Landscape Irrigation Management Program

IS005 Quick Answer

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INTRODUCTION

The Excel program LIMP.XLS is used to calculate ET_o rates, determine landscape coefficient (K_L) values, estimate landscape evapotranspiration (ET_L) and determine irrigation schedules. In addition, there is another Excel program DU.XLS, which is used to determine distribution uniformity of sprinkler systems.

Evapotranspiration from landscape vegetation is estimated by using a regional measure of evaporative demand (ET_o from the California Irrigation Management Information System or CIMIS), a microclimate coefficient (K_m) to estimate the ET_o in a "local" microclimate, a vegetation coefficient (K_v) that accounts for species differences in ET from well watered vegetation, a density coefficient (K_d) that adjusts the ET estimate depending on vegetation density, a stress coefficient (K_s) that adjusts for reductions in ET due to water stress and an evaporation coefficient (K_e) that defines a baseline coefficient value. Initially, the coefficient (K_w) to estimate ET of a well-watered vegetated cover is estimated as:

$$K_w = K_m \times K_v \times K_d$$

Then K_w is multiplied by a stress coefficient (K_s) to adjust for reductions in *ET* below that of well-watered vegetation. However, the evaporation coefficient is a baseline, so the landscape coefficient is calculated as:

$$K_l = K_w \times K_s > K_e$$

and the landscape evapotranspiration (ET_l) is calculated as:

$$ET_l = ET_o \times K_l \,.$$

WEATHER WORKSHEET

In the worksheet "Weather", the upper table is used to estimate regional daily ET_o rates by month and to enter the coefficients used to calculate landscape *ET* (ET_l). The lower table is used to input weather data representing the microclimate of the irrigation site to develop monthly microclimate correction factors to estimate the "Local" ET_o rates. Either daily mean ET_o rates or weather data are input to estimate "Regional" ET_o rates in the upper table. Then LIMP uses a smooth curve fitting technique to estimate daily ET_o rates during the year from the monthly data. Weather inputs can include the daily mean (1) solar radiation (MJ m^{-2} d^{-1}), air temperature (^oC), wind speed (m s^{-1}), and dew point temperature (^oC). The program calculates ET_o using the Penman-Monteith (PM) equation (Monteith, 1965) as presented in the United Nations FAO Irrigation and Drainage Paper (FAO 56) by Allen et al. (1998) and using the Hargreaves-Samani (HS) equation (1982 and 1985). If only temperature data are input, then the Hargreaves-Samani equation is used. For the *ETo* calculations, the station latitude and elevation must also be input. If the cells are left blank, then latitude 0^o and elevation 0 meters above sea level are used.

Climate data representing the "Local" site are input in the lower table of the Weather worksheet and ET_o is calculated using the PM and HS equations. The ratio of "local" over "regional" ET_o is computed and displayed in the right-hand column of the lower table. This ratio represents a monthly calibration for microclimate. While the microclimate (K_m) factors are shown in the lower table, they are only used by the program if they are copied to the right-hand column of the upper table using "Copy – Paste Special – Values". A smooth curve fitting procedure is used to estimate daily K_m values for the year. If no values are input into the right-hand column of the upper table, the default value of $K_m = 1.0$ is used.

The vegetation coefficient (K_v) is used to adjust *ET* for plant species differences from ET_o (i.e., the *ET* of tall, cool-season grass). The K_v coefficient represents a well-watered vegetation with a full canopy. The K_v accounts for morphological and physiological differences between the vegetation and the reference surface (ET_o), but adjustments for water stress are done with a stress coefficient (K_s). Therefore, K_v accounts for differences in net radiation, turbulence due to surface roughness, and stomatal differences relative to ET_o, which is an approximation for cool season grass that is 0.12 m tall and well-watered. It is assumed that the plant physiology changes little during the year, so one value is used for K_v all year. The K_v value is input at the top of the Weather worksheet.

Sparse canopies have lower *ET* than dense canopies of the same vegetation and a density coefficient (K_d) is needed for the adjustment. Since there is no known correction for landscape vegetation, the following correction for immature deciduous orchards is used to estimate K_d in LIMP.

$$K_d = sin\left(\frac{C_G}{70}\frac{\pi}{2}\right)$$

where C_G is the percentage of ground covered by green growing vegetation. It is assumed that this relationship accounts for differences in light interception by canopies with cover less than 70 %. For canopies with more than 70 % cover, $K_d = 1.0$. The percentage ground cover is input by month in the upper table of the Weather worksheet, the monthly K_d values are calculated and curve fitting is used to estimate the daily K_d values. If the ground cover cells are left blank, the default value $K_d = 1.0$ is used.

