Using a SWB Model to Analyze the Anthropogenic Effects on Groundwater Recharge in the Ballona Creek Watershed, Los Angeles County, CA

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The Ballona Creek watershed of Los Angeles County in southwestern California has been experiencing urban development since the 1900's, destroying the previously extensive wetlands. With 91% of the watershed developed, Ballona Creek is one of the most extensively developed watersheds in Los Angeles County. The watershed has a population of 1.5 million and typically imports 80% of their water supply. Groundwater is the primary local water source and accounts for approximately 11% of water Ballona's water supply in an average year and 30% during drought years. The severe drought currently being experienced in California highlights the need for studies on local sustainability and groundwater recharge.

This research had three primary questions being considered; how has highly altered land cover changed recharge rates? How do native and non-native vegetation compare in regards to how much water is being evapotranspirated verses recharged? And how much variation is there between pre and post-development recharge and evapotranspiration (ET) rates. To be able to answer these questions a Soil-Water Balance (SWB) model was used to model the current and historical land cover of the Ballona Creek watershed.

To be able to model the post-development Ballona the first step was to organize the tabular data inputs. To be able to do this climate data had to be compiled for the 11 year time span between 1999 and 2010. The climate data consists of precipitation, temperature (min, max, and average), relative humidity (min and average), and daily wind speeds. A land use look up table was also created as part of the tabular data. The table essentially describes the area to the model given any soil type and land cover available in the area. The area is described using maximum recharge values, curve numbers, root zone depths, assumed impervious percentages, and interception values (growing and non-growing seasons) for any combination of land cover and soil type.

Gridded data was the next input needed (Fig. 2). This involved turning the hydrologic soil group and available water capacity shapefiles (polygons) into raster grids and then into the gridded format ASCII, which is the format that is read by the model (Fig. 1). The land use raster, developed by the U.S. Geological Survey's National Land Cover Dataset (USGS NLCD), and the flow direction grids were already in the raster format therefore only needed to be converted to the ASCII format.

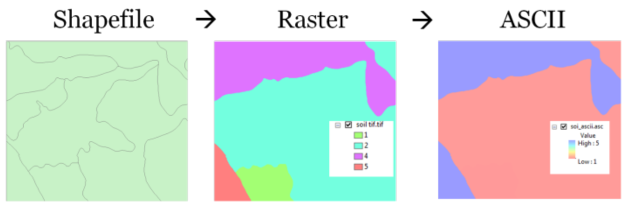


Fig.1: Shapefile to gridded format raster and then to gridded format ASCII sequence for the hydrologic soil group.

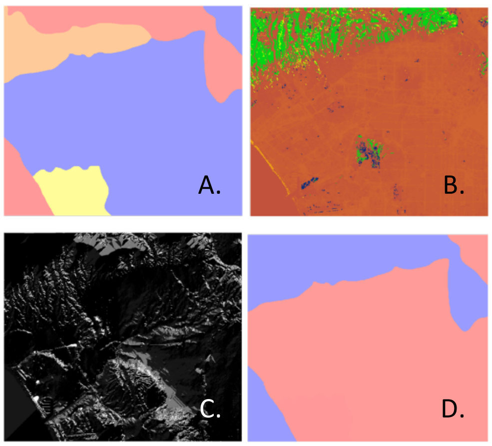


Fig. 2: Inputs for the SWB model

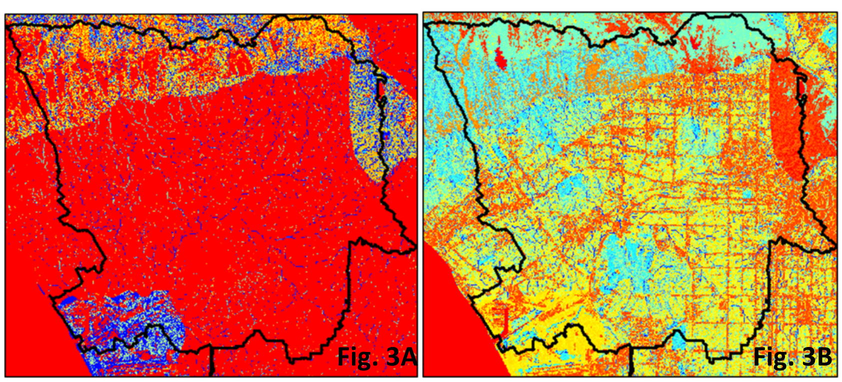
A. Available Water Capacity
soil_awc_inch.asc
Value
High : 5.25
Low : 0

