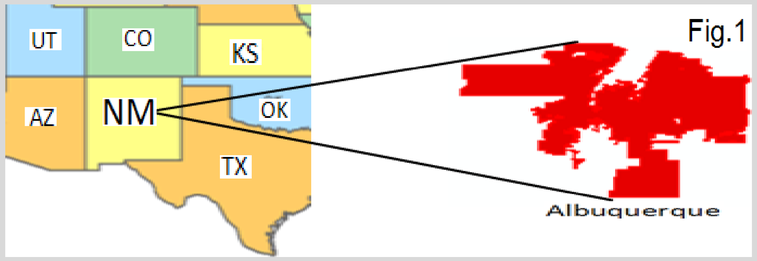

Fig.1

We built a web calculator allows residents to view their landscapes by address searches, and calculate their landscape features areas. The interface was supported with different water budget calculation methods with different levels of details and complexity. However, users can follow calculation steps easily (Fig. 2).

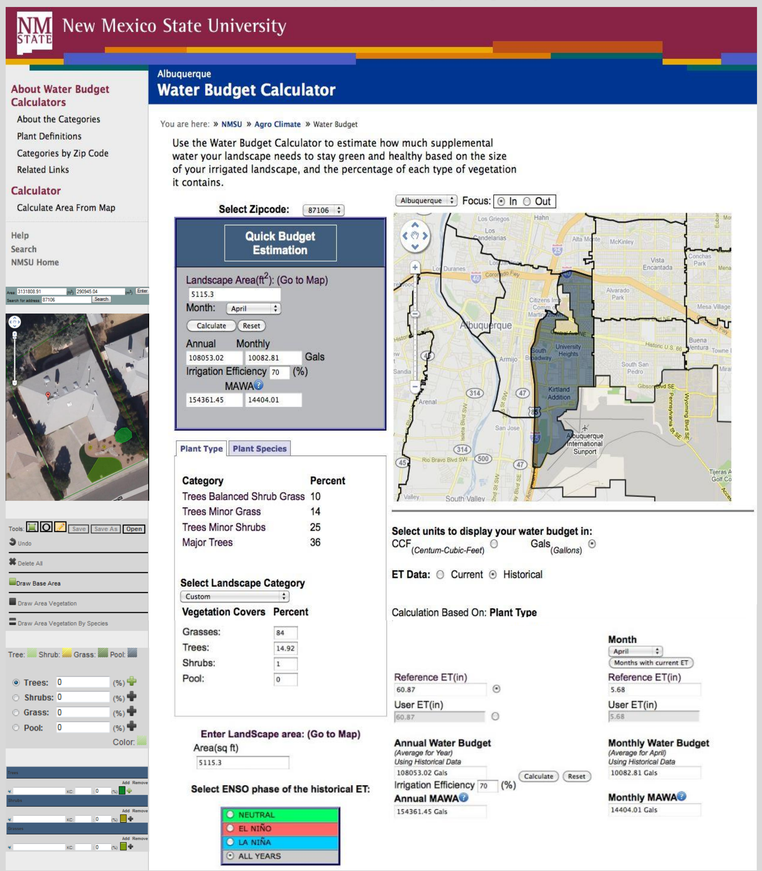

Fig. 2. Residential landscape water budget calculator web interface.

Methodology

Water Budget Calculation Approaches

1) Modified Landscape Water Budget (MWB),

$$MWB = (ET_o)(ZKc)(LA)(CF)$$ .....(Eq. 1)

2) Vegetation Fragmented Water Budget (VFWB),

$$VFWB = \sum_{i=1}^{3} Water\ budget(V_i)$$ .....(Eq. 2)

Where: Water budget (Vi) = ET_o (CF) (Ai) (ViKc)

3) Species Fragmented Water Budget (SFWB),

$$SFWB = \sum_{i=1}^{3}\sum_{j=1}^{n} Water\ budget(S_{ij})$$ .....(Eq. 3)

Where: Water budget (Sij) = ET_o (CF) (Aj) (jKc)

Where: ZKc*= Zip code Mixed Vegetation Coefficient; LA= Total landscape area (f^2); CF= Conversion Factor (0.632 G/f^2in); Vi= Vegetation types (V_1= Trees, V_2= Shrubs V_3= Grass); ET_o= Monthly or annual zip code ref. evapotranspiration; Ai= Total landscape areas of vegetation i (f^2); V_iKc**= General v_i Coefficient; j= Specific landscape plant specie; Aj= Landscape area of specie (j); jKc= Specie (j) Coefficient.

***ZKc's:** developed based on zip code average % of residential vegetations (vegetation raw data was obtained from previous study).

****ViKc:** calculated based on the common Kc value for trees, shrubs, or grasses.

Reference Evapotranspiration

We used Geographic Information System (GIS) and parcels base map to identify the latitudes and longitudes of five purposive ET_o points in each zip code. Penman-Monteith equation was used to calculate the current ET_o using forecasted data from the National Weather Service Forecaster Office. Monthly and yearly historical ET_o (1931-2009) were calculated (Fig. 3) using Hargreaves equation with a coefficient of 0.0023.

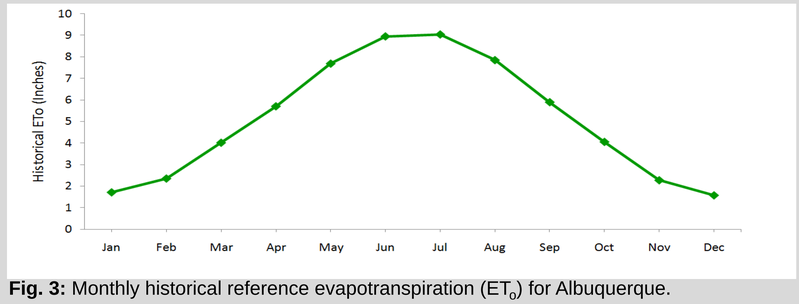

Fig. 3: Monthly historical reference evapotranspiration (ET_o) for Albuquerque.