Monthly stress coefficient (K_s) values are input into the upper table of the Weather worksheet. A coefficient of $K_s = 0$ would force $ET_l = 0$ and a $K_s = 1.0$ implies no reduction in ET_l due to water stress. After entering the monthly data, daily K_s values are computed for the entire year using a curve fitting technique. In older literature, it was common to talk about water use differences between vegetation and a "species" coefficient was used to estimate the vegetation *ET* from ET_o. However, in LIMP, the vegetation coefficient (K_v) is used to estimate the *ET* of vegetation with adequate water to not inhibit *ET* and the K_s coefficient is used to estimate the *ET* when the vegetation is stressed.

Bare soil evaporation is estimated for each day of the year using daily ET_o estimates and the number-of-rainy-days per month (NRD), which are input into the "Weather" worksheet. The NRD is used to estimate the days between rainfall for each month and the results are used with ET_o to estimate bare soil evaporation (E_s) using a 2-stage model. Then the estimated soil evaporation (E_s) is used to calculate a daily mean $K_e = E_s/ET_o$ value for bare soil for each month. Curve fitting is used to estimate daily values of K_e over the year. The K_e is a baseline coefficient, so the K_l values must be greater than or equal to K_e.

OUTPUT

Daily values from each of the coefficients is both plotted in LIMP (charts Km_plot, Kd_plot, *K*s_plot and *K*l_plot) and listed in tables (worksheets *Km*, *Kd*, *Ks*, *Ke* and *Kl*). The baseline coefficient K_e is also plotted in Kl_plot. The OUTPUT worksheet contains a row of all coefficient and *ET* calculations for each day of the year.

SCHEDULING

The LIMP program also supplies information for irrigation scheduling. The worksheet RT is used to estimate the daily sprinkler runtime needed to replace the ET_l losses and account for application efficiency. The application rate and efficiency are input at the top of the worksheet and the runtime minutes to efficiently irrigate are displayed in the table. When the application area is input, the total runtime hours and application amount for the year are displayed at the top of the table.

The CRT worksheet shows the cumulative runtime minutes to replace ET_l losses during the year. If any character is input in the small cell immediately left of a cumulative value, the cumulative runtime is reset to zero on that date and the runtime will accumulate until the end of the year. If one knows the maximum runtime possible to avoid runoff, entering characters on dates with that runtime or less will provide a schedule during the year.

The worksheet Kl_Mult is used to input the K_l values for up to 20 watering zones. To input the K_l values, create the K_l values for the vegetation of interest using the Weather worksheet and then copy the daily K_l column from the OUTPUT worksheet to the appropriate column in K1_Mult. When a column of K_l values is copied to the worksheet, a column of runtime values is created in the RT_Mult worksheet. Then the application rate and application efficiency are input at the tops of the columns in the RT_Mult worksheet. Assuming little or no runoff, the distribution uniformity can be used to estimate the application efficiency. The runtime needed to replace daily water losses on each day of the year by zone is displayed under the application efficiency. The CRT_Mult worksheet provides the corresponding cumulative runtime requirements for each day of the year for each of the 20 zones. Entering any character in the blue column to the left of the table will zero the accumulation on the corresponding date and the runtimes will begin to accumulate again on the following day.

The LIMP program can determine runtimes needed for irrigation of urban landscape vegetation using daily ET_o calculated from monthly climate data. However, one can also input the current ET_o data into the ETo worksheet, which is just to the right of the Weather worksheet. To change ET_o values, click on the cell to the left of where data are to be changed and then enter the current ET_o value. The program will automatically update all ET_l calculations in the scheduling worksheets.

DISTRIBUTION UNIFORMITY CALCULATION

For the distribution uniformity calculations, use the program "DU.XLS". Catchcan data from a system evaluation are input in the "DU" worksheet. The units are selected at the top. The catchcan opening diameter, sprinkler runtime, and the volume or depth units for entering the volumes of water collected must be selected. The volumes or depths from each catchcan are input into the upper spread sheet and the distribution uniformity (DU) and application rate (AR) are automatically displayed. The low quarter of the catchcan containers receiving the least volume of water is highlighted to show where the sprinkler applications might be deficient. The input data are ranked from highest to lowest and are plotted in the chart "rankplot". The mean of the low quarter and the sample mean are also displayed on the plot. When using the CRT_Mult worksheet of LIMP, input the application rate and efficiency above the columns. Use the DU from the system evaluation as an estimate of the application efficiency, which is also input at the tops of the columns. This is a valid use of the DU as long as there was little or no runoff and the generated runtimes are used in the schedule.

REFERENCES

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