B. Land Cover
land_cover.asc
Value
High : 95
Low : 11

C. Flow Direction
flow_direction.asc
Value
High : 255
Low : 1

D. Hydrologic Soil Groups
soi_ascii.asc
Value
High : 5
Low : 1

The outputs came in the form of gridded files as well as raw data. The gridded data shows the anticipated results of low recharge rates as well as low ET rates in the developed areas (Fig. 3A & 3B). The undeveloped areas where natural vegetation remained had experienced both higher recharge and ET rates. Irrigation was not accounted for in this run of the model. However, one would expect slightly higher rates of ET in the developed areas due to the increase in available water supplied by irrigation. The raw data was used to create a bar graph illustrating the amount of runoff for each land cover type (Fig. 4).



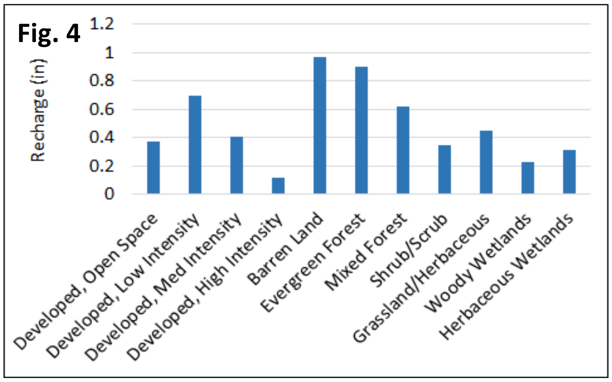


Fig. 3A: 1990 recharge post-development

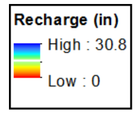


Fig. 3B: 1990 evapotransiration post-development

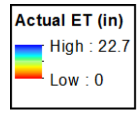


Fig. 4: Bar graph showing the mean monthly recharge for each land cover present in the Ballona Creek watershed post-development.

The next step is to run the model a second time with all parameters remaining the same with the exception of the land cover gridded input. With the change in only this parameter any variations in the results between the pre and post-development model runs will be due to the change in land cover.

To be able to create the pre-development land cover grid; papers, datasets, and T-sheets had to be thoroughly studied. Information was gathered and the extent of each land cover was estimated using the different sources. A shapefile was then created (Fig. 5).

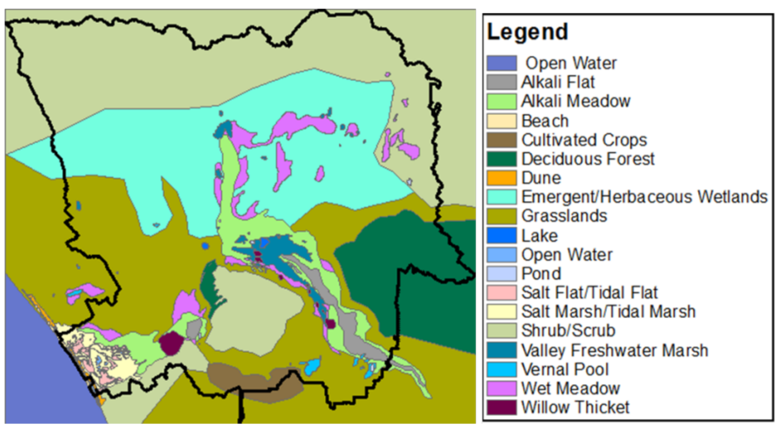


Fig. 5: Shapefile of the Ballona Creek watershed pre-development

Future steps include converting the shapefile for the pre-development land cover into ASCII, and then running the model. Calibration, validation, and sensitivity analysis of the post-development land cover results will also be conducted. The pre and post-development results will then be compared to determine the impact of land cover changes on recharge and ET rates.

Once completed, this study may be used to estimate sustainable water supply and sustainability capacity (population, outdoor water use, etc.) for the basin. The sustainable estimates will be compared to current demands to evaluate the amount of supplemental water required, highlighting the need for imported water and potential for innovations in water reuse and treatment.