Transfer of Non-Turf Landscape Plants Kc's

Non-turf plant Kc's were transferred from "California guide for estimating irrigation water needs of landscape plantings" (Costello and Jones, 2000), which includes a list of plant Kc's for each of climate regions. The Transfer was done after matching California climate regions with Albuquerque. We compared the ET_o zones (Table 1), and climate divisions parameter (length of growing season (Fig. 4), annual temperatures (Table 2), and spring cold hardiness zones).

Table 1: Root Mean Square Error (RMSE) of monthly historical evapotranspiration between Albuquerque and each of California climate regions.

California Climate Regions	Reference Evapotranspiration Zones	Average Mean Square Error (MSE) (in/month)
North-Central Coastal (1)	1, 2, 3, 4, 6, 8	1.91
Central Valley (2)	12, 14, 15, 16	0.59
South Coastal (3)	1, 2, 4, 6	2.10
South Inland Valley (4)	9	1.90
High and Intermediate Desert (5)	14, 17	0.72
Low Desert (6)	18	0.97

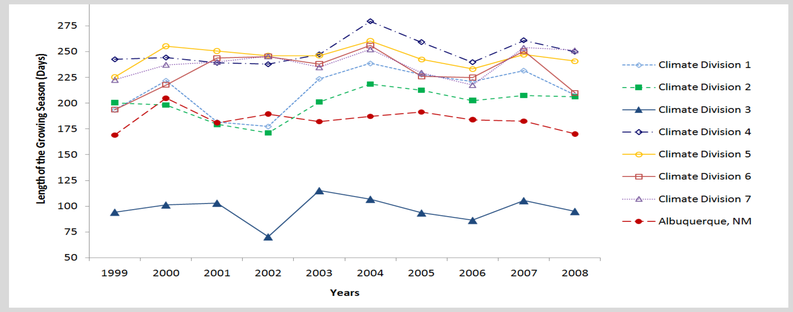

Fig. 4: Average length of the growing seasons (1999-2008) for California climate divisions and New Mexico climate division (5).

Table 2: Average annual temperature (F°) of California climate divisions and New Mexico climate division number 5 (1999-2008) and their differences.

Climate Division	Years 1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	AV. ANNU	Cal –NM (Difference)
CA-1	54.5	55.7	55.9	55.8	56.2	56.7	55.8	55.4	55.6	55.5	55.71	-1.56
CA-2	55.5	55.9	56.9	56.4	57	56.7	56.3	56.4	56.5	56.6	56.42	-0.85
CA-3	45.1	45.5	46	45.6	46.3	45	45.2	44.9	45.4	44.4	45.34	-11.93
CA-4	57.3	58.5	58.4	58.1	59.1	58.8	58.5	58	57.8	58.1	58.26	0.99
CA-5	59.7	60.5	61.1	60.3	61.3	60.5	60.3	60	60.3	60.5	60.45	3.18
CA-6	61.5	62.6	61.6	61.5	62.8	62.3	62.2	62.8	62.3	62.6	62.22	4.95
CA-7	65.5	66.8	66.5	66.2	66.6	65.6	65.6	65.6	66.5	66.4	66.13	8.86
NM-5	57.2	58	57.5	57	58.2	56.4	57.6	57.2	57.2	56.4	57.27	

Transfer of Turf Grasses Kc's

Warm season (ws) and cool season (cs) turf grasses coefficients were calculated for Albuquerque using turf grass crop coefficients equations developed in Farmington Exp. Station/NMSU by Daniel Smeal, 2010. Growing Degree Days (GDD) were calculated from Albuquerque weather stations (Fig. 5).

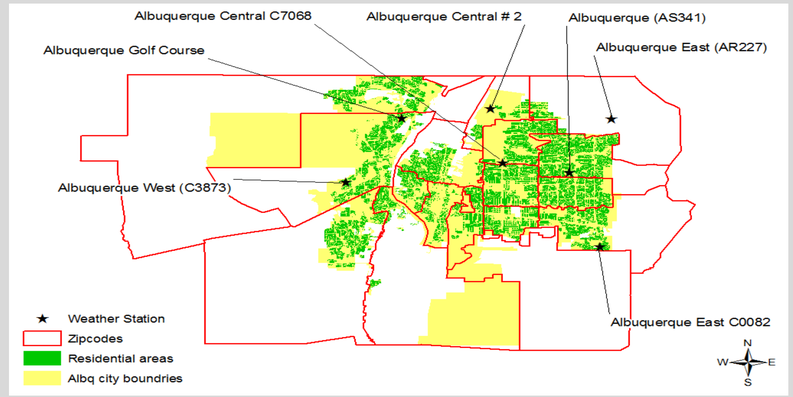

Fig. 4: Spatial distribution of Albuquerque Weather Stations used to calculate turf grass GDD's.

Results

- Formulas were embedded in the web interface with easy, simple and flexible calculation workflows.
- California Climate Region # 2 and Albuquerque showed the lowest RMSE in terms of ET_o zones, length of growing season, annual temperatures, and spring cold hardiness zone. This suggests using plants lists of region # 2.
- Landscape plants Kc's were transferred and added to the web interface for users choices.
- The web interface is ready to be released (Fig. 2), and it is available at: www.nmclimate.nmsu.edu/wb

Literature Cited

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